Towards a systematics of ecodiversity: the EcoSyst framework

**APPENDIX S1 | GLOSSARY**

This glossary contains definitions of all terms italicised in the main text as well as other important EcoSyst terms. The corresponding term in Norwegian is also included, as used in ‘Nature in Norway (NiN), the implementation of EcoSyst for Norway.

**TABLE S1.1** Glossary of important EcoSyst terms with corresponding term in Norwegian.

| English term | Definition | Corresponding Norwegian term (NiN) |
| --- | --- | --- |
| abiotic | the non-living chemical and physical environment, that is not associated with living organisms | abiotisk |
| abundance | the number of discrete units of an organism within a site; for non-clonal organisms the number of individuals of a given taxon, for clonal organisms, the number of clonal fragments (ramets) | abundans |
| aggregated performance | the presence or abundance of an organism, recorded by a performance measure, aggregated for a set of observation units | aggregert mengde |
| aggregated species performance | the performance of a species, recorded by a performance measure, aggregated for a set of observation units | aggregert artsmengde |
| attribute system | a non-hierarchical set of variables that facilitate systematic recording of objects and other observable characteristics at a given ecodiversity level | beskrivelsessystem |
| biodiversity | the biotic aspect of Nature's variation, on levels of organisation from biotic communities via species and populations to genes | biodiversitet |
| biotic | associated with, or derived from, living organisms | biotisk |
| bottom | generic term for marine seabeds and freshwater bottoms, i.e. the more or less solid upper layer of the Earth's crust at sites covered by water for 50 % of the time or more, with its associated community of organisms | bunn |
| characteristic (of Nature's variation) | object or property used to characterise Nature's diversity, e.g. a species or a landform | naturegenskap |
| CLG | = complex landscape gradient |  |
| complex landscape factor | abstract, categorical variable that expresses discrete, co-ordinated change in a set of correlated landscape variables | kompleks landskapsfaktor |
| complex landscape gradient (= CLG) | abstract, continuous variable that expresses more or less gradual, co-ordinated change in a set of more or less strongly correlated landscape variables, in practice used in a wide sense also including complex landscape factors | kompleks landskapsgradient |
| complex landscape variable | abstract, continuous or categorical variable that expresses co-ordinated variation with respect to (i) geo-ecological gradients, i.e. topography and broad structural patterns of the terrain and the underlying geological properties including bedrock and soil composition; (ii) climate gradients; and (iii) broad-scale gradients of human land use | kompleks landskapsvariabel |
| complex-variable | abstract, continuous or categorical variable that expresses co-ordinated change in a set of correlated single variables | kompleksvariabel |
| composition (of Nature) | the relative performance of different observable objects within a spatial unit | natursammensetning |
| convex subspace | a subspace of a conceptual geometric space in which every point can be connected to every other point by a straight line that is completely contained witin the subspace | konvekst underrom |
| continuum theory | a unified theory of biodiversity, emphasising continuous variation in species composition along continuous environmental complex-gradients | kontinuumteori |
| diversity | the richness of object categories within a spatial unit (α-diversity) and/or the variation around the mean value for a characteristic, recorded for a set of spatial units (β-diversity) | diversitet (= mangfold) |
| diversity level | level in any hierarchy that systematises Nature's diversity; organisms exemplify a biodiversity level, minerals exemplify a geodiversity level, and ecosystems exemplify an ecodiversity level | naturmangfold-nivå |
| Earth’s critical zone | the life-supporting, superficial planetary system extending from the near-surface atmospheric layers that exchange energy, water, particles, and gases with the vegetation and ground layers down through the soil to the deepest bedrock weathering fronts | økosfæren |
| ecodiversity | diversity of units defined by biotic as well as abiotic components and their interactions, and the processes that give rise to variation in the structure and composition of these components | økodiversitet (= økologisk mangfold) |
| ecodiversity distance unit (= EDU) | unit of compositional turnover of the key characteristic at an ecodiversity level along a complex variable in the key source of variation at this level | økodiversitetsavstandsenhet |
| ecodiversity distance unit in ecosystems (EDU−E) | unit of species compositional turnover along an environmental complex-gradient | økologisk avstandsenhet |
| ecodiversity distance unit in landscapes (EDU−L) | unit of landscape element compositional turnover along a complex landscape gradient | landskapsavstandsenhet |
| ecodiversity level | level in the hierarchy of increasing complexity of variation towards broader spatial scales at which biotic and abiotic components and their interactions, and the processes that give rise to variation in their structure and composition, are considered together, e.g. landscape and ecosystem | naturtypenivå |
| ecodiversity model | a theory of variation and relationships at the ecodiversity level of Nature's diversity | økologisk modell |
| ecodiversity space | the conceptual geometric space spanned by major complex-variables in the key source of variation at an ecodiversity level | økodiversitetsrom |
| ecological space | conceptual geometric space with major environmental complex-variables as axes | økologisk rom |
| ecological space model | conceptual geometric model with species’ aggregated performances as response variables and major environmental complex-gradients as axes |  |
| ecological structuring prosess | the ecological mechanism responsible for species' responses to variation along important environmental complex-variables; the proximal ecological cause of variation in species composition | økologisk strukturerende prosess |
| ecosystem | a more or less uniform area with all organisms, the total environment they live in and are adapted to, and the processes that regulate relations among organisms, and between organisms and the environment (natural, or dependent on or shaped by human activities) | økosystem |
| EDU | = ecodiversity distance unit |  |
| EDU−E | = ecodiversity unit in ecosystems |  |
| EDU−L | = ecodiversity unit in landscapes |  |
| elementary segment | one interval in a set of smallest intervals into which a complex-gradient in a key source of variation for a given ecodiversity level is divided, defined by universal criteria that apply across all major types | basistrinn |
| environmental complex-factor | abstract categorical variable that expresses discrete, co-ordinated change in a set of correlated environmental variables | kompleks miljøfaktor |
| environmental complex-gradient | abstract continuous variable that expresses more or less gradual, co-ordinated change in a set of correlated environmental variables (= complex-gradient); in practice used in a wide sense also including environmental complex-factors | kompleks miljøgradient |
| environmental complex-variable | abstract continuous or categorical variable that expresses the co-ordinated change in a set of more or less strongly correlated environmental variables |  |
| environmental factor | categorical variable that expresses discrete variation in an observable environmental characteristic | miljøfaktor |
| environmental gradient | continuous variable that expresses more or less gradual variation in an observable environmental characteristic | miljøgradient |
| environmental variation | variation in an observable environmental characteristic | miljøvariasjon |
| environmetal variable | variable that expresses the variation in an observable environmental characteristic | miljøvariabel |
| explanatory variable | a variable which, when used as a predictor in a statistical model, may potentially account for some variation in the model’s response variable | forklaringsvariabel |
| function (of Nature) | generic term for geological, geomorphological and/or ecological processes and the mechanisms by which they, directly or indirectly, give rise to variation in Nature's structure and composition | naturfunksjon |
| general ecodiversity model | a conceptual geometric model which describes the response of a key characteristic (response) to gradients in one or more key sources of variation | (den) generelle naturmangfoldmodellen |
| generalised composition data | lists of aggregated performance values for variables that represent the key characteristic in a specific subspace of an ecodiversity space (e.g. species in a candidate ecosystem type), obtained for a set of infinitely many abstract map units by expert judgement according to a standard procedure | generaliserte artslistedata |
| geodiversity | the abiotic features of Nature's variation including the lithosphere, atmosphere, hydrosphere and cryosphere, with diversity levels exemplified by minerals, bedrock and landforms, and the processes that give rise to variation in their structure and composition | geologisk mangfold |
| ground | the terrestrial (i.e. not covered by water for 50 % of the time or more), more or less solid upper layer of the Earth's crust, with the associated community of organisms | mark |
| key characteristic | characteristic of Nature's variation that provides response variables in an ecodiversity model for a specific ecodiversity level; e.g. species composition at the ecosystem and landscape element composition at the landscape levels of ecodiversity | karakteriserende naturegenskap |
| key source of variation | source of variation that provides predictors in an ecodiversity model for a specific ecodiversity level; e.g. local environmental complex-gradients in ecosystems | karakteriserende kilde til variasjon |
| land-cover mapping | delineation of spatial units of any kind, defined by criteria relating to their bio-, geo- or ecodiversity, with the purpose of creating a map | naturtypekartlegging |
| land-cover type | abstract type unit of any kind, defined by criteria relating to its bio-, geo- or ecodiversity | naturtype |
| landscape | a more or less uniform area including multiple ecosystems – aquatic as well as terrestrial – characterised by its content of observable, natural and human-induced landscape elements, i.e. natural or human-induced objects or characteristics, including spatial units assigned to types at a an ecodiversity level lower than the landscape level, which can be identified and observed on a spatial scale relevant for the landscape level of ecodiversity | landskapstype |
| landscape element | natural or human-induced object or characteristic, including spatial units assigned to types at a an ecodiversity level lower than the landscape level, which can be identified and observed on a spatial scale relevant for the landscape level of ecodiversity | landskapselement |
| landscape factor | categorical variable that expresses discrete variation in an observable landscape characteristic | landskapsfaktor |
| landscape gradient | continuous variable that expresses more or less gradual variation in one or several properties that are relevant at the landscape level of ecodiversity | landskapsgradient |
| landscape space | conceptual geometric space with major complex landscape gradients as axes | landskapsrom |
| landscape space model | conceptual geometric model with aggregated performance of landscape elements as response variables and major complex landscape gradients as axes |  |
| landscape variable | variable that expresses variation in a characteristic that is observable at the landscape scale | landskapsvariabel |
| LEC | = local environmental complex-variable |  |
| local environmental complex-factor | environmental complex-factor that expresses local variation | lokal kompleks miljøfaktor |
| local environmental complex-gradient (LEC) | environmental complex-gradient that expresses local variation; in practice often used in a wide sense also including environmental complex-factors | lokal kompleks miljøfaktor |
| local environmental complex-variable | environmental complex-variable that expresses local variation | lokal kompleks miljøvariabel |
| local environmental variable | environmental variable that expresses local variation | lokal miljøvariabel |
| local environmental variation | variation along environmental variables that represent conditions which are typically more or less stable over centuries and that vary on spatial scales typically finer than 1 km; e.g. edaphic variation | lokal miljøvariasjon |
| local variation | variation typically expressed on spatial scales finer than 1 km; e.g. edaphic variation | lokal naturvariasjon |
| main aspect of Nature's diversity | one of the three main categories into which Nature's diversity can be divided: ecodiversity, biodiversity and geodiversity | økodiversitetshovedkomponent |
| main ecosystem component | generic term for: ground, bottom, waterbodies, snow and ice, and air | dominerende økosystemkomponent |
| major environmental complex-gradient | one among the few environmental complex-gradients that account for most of the variation in species composition within a major ecosystem type that may be attributed to environmental variation | hovedkompleksgradient |
| major type | the middle of three levels in EcoSyst type hierarchies for a specific ecodiversity level, subordinate to major-type group and comprising one or more minor types; defined as a convex subspace of the ecodiversity space for an ecodiversity level and satisfying a set of additional criteria | hovedtype |
| major-type group | the uppermost of three levels in EcoSyst type hierarchies for a specific ecodiversity level, comprising one or more major types and characterised by concordance in main charcateristics; defined as a convex subspace of the ecodiversity space for an ecodiversity level and satisfying a set of additional criteria | hovedtypegruppe |
| mapped object | spatial unit, mapped as a point, a line or a polygon | kartfigur |
| mapping unit | type, aggregate of types, or variable from an attribute system, used to delineate map objects adapted to a pre-defined map scale | kartleggingsenhet |
| minor type | the lowermost of three levels in EcoSyst type hierarchies for a specific ecodiversity level, subordinate to major type and defined by a combination of standard segments along major complex-gradients in the key source of variation at the ecodiversity level in question | grunntype |
| nature | a general and scale-independent term referring to a defined area with its biodiversity, geodiversity and ecodiversity | natur |
| Nature's diversity | the diversity of any characteristic of Nature; an overarching term that comprises biodiversity, geodiversity and ecodiversity | naturmangfold |
| nested hierarchy | type of hierarchy in which upper levels contain lower levels, e.g. Linnaean taxonomy | nøstet hierarki |
| object | physically observable characteristic that, if present, can be measured and/or counted | objekt (= element) |
| performance | collective term for the quality (presence or absence) or quantity of a natural phenomenon within one observation unit, recorded by a performance measure; e.g. subplot frequency in vegetation quadrats | mengde |
| primary ecodiversity level | one of the two ecodiversity levels, landscape or ecosystem, for which the ‘basic EcoSyst setup’ prescribes construction of an EcoSyst type hierarchy with full spatial coverage of the target region | primært naturmangfold-nivå |
| process (of Nature) | generic term that comprises geological (including geomorphological), evolutionary and ecological processes that give, and have given, rise to variation in Nature's composition, structure and dynamics | naturprosess |
| regional environmental variation | variation along environmental complex-gradients that represent conditions that are typically more or less stable over centuries and that vary on spatial scales typically broader than 1 km; e.g. climatic variation | regional mijøvariasjon |
| regional variation | variation typically expressed on spatial scales broader than 1 km; e.g. climatic variation | regional naturvariasjon |
| secondary ecodiversity level | any other ecodiversity level than the primary ecodiversity levels landscape and ecosystem, e.g. ecosystem component, ecosystem complex and landscape complex, for which an EcoSyst type hierarchy may be constructed | sekundært naturmangfold-nivå |
| source of variation | category of characteristics (of Nature's variation), e.g. species composition and landforms | kilde til variasjon |
| spatial unit | geographically delimited area or site | geografisk område |
| species composition | the species that exist together within a specific area, quantified by an approariate performance measure | artssammensetning |
| species density | the number of different species recorded in a small observation unit, e.g. a vegetation quadrat | artstetthet |
| species' performance | collective term for the quality (presence or absence) or quantity of a species within one observation unit, recorded by a performance measure | artsmengde |
| standard segment | one interval in set of intervals into which a complex-gradient in a key source of variation for a given ecodiversity level is divided, made up by one, two or more elementary segments, each comprising at least 1 ecodiversity distance unit (EDU) of variation in the key characteristic within the major type in question | standardtrinn (generell definisjon) |
| structure (of Nature) | distribution (in space and time) of observable objects within a spatial unit | naturstruktur |
| subspace | conceptual geometric space spanned by a subset of the axes that span another, higher-dimensional space | underrom |
| target area | geographical area subject to investigation | undersøkelsesområde |
| type | category in a system established with the purpose of systematising variation, defined as an abstract ideal | naturtype |
| type assignment | the process by which a mapped object is assigned to a type in a type system | typetilordning |
| type system | a system of type units, typically arranged in a hierarchy | typesystem |
| type unit | category in a type system, e.g. at any level in a type hierarchy | typeenhet |
| type-hierarchy construction | the process by which a hierarchy of types is elaborated | typehierarkikonstruksjon |

Towards a systematics of ecodiversity: the EcoSyst framework

**APPENDIX S2 | THE NiN IMPLEMENTATION OF ECOSYST PRINCIPLES**

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In this appendix, we provide a description of the NiN implementation of EcoSyst principles which is more detailed than the outline provided in Table 1 the main body of the paper. The description in Appendix S2 is a condensed version of the full description of the NiN ‘system core’ (version 2.2.0), which is published in Norwegian language (Halvorsen, Bryn, & Erikstad, 2019).

**S2.1 | Fundamental principles for building EcoSyst type hierarchies and their application to the ecosystem and landscape levels**

The following three elements make up the foundation on which the implementation of EcoSyst principles (see main text, Table 2) in NiN version 2.2.0 is based: (1) The importance attributed to variables representing the key source of variation is determined by the amount of compositional turnover in the key characteristic associated with that variable. The compositional turnover is given by the variable’s *gradient length* in the ecosystem in question. (2) Gradient lengths are measured in ecodiversity distance units (EDU), specifically defined for each ecodiversity level. (3) Structuring processes are incorporated into the principles for building type hierarchies in ecodiversity-level specific ways.

NiN version 2.2.0 contains fully developed type hierarchies for the two primary ecodiversity levels, ecosystem and landscape (Figure S2.1; also see main text, Figure 4). In principle, type hierarchies may also be constructed for the secondary ecodiversity levels, of which ‘ecosystem component’, ‘ecosystem complex’ and ‘landscape complex’ are recognised but not operationalised in NiN version 2.2.0 (Figure S2.1). According to interim principles, type hierarchies at the secondary levels are not intended for wall-to-wall coverage, and types at these levels are allowed to overlap spatially.

species

population

gene

biotic

individual

Level of biological diversity, based upon Noss (1990)

community

micro-habitat

region

**FIGURE S2.1** Relationships between the hierarchy of biodiversity levels after Noss (1990), left of the broken, grey line, and the concepts of ecodiversity, biodiversity and geodiversity in Ecosyst. The red, horizontal line separates ecodiversity, where the species composition, environmental conditions and, potentially, also other properties of Nature, are treated together, from biodiversity and geodiversity where the biotic and abiotic aspects of Nature’s variation are treated separately. Ecosystem and landscape are the two primary levels of ecodiversity, for which EcoSyst type hierarchies are included in NiN version 2.2.0. These levels are indicated by boxes with thick outer border. Relationships between the two primary and the three secondary levels are indicated by arrows. The large vertical extent of the ecosystem and landscape levels in this hierarchy after Noss indicates that these levels comprise variation over a considerable range of spatial scales.

landscape

primary secondary

I

ECO-

SYSTEM

livs-medium

IIa Landscape complex

livs-medium

II

LAND-

SCAPE

livs-medium

Increasing complexity

Ia Ecosystem component

livs-medium

Ib Ecosystem complex

livs-medium

ecosystem

økosystem

 biodiversity

geodiversity

Level of ecodiversity in EcoSyst, NiN version 2.2.0

biotic

abiotic

abiotic

A pragmatic type hierarchy for ecosystem components (microhabitats) was included in NiN version 1.0 (Halvorsen et al., 2009), but has not yet been addressed by EcoSyst principles. Its status in future versions of NiN is still undecided.

**S2.2 | Application of EcoSyst principles to the ecosystem level**

***S2.2.1 | Fundamental properties of variation at the ecosystem level***

At the ecosystem level, local environmental variation is the key source of variation and species composition is the key characteristic. Local environmental variation is operationalised as local environmental complex-variables (LECs). An LEC is a composite variable, typically made up by several single environmental variables that co-vary. All units recognised at the ecosystem level in EcoSyst shall represent integral ecosystems with respect to structure and function. An integral ecosystem is characterised by typically having several trophic levels, a diaspore bank and biotic interactions such as mycorrhiza. The demand for ecological integrity sets the lower limit for fine-grainedness of LEC variation that is taken into account at the ecosystem level: a typical LEC gives rise to patterns of variation in species composition on relatively fine spatial scales, typically (1–) 10–100(–1000) m (Figure S2.2). Furthermore, LECs give rise to patterns of compositional variation that persist for a relatively long time, typically more than ca. 100 years. Accordingly, the full set of LECs covers the major, long-term drivers of compositional variation at spatial and temporal scales comparable to those at which typical ‘plant communities’, e.g. associations of the Braun-Blanquet school (e.g. Westhoff & van der Maarel, 1978), are recognised. Spatially and temporally, LECs grade into ‘regional complex environmental gradients’ (RECs) that address variation on broader spatial scales, and ‘short-term environmental variation’ (STE) that addresses variation on finer temporal scales (Figure S2.2). Typical examples of LEC, REC and STE are ‘lime richness’ (NiN code ‘KA’; see Appendix S4), ‘bioclimatic zones’ (6SO) and ‘grazing intensity’ (7JB–BT), respectively. Both RCEs and STEs are included in NiN’s attribute system (Appendix S3).

years

(10x)

m (10x)

4

1

0

2

3

–1

0

4

3

2

1

micro-scale (ecosystem components)

short-phase variation (not addressed)

STE

LEC

REC

**FIGURE S2.2** Spatial and temporal scales addressed in EcoSyst at the ecosystem level of ecodiversity. The axes represent the scales at which the full range of variation along an environmental variable is typically encountered. LEC = local environmental complex-variables representing local complex environmental variation; REC = regional complex environmental variation; STE = short-term environmental variation.

temporal scale

spatial scale

Most LECs express continuous variation and are gradients in the strict sense. ‘Lime richness’ (KA; see Appendix S4) is an example of a continuous local environmental complex-gradient while ‘categories of prevailing water supply’ (VT) exemplifies a local environmental complex-factor. The latter enables categorisation of mires by their water supply into geogenous, limnogenous (with two subcategories) and ombrogenous mires (cf. Sjörs, 1948).

Ecological structuring processes are the ecological mechanisms underpinning species' responses to variation along important environmental complex-variables. Processes are incorporated into the type-hierarchy construction procedures (1) by classification of all LECs into process categories; and (2) by demanding that ecosystems defined by LECs associated with different process categories are recognised as separate major types (see sections S2.2.2 and S2.2.3 for details).

The amount of species compositional turnover that takes place within a major ecosystem type from one endpoint of an LEC to the opposite endpoint, i.e. the ‘gradient length’, determines the importance of the LEC within the major type in question (see section S2.4). Accordingly, as explained in depth in section S2.4.5, LECs are operationalised as complex variables separately for each major ecosystem type. Thus, from a theoretical point of view, one should distinguish between the strict concept of an LEC as defined above, and the major-type specific implementations of the LEC. While the former addresses environmental variation as such and belongs to geodiversity, the latter is an ecocline, i.e. a gradient in the environment and species composition (Whittaker, 1967), and belongs to ecodiversity. When necessary, we will refer to the two LEC concepts as LECs in the strict and the operationalised sense.

At the ecosystem level, the species composition of four out of the five main ecosystem components of all land and offshore areas are taken into consideration: ground (terrestrial ecosystems); bottom (limnic and marine seabeds); waterbodies(limnic and marine waters); and snow and ice. The fifth main ecosystem component, air, is not taken into account in NiN version 2.2.0. To operationalise species composition as key characteristic, only species groups closely associated with the main ecosystem components are taken into account. Species are ‘closely associated’ if they respond *directly* to variation at the relevant spatial and temporal scales. For instance, plants and fungi, but not large mammals, are taken into account for terrestrial ecosystems. The relative weights attributed to each species group in the estimation of gradient lengths are set *a priori*, i.e. before the identification of ecosystem types starts (Table S2.2). Thus, for instance, gradient lengths of primary producers, macrofungi and substrate-associated fauna are estimated separately and weighed 6:3:1 in terrestrial forest systems and 6:2:2 in open terrestrial ecosystems. On marine seabeds, flora and ground-dwelling animals are treated collectively in estimation of gradient lengths.

The practice with *a priori* weights has been criticised for subjectivity and for lack of theoretical ecological justification (Gaarder & Wangen, 2019). The Scientific Advisory Council for NiN has therefore decided to replace *a priori* weighing with a new ‘maximum turnover principle’ in NiN version 3, scheduled for 2023. This principle states that the broad species group (cf. Table S2.2) with the largest compositional turnover in each part of a complex-gradient shall be used for gradient-length determination and, hence, for segmentation of LECs.

***S2.2.2 | Categories of structuring processes at the ecosystem level and categorisation into process categories***

Ecological structuring processes are divided into three main categories in NiN version 2.2.0 (Halvorsen, 2012): (1) limited physiological tolerance of external impacts, with sub-categories (1a) environmental stress and (1b) disturbance; (2) interspecific interactions; and (3) demographic processes.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **TABLE S2.2** Relative weights attributed to different organism groups in the estimation of gradient lengths of local environmental complex-gradients (LECs). Each row sums to 1. When data for a specific organism group are not available, the relative weight theoretically attributable to this group is distributed on the remaining groups. \* = one list, comprising species from the two organism groups, is used for gradient-length estimation. \*\* = one list of all species from all relevant organism groups, including micro-organisms (bacteria, microfungi etc.), is used for gradient-length estimation. | | | | | |
| Ecosystems | Primary producers  (including lichens) | Macrofungi | Substrate-associated fauna | Waterbody-associated fauna | All organisms |
| Terrestrial (non-wetland and wetland) forest systems | 0.6 | 0.3 | 0.1 |  |  |
| Open, terrestrial systems with a soil cover | 0.6 | 0.2 | 0.2 |  |  |
| Open terrestrial systems without a soil cover | 0.7 |  | 0.3 |  |  |
| Wetlands | 0.7 | 0.1 | 0.2 |  |  |
| Limnic seabeds: euphotic or with chemoautotrophic organisms | 0.6 |  | 0.4 |  |  |
| Marine seabeds: euphotic or with chemoautotrophic organisms | 1.0\* |  | 1.0\* |  |  |
| Aquatic (limnic and marine) aphotic oxic ecosystems |  |  | 1.0 |  |  |
| Anoxic seabeds |  |  |  |  | 1.0\*\* |
| Marine waterbodies: epipelagic and circulating | 0.5 |  |  | 0.5 |  |
| Circulating limnic waterbodies | 0.5 |  |  | 0.5 |  |
| Marine waterbodies: meso- and bathypelagic |  |  |  | 1.0 |  |
| Non-circulating waterbodies |  |  |  |  | 1.0\*\* |
| Snow and ice systems |  |  |  |  | 1.0\*\* |

*Limited physiological tolerance of external impacts*. This category includes two continuously intergrading processes: (1a) Environmental stress, i.e. ‘external constraints which limit the rate of dry matter production of all or a part of the community in questionʼ (Grime 1979: 21). A typical example of a ‘stress LEC’ is ‘growing-season reduction due to prolonged snow cover’ (SV) which addresses the limited tolerance of alpine and arctic vascular plant species to long-lasting snow cover, set by requirements for a minimum of warmth and a sufficiently long-lasting snow-free period to complete their life cycles (Gjærevoll, 1956; Resvoll, 1917). (1b) Disturbance, i.e. ‘mechanisms which reduce biomass by causing its partial or total destruction’ (Grime, 1979: 39). Disturbance acts by increasing the density-independent mortality of the affected species. Grime (1979) includes in his concept of disturbance not only effects of wind, frost, drought, erosion and wildfires but also effects of herbivores, pathogens and all kinds of human activities. In NiN and EcoSyst, sudden, man-made impacts that reduce biomass are regarded as disturbance, while the impacts of other organisms are not (Halvorsen et al., 2019). A typical example of a ‘disturbance LEC’ is ‘avalanche intensity’ (RU), which addresses the intensity by which open spaces are created on talus slopes by recurrent snow, ice and water avalanches. High avalanche intensity has a particularly destructive impact on woody plants (Halvorsen et al., 2019). While environmental stress implies a more or less constant impact on the biotic community by the factor in question (‘regulation by averages’), disturbance implies that the community is impacted by less frequent but more severe events (‘regulation by extreme values’).

*Interspecific interactions*. This category comprises interactions between individuals of (two) different species that bring about change in the performance of one or both species relative to their physiological potential. Five sub-categories of interactions are recognised (Goldberg, 1990; Haskell, 1947): competition (–,–), amensalism (0,–; after Burkholder 1952), commensalism (0,+), mutualism (+,+) and predation, parasitism and contramensalism (+,–; the latter after Arthur 1986). An example of contramensalism is given by Mitchell & Arthur (1998). The notation ‘(a,b)ʼ indicates the outcome of the interaction as seen from the point of view of each of the two organisms, a and b: ‘+’ indicates a positive outcome, ‘–‘ indicates a negative outcome, and ‘0’ indicates a neutral outcome.

*Demographic processes*. This category addresses processes, often with a strong stochastic element, that cause variation in a species’ performance not possible to explain as the response to environmental-complex gradients, contemporary or historical, or as the outcome of interactions with other organisms (van Groenendael, Ehrlén, & Svensson, 2000). Sub-categories (Halvorsen, 2012) include ‘dispersal into new sites’, ‘within-population demographic processes’ and ‘space limitation’. Within-population demographic processes comprise the processes that determine the fate of individuals such as mortality by senescence. Space limitation comprises stochastic effects brought about by limitations on the number of individuals, of the same or different species, that can co-occur in an observation unit of a given size (Oksanen, 1996).

*The roles of different categories of structuring processes in construction of EcoSyst type hierarcies.* Because demographic processes address the summed fates of individuals in a population, they are not directly relevant for construction of ecosystem type hierarchies. Interspecific interactions, on the other hand, are relevant for ecosystem type hierarchies as far as interactions of similar kind occur over large areas and thus give rise to consistent patterns on relevant spatial scales. Two of the five sub-categories, competition and amensalism, may potentially have a structuring effect on the species composition that is strong enough to make them relevant for type-system construction. Accordingly, the EcoSyst type systems for the ecosystem level do not only express variation due to environmental stress and disturbance LECs, but also recognise the role of structuring species groups. Structuring species groups are functional species groups which impact ecosystem structure and/or function to such an extent that ecosystems dominated by these species differ substantially from otherwise comparable systems (Halvorsen et al, 2019). The notion of ‘substantial difference in species composition’ is discussed in section S2.4.6.

While environmental stress (hereafter just ‘stress’) comprises a rather homogeneous group of LECs, disturbance LECs make up a heterogeneous group, covering processes that act on the species by widely different mechanisms. In NiN version 2.2.0, disturbance is divided into subcategories by the following three dichotomies: (1) By the role of human activities in the disturbance process, disturbance LECs are divided into (a) natural disturbances, not resulting from human activities in a broad sense, including livestock grazing etc., and (b) anthropogeneous disturbances, brought about by human activities. (2) By differences in the underlying geological or geomorphological processes, e.g. avalanches and landslides, that cause removal of the ground itself. Exposure of new substrates brings about changes in species composition. (3) By the characteristic combination of the four ‘dimensions’ of disturbance events – spatial extent, severity, frequency and predictability (Halvorsen et al., 2019; Rydgren, Økland, & Hestmark, 2004; White, 1979) – into (a) regulating disturbance (low severity, high frequency) and (b) destabilising disturbance (high severity, low frequency and predictability). Note that the disturbance sub-categories do not address the total impact of the disturbance process, i.e. its intensity (Sousa, 1984), which varies along each disturbance LEC, but the way the four dimensions are combined. A disturbance regime is regulating when, at moderate intensities, the ecosystem is frequently impacted and each impact neither brings about large compositional shifts nor initiates a long-lasting succession. The regime is destabilising when, even at moderate intensities, each disturbance event brings about considerable compositional shifts and, if not interrupted, initiates a succession that lasts for several years. Regulating disturbances typically occur several times per year, while destabilising disturbance events typically occur unpredictably and less often than once a year, in many cases not even once per millennium. (4) By current activity of the disturbance process, into (a) active disturbances and (b) historical(‘fossile’)disturbances. Historical disturbance is relevant for the type-system to cover sites affected by high-intensity disturbance events with large spatial extent, such as quick clay slides. Such sites are assigned to a type unit defined by historical disturbance as long as the successional end-point, e.g. towards forest, has not yet been reached. In NiN, the successional end-point is reached when the species composition is no longer observably different from, and the rate of compositional change is of similar magnitude to, that of a comparable non-successional system; i.e. the dynamics of the system lacks a clear direction and the processes of a natural system have been resurrected (Halvorsen et al., 2019). The distinction between LECs and short-term environmental variation (STE; Figure S2.2) implies that the successional gradient after a historical disturbance event is treated as an LEC, ‘Slow succession’ (LA), when expected to last for more than 100(–200) years, and otherwise as an STE, ‘Rapid succession’ (7RA; see Appendix S5).

The enormous diversity of anthropogenous influences on ecosystems calls for a phragmatic but theoretically well-founded procedure for incorporating human impacts into the ecosystem type system. In NiN, this is accomplished primarily by categorising ecosystems by the intensity of anthropogenic disturbances into natural systems, semi-natural systems and strongly altered systems. Natural systems are characterised by lack of, or only weak impact by, anthropogenic disturbances. No anthropogenic-disturbance LEC is, by definition, needed to account for a natural system’s structure and function. Semi-natural systems are integral ecosystems characterised by anthropogenic disturbances that alter, or have altered, the structure and function of the system from which the semi-natural system originated, to such a degree that a substantially different species composition results. Strongly altered systems are characterised by anthropogenic disturbances so strong that the resulting ecosystems are no longer integral, lacking important components such as food webs, diaspore bank, mycorrhizas and other biotic interactions, etc.

The semi-natural and strongly altered systems are divided into systems shaped by systematic land management impact and systems shaped by other anthropogenic disturbances. Systems shaped by systematic land management impact are further divided by management intensity into unmanaged, extensively managed and intensively managed systems. The LEC ‘land management intensity’ (HI) is defined as the intensity of recurrent, regular human activities that maintain specific types of nature through disturbance, such as mowing, livestock grazing, prescribed burning, plowing, tree-cutting, application of pesticides, artificial fertilisation and/or irrigation, sowing and harvesting of the tree and/or the understory layers. This definition of land management also includes use of land for other purposes than agricultural production in the strict sense, i.e. crops for fodder for domestic animals, ornamental plants, and raw materials for bioenergy. Results of systematic management thus also include parks, lawns and flowerbeds.

***S2.2.3 | Principles for construction of the ecosystem type hierarchy***

EcoSyst type hierarchies are strictly divisive, i.e. starting with all of Nature within the target area. The first division is into major-type groups, the next is into major types and the third and final is into minor types. In principle, all of Nature’s variation on relevant spatial and temporal scales that is of interest for someone to describe shall be accomodated in the flexible attribute system (EcoSyst taxonomic principle #3). In NiN version 2.2.0, only variation that is not captured by the type hierarchy, but including ‘residual variation’ in the key source of variation and the key characteristic, is formally included in the attribute system. At each level in the divisive process of constructing the type hierarchy, types are constructed by a applying a set of criteria listed in order of decreasing priority (Box S2.1).

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| **BOX S2.1** Principles and criteria used in NiN version 2.2.0 to define major types at the ecosystem level.  **Ecosystem major types have to satisfy the following five main criteria:**   1. One and the same group of major local environmental complex-gradients (mLECs) shall be relevant for describing the variation in species composition and environmental conditions throughout the entire major type. Two candidate major types thus have to possess at least one LEC in their group of important LECs not shared by the other major type in order for the candidates to be accepted as separate major types. 2. One and the same major type can encompass substantially different species compositions (> 3 EDU–E) if and only if one and the same set of ecological structuring processes (environmental stress, regulating disturbance or destabilising disturbance) is important throughout the entire major type. 3. The entire variation within a major type shall be contained within one and only one of the 19 process categories listed in Box S2–2. 4. Each major type shall comprise more than 1 EDU–E of variation in species composition. 5. Major ecosystem types that include dynamic equilibrium situations shall include all short-term environmental variation caused by impacts of any kind except successional end-points belonging to a different natural major ecosystem type.   **Ecosystem major types should preferably satisfy the following supplementary criteria:**   1. A major type should give a consistent visual impression, i.e. that the same life forms or functional organism groups dominate throughout the main type. 2. Potential major types defined by structuring species groups shall be recognised when and only when dominance by species of this group results in a system with a species composition that differs by > 2 EDU–E from an otherwise comparable system. 3. An end-point segment along a normal LECs shall not be separated as a major-type on its own unless the following conditions are satisfied:    1. this segment cannot be included in another major type to form a convex subspace of its ecological space, or    2. both of the general criteria #1 and #2 are satisfied by both major-type candidates 4. Ecosystems conditioned on natural disturbance and environmental stress shall be separated from anthropogenous, i.e. semi-natural and strongly altered ecosystems at the major-type level. 5. Ecosystems conditioned on activities of wild animals (e.g. grazing) and/or other natural disturbance in such a way that the ecological processes and species composition are inseparable from systems conditioned on management and/or other anthropogenic disturbance processes shall be included in the most appropriate anthropogenic major type (examples are tidal meadows heavily grazed by geese and beaver-dammed creeks). 6. Ecosystems characterised by environmental stress, active regulating disturbance, active destabilising disturbance and historical disturbance shall be filed into different major types. 7. Natural ecosystems that undergo slow succession shall be separated from corresponding systems that undergo rapid succession. Accordingly, terrestrial ecosystems on bare rock are separated from systems with soil-covered ground at the major-type level. 8. Major types for specific natural systems shall be separated from corresponding normal major types when the species composition of the LEC end-point has a species composition that is substantially different (> 3 EDU–E) from the end-point at the ‘normal end’, thus allowing a division of the LEC into 3 or more major-type specific segments. Of these, the segment at the ‘normal end’, and this segment only, shall be contained within the normal major type. 9. Ecosystems conditioned on anthropogenic disturbance shall be separated from natural ecosystems by the definitions of semi-natural and strongly altered ecosystems. 10. Semi-natural and strongly altered ecosystems shall belong to different major types. 11. Semi-natural and strongly altered ecosystems that differ with respect to management regime (unmanaged, extensively managed and intensively managed) shall belong to different major types. 12. Semi-natural and strongly altered ecosystems are divided into agricultural ecosystems and non-agricultural ecosystems at the major-type level. |

*Division into major-type groups.* The divisive process starts with sorting of the fourmain ecosystem components ground, bottom, waterbodies, and snow and ice, into separate major-type groups. This implies that closed aquatic systems such as lakes will consist of one set of major types for seabeds and one set for waterbodies, and that these sets will belong to different major-type groups. Within each of the four main ecosystem components, three criteria are used to decide if more than one major-type group shall be recognised: (1) A major-type group shall have a common basic environmental structure, i.e. a common set of important LECs, that differs from that of other major-type groups. (2) A major-type group shall have a minimum of commonness in dominant life forms and species composition. (3) A major-type group shall be characterised by logically consistent delimitation from other major-type groups.

Operationalisation of the criteria rests upon two important EcoSyst concepts; the normal variation and the specific variation, and the corresponding categorisation of local environmental complex-gradients (LECs). The normal variation within a major-type group is defined as the normally occurring variation in species composition and environmental conditions, i.e. the range of variation that occupies most of the area or volume covered by the major-type group, which can be described by a limited number of important local environmental complex-variables. The specific variation is the complement of the normal variation. The normal variation is the reference with which all other, i.e. the specific, variation is compared when EcoSyst type hierarchies are constructed.

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| **BOX S2.2** Process categories of ecosystems within a major-type group that shall be filed into different major types.  I Normal variation within the major-type group   1. Without variation conditioned on dominance by a structuring species group 2. With variation conditioned on dominance by a structuring species group   II Specific variation within the major-type group  A Characterised by environmental stress or natural disturbance, not conditioned on dominance by a structuring species group   1. Characterised by environmental stress 2. Characterised by active regulating disturbance 3. Characterised by active destabilising disturbance 4. Characterised by historical disturbance    1. Rapid succession    2. Slow succession   B Characterised by environmental stress or natural disturbance, conditioned on dominance by a structuring species group   1. Characterised by environmental stress 2. Characterised by active regulating disturbance 3. Characterised by active destabilising disturbance   C Conditioned on moderate or strong anthropogenic disturbance; semi-natural or strongly altered systems   1. Semi-natural system not conditioned on land management 2. Semi-natural system conditioned on land management    1. Semi-natural non-agricultural ecosystem    2. Semi-natural agricultural ecosystem 3. Strongly altered system not conditioned on land management    1. Rapid succession    2. Slow succession 4. Strongly altered system conditioned on extensive land management    1. Strongly altered non-agricultural ecosystem    2. Strongly altered agricultural ecosystem 5. Strongly altered system conditioned on intensive land management    1. Strongly altered non-agricultural ecosystem; constructed and artificial systems    2. Strongly altered agricultural ecosystem (arable land) |

Local environmental complex-gradients are sorted into normal or specific LECs according to the variation in a major-type group they express, i.e. their gradient length. The method for measuring, and the terminology of, compositional turnover estimation in ecodiversity distance units in ecosystems (EDU–E), are explained in sections S2.4.2–4. The term normal environmental complex-variable (nLEC) is used for LECs within the normal variation, associated with more than 2 EDU–E of compositional variation between endpoints. If the variation exceeds 3 EDU–E, ‘substantial variation’ in NiN terminology, the term major nLEC (mnLEC) is used. The term minor nLEC (inLEC) is used for nLECs associated with gradient lengths between 2 and 3 EDU–E, referred to as ‘considerable variation’. Similarly, the term special environmental complex-variable (sLEC) is used for LECs associated with more than 2 EDU–E of compositional variation between extremes, of which one endpoint lies within normal variation in an ecosystem while the other endpoint does not. The terms major sLEC (msLEC) and minor sSLE (isLEC) parallels mnLEC and inLEC, respectively. The terms major and minor LEC (mLEC and iLEC, respectively) are used in contexts where reference to LEC properties as normal or specific is not relevant.

The first criterion, i.e. the demand for a common environmental structure, translates to two criteria for splitting a candidate major-type group into two or more major-type groups: (a) existence of two or more sets of normal variation with separate sets of important LECs, and (b) that each set possesses important specific LECs that are not shared by the other(s). A specific LEC is defined as important in an ecosystem when its gradient length, i.e. the species compositional turnover between gradient end-points, exceeds 3 EDU–E. This corresponds to the minimum gradient length required to define specific major types (Box S2.1: criterion #13). The second criterion, a minimum of commonness in dominant life forms and species composition, is operationalised by comparing the normal variation of the major-type groups. The third criterion is operationalised by demanding that the normal variation within a major-type group shall span a convex-shaped subspace of the ecological space (see Appendix S1 for definition and section 4.1 for explanation).

Applying these criteria, seven major-type groups are recognised in NiN version 2.2: marine seabed systems, marine waterbody systems, freshwater bottom systems, limnic waterbody systems, terrestrial systems, wetland systems, and snow and ice systems.

*Division into major types.* Division of each of the seven major-type groups into major types is accomplished by the principles outlined in Box S2.1. Criterion #3 is a cornerstone, specifying that variation conditioned on different among the 19 process categories listed in Box S2.2 shall be sorted into different major types. Each process category comprises the variation within a major-type group that is characterised by one main ecological structuring process or a characteristic combination of processes. According to criterion 3, a major type cannot contain variation belonging to more than one process category. Within one process category, however, the variation may be divided into two or more major types.

The division of major-type groups into major types starts with deciding, by criteria #1 and 2 in Box S2.1, if the normal variation in the major-type group shall be distributed on two or more major types. Thereafter, criteria #7–17 specify the order in which major types are defined within each major-type group, starting by separating variation due to structuring species groups from other variation. In practice, this means that otherwise comparable systems with and without the species group in question have to differ by more than 2 EDU–E. The most prominent example of a structuring species group is trees, but also stone corals and macrohelophytes are recognised as structuring species groups in the NiN implementation of EcoSyst principles for Norway. Ecosystems with trees are divided into forests and other tree-covered areas. Forests are natural ecosystems with trees as structuring species group, characterised by long-term influence by trees on the ground, which at a given time-point is tree-covered or which in near future is expected again to become tree-covered. Tree-covered area, on the other hand, is a broader term that comprises all land in which more than 10 % of the area lies within crown perpheries of trees. While clear-cutting changes the state of a forest from tree-covered to open (treeless), the clear-cut forest is still recognised as a forest as long as the deforested area is planted or left for natural regeneration. Conversely, this definition of forest

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| variation along a major normal complex gradient (mnLEC)          variation along a minor normal LEC (inLEC)          variation along a major normal complex gradient (mnLEC)          variation along specific LEC (sLEC) that defines a separate major type            (a)  (b) |
| **FIGURE S2.3** Illustration of EcoSyst principle #13 for separating specific major ecosystem types from normal variation. (a) A major-type within normal variation, which in the example is spanned by two LECs. The horizontal axis represents a major normal LEC (mnLECs) of length between 4 and 5 EDU–E, which is divided into four standard segments, each spanning at least 1 EDU–E. This is the maximum number of segments with a breadth of at least 1 EDU–E that can be obtained for an LEC of this length. The vertical axis represents a minor normal LEC (inLEC) of length 2–3 EDU–E, which is divided into two segments. The inLECs represents specific variation with too low impact on the species composition to give rise to a specific major type. Instead inLECs give rise to a series of minor types within the normal major-type. The circumscription of this major type is indicated by the black, broken line in (a). (b) Illustration of the situation in which a specific major type is separated from the normal major type based upon an sLEC. The horiziontal axis is the same as in (A), but the vertical axis now represents a specific LEC (sLEC), associated with substantial variation in species composition (here: between 3 and 4 EDU–E between LEC end-points). This sLEC satisfies the criteria for a defining LEC (dLEC) for a specific major type and because it is divided into three standard segments. The segment at the ‘normal end’ of the sLEC (gray boxes) is retained in the normal major type (circumscribed by the black, broken line), while the residual variation (2–3 EDU–E; orange boxes) is included in a specific major type (circumscribed by the red, broken line) for which the sLEC is both a defining and a minor LEC (dLEC and iLEC). |

excludes tree-covered semi-natural and strongly altered ecosystems such as coppiced meadows and parks because these are not natural ecosystems. A tree is defined in NiN version 2.2.0 as a woody plant with perennial main stem, more than 5 m high, also *including* woody plants of species that may under favourable conditions reach 5 m but due to growth-limiting site conditions are at least 2 m. ‘Tree’, ‘forest’ and ‘tree-covered area’ are examples of terms that do not appear in EcoSyst principles. They may be substituted by more appropriate terms or definitions in implementations of EcoSyst principles for other target areas.

Separation of specific variation from normal variation, which is done separately for variation characterised by, and not characterised by, a structuring species group. Separation starts with identification of major normal LECs (mnLECs) of the major-type group. In accordance with criterion #13, major types for specific variation are separated from corresponding normal major types when the ‘disturbed’ or ‘stressful’ end-point along an sLEC has a species composition that is substantially different from the end-point at the ‘normal end’ (> 3 EDU–E; see Figure S2.3b). The sLEC can then be divided into three or more standard segments (see section S2.4.6). The segment at the ‘normal end’ is retained in the normal major type while all other segments are kept within the specific major type for which the sLEC becomes the defining LEC (Figure S2.3b). Conversely, specific LECs with shorter gradient lengths than 3 EDU–E are kept within the normal major type as a minor normal LEC (inLEC; Figure S2.3a).

Criterion #4, demanding a minimum of 1 EDU–E of variation within a major type, ensures that status as major type is reserved for processes of a certain importance. From criterion #11 follows that all variation due to an sLEC, including disruptive endpoints, is included in the same major type. A disruptive end-point is the point along an LEC where the intensity of the destabilising process is too strong to uphold a permanent species composition. Within each process category that satisfies criterion #4, criteria #1 and 2 are used to decide if the variation shall be kept within one major type or split into several major types.

*Division into minor types.* Establishment of minor types within starts with recognition of the complex-variable group of each major type, i.e. the major-type specific set of all minor and major LECs. Each LEC of each major type’s complex-variable group is subsequently divided into standard segments by the procedure outlined in section 3 and Figure 4, and described in detail in section S2.4.6. In principle, all realised ideal combinations of standard segments (or standard classes, the parallel to segments for categorical LECs) along all LECs in a complex-variable group make up one minor type. Thus, as exemplified in Figure S2.3b, a major type with two LECs, divided into 4 and 2 standard segments, respectively, comprises 4 × 2 = 8 minor types unless exceptions apply.

Environmental stress or disturbance LECs may, at high intensities of the process in question, ‘overrule’ variation in species composition along other LECs. In such cases, combinations of standard segments along the other LECs shall be amalgamated to the appropriate number of minor types. Thus, if for the rightmost segment along the mLEC in Figure S2.3b the variation along the sLEC within the specific major type drops below 2 EDU–E, the two candidate minor types are amalgamated to one and the number of minor types in this major type is reduced to 7. This omission of combinations of standard segments that are not, or hardly, realised, implies a ‘pruning’ of the type hierarchy. Operationalisation of this criterion is accomplished by demanding of all minor types that the theoretical mid-point in the hypervolume defined by a combination of standard segments along all LECs in the complex-variable group is realised.

All variation in species composition and environmental conditions that does not satisfy the criteria for defining major or minor types, is left to the attribute system. LECs associated with 1–2 EDU–E of variation between LEC endpoints, termed subordinate LECs (uLECs), may be used on demand to describe type variants and split mapping units.

**S2.3 | Application of EcoSyst principles to the landscape level**

***S2.3.1 | Fundamental properties of variation at the landscape level***

The key characteristic at the landscape level is ‘landscape element composition’, defined as variation in the occurrence and abundance of landscape elements. A landscape element is a natural or anthropogenic object or characteristic, including spatial units assigned to types at a an ecodiversity level lower than the landscape level, which can be identified and observed on a spatial scale relevant for the landscape level of ecodiversity. The largest dimension of typical landscape elements recognised in NiN version 2.2.0 is in the range 10–1000 m (Erikstad, Uttakleiv, & Halvorsen 2015; cf. Forman & Godron, 1986). Most categories of landscape elements can therefore, in principle, be identified on aerial photographs.

Landscape elements include objects that originate by a wide spectrum of processes, representing many sources of compositional and structural variation recognised in NiN (see Appendix S3). This is exemplified by physiognomically distinct patches of ecosystem major-types, potentially also ecosystem complexes, which express local environmental structure and species composition. Presence of natural, semi-natural and strongly altered ecosystems belonging to all major-type groups (marine, aquatic and terrestrial) may, in principle, be recognised as landscape elements. Compositional variation is also expressed in the occurrence of landforms moulded in hard rock or sediments, buildings and other infrastructure. Landscape elements of all kinds contribute to structural variation by their distribution in space.

The considerable diversity of landscape elements, both with respect to expressed properties and origins, opens for many alternative candidate ecodiversity models for the landscape level. This is reflected in the large diversity of published landscape-type approaches (Simensen, Halvorsen, & Erikstad, 2018). In EcoSyst, several different characteristics which together explain most of the variation in the composition and structure of observable landscape elements (Erikstad et al., 2015) are taken as the key sources of variation at the landscape level. The specific complex landscape gradients (CLGs; Erikstad et al., 2015) that make up this set in NiN express patterns of continuous variation in landscape element composition and structure on spatial scales between those addressed by ecosystems on one hand and biomes or regions on the other. The landscape level of ecodiversity in EcoSyst, as implemented in NiN 2.2.0, thus addresses the material, observable landscape (Simensen et al., 2018).

The complex landscape gradient (CLG) concept plays the same fundamental role in the building of an ecodiversity model and, hence, a type hierarchy, at the landscape level, as does the ‘local environmental complex-variable’ (LEC) at the ecosystem level. The term ‘complex landscape gradient’ is preferred to ‘complex landscape variable’ because almost all variation in landscape element composition and structure that is relevant for systematisation of variation at the landscape level is continuous. The CLG concept is burdened with the same inherent ambiguity as the LEC concept (see section S2.2.1): both are used for variation in the key sources of variation as such (LECs and CLGs in the strict sense) as well as for expressions of the compositional variation 'explained' by the strict LECs and CLGs. The terms operationalised LEC and CLG refer to the broad meaning of these complex-gradient concepts. Note that CLGs and LECs are operationalised by similar procedures; CLGs separately for each candidate major landscape type by addressing the compositional turnover of landscape variation along the strict CLG in question. Accordingly, we define the strict CLG as a composite variable, typically made up of several single variables in the same functional variable category, that co-vary more or less strongly, and that give rise to gradual or stepwise variation in the presence and/or abundance of landscape elements. This definition emphasises the predictors in the ecodiversity model, i.e. the source of variation, without taking the response explicitly into account. By a slight change of the wording, the definition of the strict CLG is turned into a definition of the operationalised CLG: a composite variable, typically made up by several single variables in the same functional variable category, that co-vary more or less strongly, and the gradual or stepwise variation in the presence and/or abundance of landscape elements they give rise to. The latter definition emphasises the response in the ecodiversity model, i.e. the actual variation in landscape-element composition.

Segmentation of the target area into concrete spatial landscape units or landscape polygons, with largest dimension of (1–)2–5(–8) km, is integrated into the process by which the hierarchical system of NiN 2.2.0 landscape-type units is constructed (see section S2.3.3). This contrasts the procedure for constructing the ecosystem type hierarchy, which is purely theoretical without involving any aspect of mapping. The variation in landscape element composition addressed in NiN 2.2.0 thus corresponds to the spatiotemporal domain defined by Delcourt, Delcourt, & Webb (1982) as ‘meso-scale’, i.e. abiotic and biotic patterns occurring at a spatial scale of approximately 106-1010 m² and temporal scales of 101-104 years. This domain also accords with spatial scales typically applied in biophysical landscape characterisation and mapping (Simensen et al., 2018).

***S2.3.2 | Categories of structuring processes and complex gradients at the landscape level***

At the landscape level, structuring processes, i.e. the mechanisms responsible for variation in landscape-element composition and spatial structure, are incorporated into the hierarchy construction procedure. This is done primarily by sorting complex landscape gradients (CLGs inthe strict sense) into three functional categories which represent fundamentally different landscape-forming processes: (1) geo-ecological, (2) bio-ecological, and (3) human land-use related CLGs.

*Geo-ecological CLGs* (CLG–Gs) express variation in broad structural patterns of bedrock, surficial deposits and topography and the resulting variation in local environmental conditions and composition and structure of ecosystems. This category is the result of predominantly abiotic processes that, in turn, control and/or constrain biotic processes (Swanson, Kratz, Caine, & Woodmansee, 1988). The long list of processes that underlie CLG–Gs includes fundamental geological and geomorphological processes like plate tectonics, volcanism, orogeny and glacial-interglacial climatic cycles, as well as soil development and hydrological processes which result from or interact with broad- or fine-scale environmental disturbance processes driven by, e.g. wind, frost, drought and wildfire (Turner, 2010). The composition and structure (abundance and distribution) of ecosystems conditioned on geo-ecologcal variation, such as peatlands, lakes and glaciers, is also categorised as geo-ecological variation.

*Bio-ecological CLGs* (CLG–Bs) express landscape-scale manifestations of environmental variation resulting from ecological and biological processes that are not directly related to the basic geo-ecological processes. Variation that is here regarded as bio-ecological partly results from abiotic processes like those associated with the climate regime (operationalised in NiN as regional environmental complex-variables; RECs), partly from ubiquitous biotic and biogeographic processes such as interactions between species (Tilman & Kareiva, 1997), dominance by key species (Paine, 1969), dispersal (van Groenendael et al., 2000) and landscape-scale consequences of trophic cascades (Paine, 1980; Ripple et al., 2016). All of these processes may scale up to structural patterns of expressed ecological landscape elements at landscape-relevant spatial scales. The gradient from forested towards tree-less and barren alpine areas is a typical example of a CLG–B.

*Human land-use related CLGs* (CLG–Ls), express variation in the intensity of anthropogenous influence. This category comprises gradients in the aggregated outcomes of past and present exploitation of natural resources; typically expressing variation from natural via rural to urban landscapes and from landscapes with few traces of cultivation to landscapes shaped by intensive farming.

***S2.3.3 | Principles for construction of the landscape-type hierarchy***

EcoSyst type hierarchies for the landscape level contain landscape-type units at three hierarchically nested level – the major-type group, the major type and the minor type (Figure S2.4). The landscape type system of NiN version 2.2.0 was constructed by a process which integrates delimitation of abstract types with operationalisation of concrete spatial landscape units. Accordingly, a landscape-type map was produced alongside with, and as a by-product of, the type-hierarchy construction process.

The starting point for this integrated theoretical and practical process was the identification of a few, major, meso-scale landforms (106 – 1010 m2; Dikau, 1989; Karagulle et al., 2017) by a set of explicit geomorphometric criteria (see Box S2.3). Statistical analyses of landscape element composition data (T. Simensen et al., unpubl. results) gave strong support for recognition of three meso-scale landforms in coastal and inland Norway: ‘plains’, ‘hills and mountains’ and ‘fjords and valleys’. Criteria for identification of meso-scale landforms were operationalised in NiN version 2.2.0 by a quantitative methodology for delineation of spatial landscape units (polygons) based upon empirical surface geometry data (Hengl & MacMillan, 2009). Other meso-scale landforms may, of course, be relevant in other parts of the World, e.g. to capture tablelands, escarpments and continental shelfs (cf. Karagulle et al., 2017).

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| (a)  (b) |
| **FIGURE S2.4** Assignment of spatial landscape units to minor landscape type (within a major type) in NiN version 2.2.0. Prior to type assignment, Norway was divided into major-type polygons which were in turn further divided into spatial landscape units by a rule-based segmentation procedure which takes into account landform, terrain properties and surface geometry. Each spatial landscape unit was finally assigned to minor type according to the combination of segments along each major-type specific important complex landscape gradient (iCLGs) that characterises the spatial landcape unit. (a) Type assignment exemplified by the major type ‘inland hills and mountains’ and the minor landscape type ‘steep and rugged barren mountains with glacier’ (CLG-segment combination REF·5 – BPR·2 – VEG·1 – ABI·1 – JBI·1; code IA52111), shown by red boxes. Theoretically, major-type specific segments along the five iCLGs for this major type can be combined in 5 · 2 · 4 · 4 · 2 = 320 ways. Most of these combinations are, however, never realised, as exemplified by the unrealistic combination ‘steep mountains with glacier, forest cover, city and high agricultural land use’. In the NiN 2.2.0 landscape-type map for Norwegian coastal and inland landscapes, 54 of the potential 320 minor types within the major type ‘inland hills and mountains’ are represented by at least one spatial unit. (b) Distribution of the 97 spatial landscape units representing the minor landscape type ‘steep and rugged barren mountains with glacier’ in Norway shown in red. A total number of 21 508 out of 45 640 spatial landscape units were assigned to the ‘inland hills and mountains’ major type. Abbreviations: Ty = CLG category: GE = geo-ecological gradient; BE = bio-ecological gradient; LU = land-use-related (anthropogenous) gradient. |

Next, the coastline was added to the map of meso-scale landform polygons and the major-type group ‘coastal landscapes’ was separated from major-type groups ‘marine landscapes’ on the seaward side and from ‘inland landscapes’ on the landward side by a set of operational, mainly geomorphological criteria. As a result, ‘coastal landscapes’ were identified as the interface between the land and marine landscapes as a continuous belt along the coastline. The three major-type groups thus identified reflect meso-scale terrain and landform variation and dominance of marine vs terrestrial landscape elements, including interactions between them. Statistical analyses show that ‘inland landscapes’, which include terrestrial, wetland and limnic components as well as snow and ice, have very distinctive properties in Norway. The major-type group ‘marine landscapes’, which exclusively consists of submerged marine landscapes, is regarded as no less distinctive that the other two. Accordingly, 3*n* landscape major-type candidates were obtained by intersecting the 3 major- type groups with the *n* meso-scale landforms. The map of major landscape-type polygon candidates form the basis for defining EcoSyst landscape major types.

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| **BOX S2.3** Principles, procedures and criteria used in NiN version 2.2.0 for constructing the type hierarchy for the landscape level.  **Basic principles and procedures**   1. The EcoSyst type hierarchy for the landscape level is constructed by a process that integrates identification of abstract types with operationalisation of these units as concrete spatial landscape units. 2. A maximum of three major-type groups are recognised – ‘coastal landscapes’ which include the coastline and the adjacent strips of sea and land; ‘marine landscapes’ on the seaward side and ‘inland landscapes’ on the landward side. 3. A small number *n* of basic geomorphologic forms (meso-scale landforms), e.g. ‘plains’, ‘hills and mountains’ and ‘fjord and valleys’ are recognised, each defined by a set of explicit geomorphological criteria. 4. Landscape major-type candidates are obtained as the up to 3*n* realised combinations of 3 major-type groups and *n* meso-scale landforms. These candidates are the templates for division into landscape major types.   **Landscape major types have to satisfy the following five main criteria:**   1. Landscape major types shall be characterised and defined by distinct, meso-scale geomorphological features such as plains, hills, fjords, valleys and mountains, and be mappable by landform classification procedures based on surface geometry. Accordingly, landscape major types are nested within landscape major-type candidates. 2. A spatial unit representing a major-type candidate may be divided into two or more major types if they all satisfy the criterion that one and the same group of complex landscape gradients (CLGs) is relevant for describing the variation in landscape element composition throughout each major type. Two candidate major types thus have to possess at least one CLG in their group of important CLGs (iCLGs) not shared by the other major type. 3. Each major type shall comprise more than one landscape distance unit (LDU) of variation in landscape-element composition..   **Landscape minor types have to satisfy the following main criteria:**   1. Minor types are defined as ideal combinations of major-type specific segments along the CLGs that are important within the major-type in question. CLGs are sorted by functional category in the order (1) geo-ecological CLGs, (2) bio-ecological CLGs, and (3) CLGs related to human land-use. Within each of these categories, CLGs are ordered by importance, i.e. gradient length. 2. The areas that shall be assigned to minor type are spatial landscape units, i.e. areas obtained by segmentation of major-type polygons by a rule-based procedure by which landform, terrain properties and surface geometry are taken into account. As a basic rule, the spatial landscape units shall have a minimum size of 4 km2. |

Each major landscape-type candidate, with the set of spatial units representing it, is divided into two or more major types when certain criteria are met (see Box S2.3). The major landscape type is defined as a relatively homogeneous landscape with respect to meso-scale terrain and landform variation. The criteria for landscape major types outlined in Box S2.3 imply that major types shall possess a set of important complex landscape gradients, iCLGs. This set, which constitutes the CLG group of the major type, shall differ from the CLG groups of all other major types. The iCLG concept is central to the procedure for defining major types. In order for a CLG to be an iCLG, it has to satisfy a set of criteria with respect to gradient length within the spatial unit in question. The gradient length is the amount of compositional turnover in landscape element composition between CLG end-points.

Compositional turnover is measured in ecodiversity distance units in landscapes(EDU–L) by a standard method, parallel to the method for defining ecodiversity distance units in ecosystems (EDU–E); see section S2.4.5 for details. The criterion that each major type has to possess at least one CLG that is not shared by another major type is a parallel to criterion #1 for ecosystem major types (see Box S2.1).

**S2.4 | Principles and a method for division of complex-gradients into standard segments**

***S2.4.1 | Basic principles and terms***

A fundamental property of EcoSyst is that the amount of compositional turnover in the key characteristic along complex gradients in the key source of variation is used as a measure of the importance of the latter. Accordingly, implementation of EcoSyst principles requires a method for quantification of compositional turnover along complex gradients (see sections S2.2.3 and S2.3.3). In this section we describe the method adopted in NiN version 2.2.0 and the rationale that underpins it, primarily using examples from the ecosystem level of ecological diversity (see Figure 1).

The key characteristic at the ecosystem level is species compositon. The EcoSyst method for quantification of compositional variation, implemented in NiN version 2.2.0, has four elements: The basic element is a method for calculation of compositional dissimilarity between two compared sites, or observations, or candidate types, by means of species compositional data. Secondly, a unit for measurement of compositional distance, the ecodiversity distance unit (EDU), has to be defined and adapted to the appropriate ecodiversity level. For ecosystems, this unit is termed the ‘ecodiversity unit in ecosystems’ (EDU–E), defined as the difference in species composition as an expression of environmental differences and differences with respect to structuring ecological processes. The corresponding unit at the landscape level is the ‘ecodiversity unit in landscapes’ (EDU–L). The third element is a standard method for estimating the ecological distance between LEC end-points, i.e. the gradient length. Finally, specifications for the data to be used with this method have to be decided upon, in order to make results comparable among LECs and ecosystems.

Access to a method for estimating gradient lengths opens for development of a standard, criterion-based procedure for dividing LECs into segments of comparable lengths. For practical reasons, this standard segment length is defined to be one EDU (section 4.1, Figure 4b). The method for gradient-length estimation applies to any pair of species lists etc.

***S2.4.2 | Quantification of compositional dissimilarity and its relation to ecodiversity distance***

Estimation of ecodiversity distances (ED) between points in an ecological space can, in principle, be approached in two different ways; by multivariate ordination methods or by direct use of compositional dissimilarity indices (Økland, 1986, 1990). Ordination methods, which are generally useful for relating species composition to underlying environmental complex-gradients (e.g. Rydgren et al., 2004, 2019), are, however, unsuited for the present purpose because they require at least 10–20 observation units to give reliable results (cf. Økland, 1990). Type-hierarchy construction, on the other hand, requires a method for estimation of ecodiversity distances that is reliable also when used for two or relatively few points in ecodiversity subspace (section 4.1, Figure 4b). A necessary condition for direct use of compositional dissimilarity measures for this purpose is that compositional distances, expressed in ecodiversity distance units, can be modelled as a linear function of compositional dissimilarity.

Based on theoretical considerations, simulations and analyses of real data (Halvorsen et al., 2019: Appendix 2), the 'proportional dissimilarity' index (PD; Økland, 1986, 1990), also known as Czekanowski’s index after Czekanowski (1909), was chosen for quantification of compositional variation in EcoSyst. The original, unstandardised version of the PD index with values between 0 and 1 was used. This index is often, but erroneously (Yoshioka, 2008), referred to as the ‘Bray-Curtis index’, but Bray & Curtis (1957) used a standardised version of the index. The term ‘percentage dissimilarity’ is often used for proportional dissimilarity (PD) values expressed on a percentage scale (Gauch & Whittaker, 1972). The PD index is known as one of the best compositional dissimilarity measures in terms of linearity with ecological distance (Faith, Minchin, & Belbin, 1987; Økland, 1986).

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| **TABLE S2.3** The M7 and M3 scales for assigning abundance values to species in generalised species-list data sets (GADs) in NiN version 2.2.0. Depending on organism group, species’ abundance values express a combination of constancy (frequency of presence) and mean cover, or mean fraction of total biomass, in an infinite number of standard virtual observation units (VOUs). The VOUs make up an ideal, representative sample for a candidate nature type. The simplified M3 scale is used when the detailed knowledge required for using the M7 values is not available. A value of 1 is added to the abundance value given by constancy when the mean cover or mean biomass fraction in the set of VOUs is > 1/8. This is referred to in the table as the M condition. | | |
| M7 scale | M3 scale | Constancy |
| 0 | 0 | 0 |
| 1 | 0 | < 1/32 (0,03125) |
| 2 | 1 | 1/32 – 1/8 (–0,125) |
| 3 | 1 | 1/8 – 3/8 (–0,375) |
| 4 | 1 | 3/8 – 4/5 (–0,8) |
| 5 | 2 | 3/8 – 4/5 (–0,8) *and* M; or > 4/5 |
| 6 | 2 | > 4/5 *and* M |

The proportional dissimilarity (PD) index does not unconditionally satisfy the linearity criterion unconditionally; all ED estimates based upon PD or other compositional dissimilarity indices are burdened with two main caveats (Halvorsen et al., 2019: Appendix 2; Økland, 1986): (1) The so-called 'internal association problem' (IA; Whittaker, 1960), i.e. that stochastic variation in species composition among ecologically similar sites precludes reliable estimation of ecological distances from compositional dissimilarity values for ED values close to 0. (2) The non-linear relationship between compositional dissimilarity and ecodiversity distance for large EDs; the PD index approaches 1 for observation units with few or none species in common, but can never exceed this limit. PD thus no longer discriminates between ecodiversity distances when the true ecodiversity distance is large. The non-linearity of species’ responses to LECs (Figure 2) results in a sigmoid relationship between PD, as well as or other measures of compositional dissimilarity, as a function of positions along an LEC that is scaled in ED units. The sigmoid curve crosses the ordinate axis at the internal assiociation level, thereafter passes gradually into to a linear segment and finally approaches PD = 1 asymptotically.

These caveats are handled in EcoSyst by use of so-called generalised species-list data sets (GADs) to infer ED, measured in EDU units, from PD values (section S2.4.3), and by establishing a set of specific procedures for estimation of EDU from compositional dissimilarity values (section S2.4.4).

***S2.4.3 | Generalised species-list data sets***

A generalised species-list data set (GAD) is a collection of species lists in which species abundances are scored in a standardised way (Table S2.3). Each list in a GAD is the result of expert judgement, i.e. systematic compilation of information for a sample of abstract sampling units that represent a combination of pre-defined segments (i.e. a *hypercube*) in an ecological space spanned by a set of putatively important LECs. A total of 13 GADs with a total of 380 GAD lists were established and analysed in the process of developing NiN version 2.0.0 (Halvorsen 2015). Halvorsen et al. (2019) list 11 demands on the GADs.

(1) A GAD shall address variation in a specific ecological subspace with a set of putatively important LECs as axes. Typically, a GAD addresses variation within a candidate major type and the GAD-specific ecological space is defined by LECs that are potentially important in this candidate major type. One species list in one GAD (i.e. a GAD list) shall comprise a restricted and well-defined range of variation, a hypercube, in the GAD-specific ecological space. A typical GAD consists of one GAD list for each candidate minor type within a candidate major type.

(2) Variation due to other sources than the LECs that define the GAD-specific ecological space shall be kept at a minimum. Accordingly, a GAD consists of species lists from the same, restricted range along regional (climatic) and short-term environmental complex-gradients (RECs and STEs, respectively; see Figure S2.2 and Appendix S5) within a well-defined geographical area of limited extent.

(3) One GAD shall represent a congruent set of hypercube cells, i.e. a regular grid in the GAD-specific ecological space. This allows GAD lists to be compared for each series of segments along *one* LEC while variation along all other LECs are kept constant.

(4) Each GAD list shall be representative for the entire range of environmental variation in the hypercube that defines it. This is accomplished by demanding that each GAD list shall summarise species compositional variation in an imaginary data set consisting of an infinite number of virtual, or abstract, observation units (VOUs) that is representative for the variation along all LECs that define the hypercube.

(5) Representativity of each GAD list is achieved by conceptualising the list-specific set of VOUs as an area-representative sample of observations from sites in the list-specific hybercube within the geographic circumscription of the GAD. GAD lists are thus species-pool lists for the hypercube (Taylor, Aarssen, & Loehle, 1990), i.e. containing all species that are potentially capable of existing in a certain community (Eriksson, 1993). Species pools are scale-dependent, and GAD lists as here defined correspond to regional species-pool lists according to Pärtel, Zobel, Zobel, & van der Maarel (1996). GAD lists, in which abundances are assigned to each species by expert judgement with reference to the abstract, list-specific set of VOUs, thus describe a typical representation of the species composition of the hypercube in question. Geometrically, GAD lists are conceptualised as representing the point of gravity in this hypercube. Similarly, the set of lists in a

GAD are conceptualised as a set of points in the GAD-specific ecological space.

(6) Species’ abundances, i.e. the ‘degree of presence’ of each species, shall be expressed on a standard scale across all ecosystems and for all species groups. The scales used in NiN version 2.2.0 are shown in Table S2.3. For plants and sessile organisms, abundance is recorded as cover, i.e. the vertical projection of living biomass, expressed as fraction of the area of the observation unit (Wilson, 2011). For mobile animals, plankton etc., the biomass fraction is used, i.e. the fraction of the total biomass of organisms belonging to a species group contributed by a specific taxon.

(7) A standard virtual observation unit is defined as 100 m2 (10 × 10 m) in main ecosystem components ground and bottom, 100 × 100 × 100 m (1 000 000 m3) in water masses and 10 000 m2 (100 × 100 m) in snow and ice ecosystems. Necessary adaptations are made to fit ecosystems with specific properties such as small extent, occurrence as linear elements, in mosaics, etc. A species is recorded as present and assigned an abundance value of ≥ 1 if and only if it has positive fitness, i.e. that it is able to maintain source populations (cf. Pulliam, 1988) somewhere within the hypercube addressed by the GAD list.

(8) The same set of species (or taxa) are taken into consideration for all GAD lists that make up a GAD.

(9) Ideal GAD lists are complete, containing the entire regional species pool of the taxonomic and/or ecological group addressed (i.e. all plants, all insects, all marine mesofauna, etc.) within the entire hypercube. If infrequent species, typically specialists or other species with tolerance that deviates from the average, are missing from a GAD list, estimates of ecological distance will be biased. An index *R* of tolerance representativity, estimated for each LKM in the GAD, is used to correct estimates of compositional dissimilarity. Tolerance representativity here refers the ratio of the mean tolerance of species included in the GAD to the tolerance of all species that theoretically satisfy the criterion for being included.

(10) For each GAD, the state of knowledge is evaluated and scored on a scale from 0 (virtually no knowledge) to 5 (fully adequate knowledge).

(11) Each GAD shall be equipped with standardised metadata and other relevant documentation.

***S2.4.4 | Method for inferring ecodiversity distance from compositional dissimilarity***

The non-linear relationship between ecodiversity distance (ED) and compositional dissimilarity is circumvented by development of a method for robust translation of compositional dissimilarity index values to EDU estimates. The core of this method is to use the proportional dissimilarity (PD) index, which optimises linearity between compositional dissimilarity and ED, to measure compositional dissimilarity. The method, and the rationale on which it is built, can be summarised in five points as follows [for details, see Halvorsen et al. (2019)]:

(1) Ideal GAD-list data sets circumvent the internal association problem with real data, i.e. that two observation units from sites with similar environmental conditions never have exactly the same species composition (PD > 0 for EDU = 0). Almost all random variation in species composition is removed in the process of generalisation from concrete observations to species-pool lists for ideal type candidates. Uncertainty resulting from insufficient knowledge persists, though.

(2) Removal of the internal association problem also removes the non-linearity between PD and ED for low ecodiversity distances, typical of real data. For GAD-list data, PD is an approximately linear function of ED for PD ≤ 0.5. PD50, the ED that corresponds to a PD value between two compared GAD lists of 0.5, is therefore used as a reference unit for measurement of ED (the ‘PD50 unit’).

(3) For ED > 1 PD50-unit, i.e. when PD between two compared GAD-lists > 0.5), the unreliable PD values are replaced by reliable geodetic ED values (Bouttier et al., 2003), using the step-across method (De’ath, 1999; Swan, 1970; Williamson, 1978). The geodetic distance between two nodes in a network, e.g. two GAD lists that represent points of gravity for hypercubes in ecological space, is the smallest sum of reliable ED values along paths in a network of GAD lists that connect these nodes via other nodes. Thus, if PD(A,C) = 0.68, PD(A,B) = 0.37 and PD(B,C) = 0.40, the unreliable PD value of 0.68 is replaced by the geodetic proportional dissimilarity value PDgeo = 0.37 + 0.40 = 0.77. In this example, the geodetic ecodiversity distance is EDgeo = 0.77/0.50 = 1.54 PD50 units.

(4) The consistently linear relationship between PD and ED for PD ≤ 0.5 is almost unaffected by differences in species richness of the compared GAD lists. This holds true as long as the ratio of richness values for two compared species lists does not exceed ca. 2.5 (Halvorsen et al., 2019: Appendix 3). However, many LECs end with ‘*richness attenuation*’, i.e. a gradual reduction in species density towards end-points where the intensity of the underlying ecological process is so strong that no species has positive fitness. The term ‘species density’ refers to species richness in small plots of constant size, e.g. 1 m2 (Grace, 1999). A typical example of an LEC with such a disruptive end-point is ‘growing-season reduction due to prolonged snow cover’ (SV; see Appendix S4) which runs from mountain heaths via moderate, late and extreme snow-beds to vegetation-free snow-beds, ending in permanent snow and ice. Species density drops gradually from moderate snow-beds towards the snow-and-ice end of this LEC. The transition between late and extreme snow-beds coincides with the physiological tolerance limit of vascular plants, and the transition between extreme snow-beds and vegetation-free snow-beds is completed where also bryophytes and lichens give in to the harshness of the environmental conditions. Compositional dissimilarity is a meaningful proxy for ecological distance only when several species are present in the compared samples. In EcoSyst, a pragmatic solution to EDU–E estimation is chosen for richness attenuation LECs. First, the richness attenuation interval is defined as the portion of an LEC that begins where the most tolerant species reaches its optimum and ends where no species maintains stable populations. Analyses of real and simulated data underpin the decisions to fix the EDU–E of the richness-attenuation interval to 1.2 PD50 units and to define the point where the species density is 1/3 of the species density at the beginning of the richness attenuation interval as the intervals’s mid-point (Halvorsen et al., 2019: Appendix 3).

(5) The pragmatic solution for richness attenuation intervals is used, with necessary adaptations to each specific case, as a template for treating extremely species-poor communities.

***S2.4.5 | Division of LECs into elementary and standard segments: principles and four-step procedure***

D01

**Material**: Generalised species-list data sets (D01, D02 …) representing

* one major-type candidate
* a candidate division into minor types based on the candidate divisions of LECs
  + for different species groups
  + for different geographic areas

D02

D03

Analysis of each generalised data set

**Step 1**: Obtaining *data-set specific divisions* of each LEC:

* data-set specific classes (dssC: A\*, B\*, C\* …) *or*
* data-set specific segments (dssI: 1\*, 2\*, 3\*, …)

**Material**: Division of each LEC into

* candidate classes (cC; #A, #B, ...) *or*
* candidate segments (cI; #1, #2, ...)

D01

D02

D03

Generalisation across species groups and geographic areas

Consensus division into classes or segments valid across the major type

**Step 2**: Obtaining a *major-type specific division* of each LEC:

* major-type specific classes (mtsC:

[A],[B],[C] …)

* major-type specific segments (mtsI; [1],[2],[3] …)

Consensus division into elementary classes or segments which is applicable to all major ecosystem types

Generalisation across

major types

**Step 3**: Obtaining a *division of each LEC into basic units*;

* elementary classes (bC; a, b, c ...)
* elementary segments intervals (bI; a, b, c ...)

Characterisation of minor types in terms of elementary classes or segments and major-type adapted elementary classes or segments

**Step 4**: Obtaining a *major-type* *adapted division* of each LEC by *a*ggregation of basic classes or segments into*:*

* standard classes (sC; A, B, C...)
* standard segments (sI) (1, 2, 3 ...)

Re-description of the major-type specific ecological space

**FIGURE S2.5** Four-step procedure for translating results of analyses of generalised species-list data into major-type adapted divisions of LECs into segments and classes of standard width, in turn used to define minor ecosystem types.

The method for inferring ecodiversity distance (ED) from proportional dissimilarity (PD) values, and hence for estimating LEC lengths in units of compositional turnover (e.g. PD50 units and EDU–E units), opens for using GAD-list data sets to divide LECs into segments of standard breadth. Note that the segments are termed ‘classes’ if the variation along the LEC in question is treated as discrete. Gradient-length estimates obtained from one specific GAD-list data set, do, however, only represent this specific data set, typically addressing variation in a candidate major type in a climatically homogeneous region of moderate extent. Accordingly, a division of an LEC into standard segments based upon one specific GAD-list data set is therefore, strictly speaking, valid for this specificdata set only.Two or more GADs that address the same LEC and the same range of environmental variation in different regions may provide different gradient length estimates, suggest different numbers of standard segments and indicate that between-segment borders should be drawn in different positions along the LEC. This issue is resolved in EcoSyst by enforcing the rule that one and the same major-type specific division into segments shall be applied across the entire major type. This division shall be based on the largest gradient length, measured in EDU, obtained for any available GAD-list data set.

Type hierarchy

hypothesis

Test procedure

Hypothesis rejected

Hypothesis accepted

Supported type hierarchy

**FIGURE S2.6** Iterative procedure for testing candidate EcoSyst type hierarchies.

Most LECs that explain variation in species composition in at least one major type, are important in many major types. The most prominent example is ‘lime richness’ (KA), which is an important LEC in 40 major ecosystem types (Appendix S5). The procedure described above results in a plethora of different major-type specific divisions of each LEC. Unless specific measures are taken, a precise terminology for the incongruent sets of segments will have to be major-type specific. This potential terminological chaos is avoided by adding two steps to the procedure by which LECs are divided into segments: First, a consensus segmentation of the LEC into *elementary segments* is made, with the ambition of achieving the best possible fit to segment limits in all major-type specific segmentations. Subsequently, the elementary segments are combined, separately for each major type, to major-type specific standard complex-gradient segments or, simply, *standard segments* (Figure 4b).

Finding the optimal concensus segmentation is facilitated by defining elementary segments more narrowly than major-type specific standard segments. The number of elementary segments is allowed to be up to twice as high as the highest number of standard segments encountered in any single major type. The elementary segments are the indivisible building blocks, the atoms, of type systems for the ecosystem level of EcoSyst. Separately for each major type, the elementary segments are finally puzzled together to form the major-type adapted standard segments which approximate the major-type specific segmentation as closely as possible. The main difference between the major-type specific and the major-type adapted divisions into segments is conceptual: while that latter opens for minor types to be defined, described and named by a common language of labelled elementary segments, the former does not (see Figures 4 and S2.5). Naming and characterisation of elementary segments by use of generally observable properties of the LECs, such as physical or chemical characteristics, rather than characteristics of the species composition, which varies among major types, ensures applicability of segment names across major types.

The process by which a candidate type hierarchy is tested by the methodology described above and outlined in Figure S2.5 can be used for iterative improvement of EcoSyst type hierarchies by the formalised procedure of Figure S2.6.

***S2.4.6 | Definition of the ecodiversity distance unit and standardisation of LEC segment breadths***

Compositional variation along continuous LECs is mostly continuous. Accordingly, no *a priori* reason exists for choosing a specific ED value as standard length of the edge of an ideal minor-type hypercube in ecological space (Figure 4). The pragmatic solution adopted in NiN version 2.2.0 is to define 1 EDU–E (ecodiversity distance unit in ecosystems) = 0.25 PD units (= 0.5 PD50 units). This definition was motivated by the mean estimated compositional dissimilarity of 0.261 PD units between ecologically adjacent vegetation subtypes in Norway, described by Fremstad (1997), which roughly correspond to minor types in NiN version 1.0 (Halvorsen et al., 2009), along important LECs in forest, mire and alpine heath ecosystems. This definition of 1 EDU–E unit also has the pedagogical advantage of being easily to explain, as one ecodiversity distance unit in ecosystems then corresponds to an exchange of about one fourth of the species composition. Furthermore, 2 EDU–E roughly corresponds to the amplitude of major units, ‘types’ in the system of Fremstad (1997).

While the ideal standard LEC segment is exactly 1 EDU–E, the real situation is that estimated gradient lengths may take all values on a continuous scale. Thus, gradient lengths of 2.3 or 3.8 EDU–E are equally probable as gradient lengths of 2.0 or 4.0 EDU–E. Accordingly, a standard segment along an LEC is defined as the variation in species composition along a complex environmental gradient of width 0.75–1.50 EDU–E, defined by aggregation of elementary segments. Correspondingly, a standard class along a categorical LEC is defined to have a width of 1.0–1.5 EDU–E. Elementary segments shall, at the outset, cover 0.5–1.0 EDU–E of variation in the major-types with the largest estimated gradient lengths.

In practice, estimation of gradient lengths by use of generalised species-list data sets requires consideration of several technical issues in addition to those dealt with here. Detailed descriptions are given in Halvorsen et al. (2019).

The terms observable, considerable and substantial difference in species composition are used for ecodiversity distances in ecosystems of 1–2 EDU, 2–3 EDU and > 3 EDU, respectively.

***S2.4.7 | Division of complex landscape gradients into standard segments***

The method for estimation of LEC gradient length (see section S2.4.4) is used, with some important modifications, to quantify variation in landscape element composition along complex landscape gradients (CLGs). The major challenges in estimating compositional differences, associated with generalisation from analytic results, are equally relevant for landscape elements at the landscape level as for species at the ecosystem level of ecodiversity. Landscapes are shaped by the combined, interacting effects of multiple environmental controls and drivers, including both deterministic and stochastic processes (Phillips, 2007). Thus, every landscape is unique, unlikely to be duplicated exactly in composition, structure and function at any other place or at any other time-point. The random component of variation in the recorded values ​​for landscape properties implies that the expected inequality in landscape property composition between observation units that occupy the same position along a CLGs differs from zero, just like two ecologically similar but spatially separated sites never contain exactly the same species. This is referred to in section S2.4.4 as the 'internal association problem'.

At the ecosystem level, generalisation is facilitated by use of generalised species-list data sets (GADs). Unfortunately, the GAD concept cannot be adapted to the landscape level because our knowledge about quantitative variation in landscape element composition along complex landscape gradients is too fragmentary. Instead, an alternative five-step procedure is applied for quantification of variation at the landscape level. In the first step, a CLG candidate is divided into segments based on the distribution of key variable values on observation units. These key variables are obtained as axes of a reduncancy analysis (T. Simensen, R. Halvorsen, & L. Erikstad, unpublished results). Step two implies development of proxies for ‘landscape property profiles’ for each operationalised key variable. Landscape property profiles are the parallels to the generalised species lists at the ecosystem level. In step three, proportional dissimilarity is calculated between the landscape property profiles. In step four the ‘inequality between repeats’, which corresponds to the internal association at the ecosystem level (see section S2.4.4), is estimated from the PD-values obtained in step three. This estimate is used to calculate ecodiversity distances. Total CLG gradient length is estimated in the fifth and final step. The final result is a quantification of variation in landscape element composition in proportional dissimilarity (PD) units, i.e. on the scale used for LECs (section S2.4.4).

Compositional variation along most CLGs is continuous. No *a priori* reason exists for selecting a specific LD value as the edge of an ideal minor-type hypercube in ecodiversity space. Standardised stepwise division of landscape gradients is therefore, as for LECs at the ecosystem level, accomplished by adopting a pragmatic definition of one ecodiversity distance unit in landscapes (1 EDU–L) in terms of proportional dissimilarity. The definition of the EDU is, however, important because it determines the level of detail captured at the lowermost hierarchical level in the landscape-type hierarchy level, subsequently built by EcoSyst principles. A high value will result in a coarse-grained type system with few categories, while a low threshold value will provide a fine-grained type system with many categories. Based on the analyses of 85 landscape variables recorded in a total of 3966 sampling units in Norway (T. Simensen et al., unpublished results), 1 EDU–L unit was set to 0.08 PD units. One EDU–L unit then roughly corresponds to an exchange of about 1/12 of the landscape element composition.

A standardised, major-type specific division of CLGs is obtained by setting the number of major-type specific segments equal to the number of EDU–L between the gradient endpoints, rounded down to the nearest integer number. This means that the gradient length must be at least 2 EDU–L (> 0.16 PD units) in order for a CLG to be used for defining minor types, at least 0.24 EDU–L to provide three segments and define a series of three minor types, etc. The low number of major landscape types identified for Norway simplified the process of CLG segmentation by rendering the extra step via elementary segments unneccessary.

**References**

Arthur, W. (1986). On the complexity of a simple environment: competition, resource partitioning and facilitation in a two-species *Drosophila* system. *Philosophical Transactions of the Royal Society London Series B Biological Sciences*, **313**, 471–508.

Bouttier, J., Di Fransesco, P., & Guitter, E. (2003). Geodesic distance in planar graphs. *Nuclear Physics B*, **663**, 535–567.

Burkholder, P. R. (1952). Cooperation and conflict among primitive organisms. *American Scientist*, **40**, 601–631.

Bray, J. R., & Curtis, J. T. (1957). An ordination of the upland forest communities of Southern Wisconsin. *Ecological Monographs*, **27**, 327–349.

Czekanowski, J. (1909). Zur differential Diagose der Neandertalgruppe. *Korrespondenzblatt deutscher Gesellschaft für Anthropologie*, **40**, 44–47.

De’ath, G. (1999). Extended dissimilarity: a method of robust estimation of ecological distances from high beta diversity data. *Plant Ecology*, **144**, 191–199.

Delcourt, H. R., Delcourt, P. A. & Webb, T. (1982). Dynamic plant ecology: the spectrum of vegetational change in space and time. *Quaternary Science Reviews*, **1**, 153–175.

Dikau, R. (1989). The application of a digital relief model to landform analysis in geomorphology. In J. F. Raper (Ed.), *Three dimensional applications in geographical information systems* (pp. 51–77). London: Taylor & Francis.

Eriksson, O. (1993). The species-pool hypothesis and plant community diversity. *Oikos*, **68**, 371–374.

Erikstad, L., Uttakleiv, L. A., & Halvorsen, R. (2015). Characterisation and mapping of landscape types, a case study from Norway. *Belgeo*, **2015: 17412**, 1–16.

Faith, D. P., Minchin, P. R., & Belbin, L. (1987). Compositional dissimilarity as a robust measure of ecological distance. *Vegetatio*, **69**, 57–68.

Forman, R. T. T., & Godron, M. (1986). *Landscape ecology*. New York: Wiley.

Fremstad, E. (1997). Vegetasjonstyper i Norge. *Norsk Institutt for Naturforskning Temahefte*, **12**, 1–279.

Gaarder, G., & Wangen, K. (2019). Kartlegging og verdisetting av naturtyper. In I.H. Ingierd, I. Bay-Larsen, & K.H. Hauge (Eds.), *Interessekonflikter i forskning* (pp. 191–214). Oslo: Cappelen Damm Akademisk.

Gauch, H. G. Jr., & Whittaker, R. H. (1972). Coenocline simulation. *Ecology*, **53**, 446–451.

Gjærevoll, O. (1956). The plant communities of the Scandinavian alpine snow-beds. *Kongelige norske Videnskabers Selskab Skrifter*, **1956: 1**, 1–405.

Goldberg, D. E. (1990). Components of resource competition in plant communities. In J. B. Grace & D. Tilman (Eds.), *Perspectives on plant competition* (pp. 27–49). San Diego: Academic Press.

Grace, J. B. (1999). The factors controlling species density in herbaceous plant communities: an assessment. *Perspectives in Plant Ecology, Evolution and Systematics*, **2**, 1–28.

Grime, J. P. (1979). *Plant strategies and vegetation processes.* Chichester: Wiley.

Halvorsen, R. (2012). A gradient analytic perspective on distribution modelling. *Sommerfeltia*, **35**, 1–165.

Halvorsen, R., (Ed.), (2015). Grunnlag for typeinndeling av natursystem-nivået i NiN – analyser av generaliserte artslistedatasett. *Natur i Norge (NiN) Artikkel*, **2** (Version 2.0.2), 1–283. (<https://www.artsdatabanken.no/Files/14540/Artikkel_2___Analyser_av_generaliserte_artslistedatasett___grunnlag_for_typeinndeling_av_natursystem-niv_et_i_NiN_(versjon_2.0.2).pdf>)

Halvorsen, R., Andersen, T., Blom, H. H., Elvebakk, A., Elven, R., Erikstad, L., ... Ødegaard, F. (2009). *Naturtyper i Norge (NiN), Version 1.0.0.* Trondheim: Norwegian Biodiversity Information Facility. (http://www.artsdatabanken.no/naturtyper)

Halvorsen, R., Bryn, A., & Erikstad, L. [2016] (2019). NiN systemkjerne – teori, prinsipper og inndelingskriterier. Versjon 2.2. *Natur i Norge (NiN) Systemdokumentasjon*, **1** (Version 2.2.0), 1–291. (<https://www.artsdatabanken.no/Files/29717/Artikkel_1___NiNs_systemkjerne___teori,_prinsipper_og_inndelingskriterier.pdf>)

Haskell, E. F. (1947). A natural classification of societies. *Transactions of the New York Academy of Sciences Series II*, **9: 3**, 186–196.

Hengl, T., & MacMillan, R. A. (2009). Geomorphometry – a key to landscape mapping and modelling. *Developments in Soil Science*, **33**, 433-460.

Karagulle, D., Frye, C., Sayre, R., Breyer, S., Aniello, P., Vaughan, R., & Wright, D. (2017). Modeling global Hammond landform regions from 250-m elevation data. *Transactions in GIS*, **21**, 1040–1060.

Mitchell, G., & Arthur, W. (1998). Population interactions in primary succession: an example of contramensalism involving rock-colonizing bryophytes. *Lindbergia*, **23**, 81–85.

Noss, R.F. (1990). Indicators for monitoring biodiversity: a hierarchical approach. *Conservation Biology*, **4**, 355–364.

Økland, R. H. (1986). Rescaling of ecological gradients. I. Calculation of ecological distance between vegetation stands by means of their floristic composition. *Nordic Journal of Botany*, **6**, 651–660.

Økland, R. H. (1990). Vegetation ecology: theory, methods and applications with reference to Fennoscandia. *Sommerfeltia Supplement*, **1**, 1–233.

Oksanen, J. (1996). Is the humped relationship between species richness and biomass an artefact due to plot size? *Journal of Ecology*, **84**, 293–295.

Pärtel, M., Zobel, M., Zobel, K., & van der Maarel, E. (1996). The species pool and its relation to species richness: evidence from Estonian plant communities. *Oikos*, **75**, 111–117.

Paine, R. T. (1969). A note on trophic complexity and community stability. *American Naturalist*, **103**, 91.

Paine, R. T. (1980). Food webs, linkage, interaction strength and community infrastructure. *Journal of Animal Ecology*, **49**, 666–685.

Pulliam, H. R. (1988). Sources, sinks, and population regulation. *American Naturalist*, **132**, 652–661.

Resvoll, T. R. (1917). Om planter som passer til kort og kold sommer. *Archiv for Mathematik og Naturvidenskab*, **35: 6**, 1–224.

Ripple, W. J., Estes, J. A., Schmitz, O. J., Constant, V., Kaylor, M. J., Lenz, A., ... Wolf, C. (2016). What is a trophic cascade? *Trends in Ecology and Evolution*, **31**, 842–849.

Rydgren, K., Halvorsen, R., Töpper, J. P., Auestad, I., Hamre, L. N., Jongejans, E., & Sulavik, J. (2019). Advancing restoration ecology: a new approach to predict time to recovery. *Journal of Applied Ecology*, **56**, 225–234.

Rydgren, K., Økland, R. H., & Hestmark, G. (2004). Disturbance severity and community resilience in a boreal forest. *Ecology*, **85**, 1906–1915.

Simensen, T., Halvorsen, R., & Erikstad, L. (2018). Methods for landscape characterisation and mapping: a systematic review. *Land Use Policy*, **75**, 557–569.

Sjörs, H. (1948). Myrvegetation i Bergslagen. *Acta Phytogeographica Suecica*, **21**, 1–299.

Sousa, W. P. (1984). The role of disturbance in natural communities. *Annual Review of Ecology and Systematics*, **15**, 353–391.

Swan, J. M. A. (1970). An examination of some ordination problems by use of simulated vegetation data. *Ecology*, **51**, 89–102.

Swanson, F. J., Kratz, T. K., Caine, N. & Woodmansee, R. G. (1988). Landform effects on ecosystem patterns and processes. *Bioscience*, **38**, 92–98.

Taylor, D. R., Aarssen, L. W. & Loehle, C. (1990). On the relationship between r/k selection and environmental carrying capacity: a new habitat templet for plant life history strategies. *Oikos*, **58**, 239–250.

Tilman, D., & Kareiva, P. (1998). Spatial ecology: the role of space in population dynamics and interspecific interactions. *Monographs in Population Biology*, **30**, 1–416.

van Groenendael, J., Ehrlén, J., & Svensson, B.M. (2000). Dispersal and persistence: population processes and community dynamics. – *Folia Geobotanica*, **35**, 107–114.

Westhoff, V., & van der Maarel, E. (1978). The Braun-Blanquet approach. In R. H. Whittaker (Ed.), *Classification of vegetation* (pp. 287–399). The Hague: Junk.

White, P. S. (1979). Pattern, process, and natural disturbance in vegetation. *Botanical Review*, **45**, 229–299.

Whittaker, R. H. (1960). Vegetation in the Siskiyou Mountains, Oregon and California. *Ecological Monographs*, **30**, 279–338.

Whittaker, R. H. (1967). Gradient analysis of vegetation. *Biological Reviews of the Cambridge Philosophical Society*, **42**, 207–264.

Williamson, M. H. (1978). The ordination of incidence data. *Journal of Ecology*, **66**, 911–920.

Wilson, J. B. (2011). Cover plus: ways of measuring plant canopies and the terms used for them. *Journal of Vegetation Science*, **22**, 197–206.

Yoshioka, P. M. (2008). Misidentification of the Bray-Curtis similarity index. *Marine Ecology Progress Series*, **368**, 309–310.

Towards a systematics of ecodiversity: the EcoSyst framework

**APPENDIX S3 | NiN IMPLEMENTATION: ATTRIBUTE SYSTEM FOR THE ECOSYSTEM LEVEL**

**S3.0 |** **Contents**

S3.1 | Overview: sources of variation

S3.2 | Standardised recording and measurement scales

S3.3 | Species composition

S3.4 | Geology

S3.5 | Landforms

S3.6 | Natural objects

S3.7 | Man-made objects

S3.8 | Regional environmental variation

S3.9 | Short-term variation

S3.10 | Topographic structure

S3.11 | Spatial structure

In this appendix, we provide an overview of the attribute system for the ecosystem level in the NiN implementation of EcoSyst (version 2.2.0) for Norway. Appendix S3 is a condensed version of the full description of NiN the attribute system, published in Norwegian language (Halvorsen et al., 2018, 2019).

**S3.1 | Overview: sources of variation**

|  |  |  |
| --- | --- | --- |
| **TABLE S3.4** Sources of variation recognised in the NiN implementation of EcoSyst for Norway (version 2.2.0). MC = main category (C – composition; S – structure; P – process). Code = code for sources of variation addressed in NiN, used in standardised variable codes. | | |
| **MC** | **Source of variation** | **Code** |
| C | Species composition | 1 |
| C | Geological composition | 2 |
| C | Landforms | 3 |
| C | Natural objects | 4 |
| C | Man-made objects | 5 |
| S | Regional environmental variation | 6 |
| S | Local environmental variation | 0 |
| S | Short-term variation | 7 |
| S | Topographic structure | 8 |
| S | Spatial structure | 9 |
| P | Fundamental geological process | – |
| P | Geomorphological (land-forming) process | – |
| P | Fundamental ecological process | – |
| P | Ecological structuring process | – |
| P | Evolution | – |

An EcoSyst attribute system shall contain the standardised variables needed to describe all characteristics (objects, properties) that are observable at a relevant spatial scale at each ecodiversity level, in accordance with EcoSyst principle #3 for systematisation of Nature’s variation (Table 2). Construction of EcoSyst attribute systems starts with the sorting of all relevant variation into sources of variation, filed under three main categories: composition (of Nature), structure (of Nature) and process (of Nature); see Appendix S1 for definitions. Under each of these main categories, several sources of variation are recognised, as shown in Table S3.4.

Local environmental variation and species composition hold positions as key source of variation and key characteristic, respectively, in the ‘basic EcoSyst setup’ for the ecosystem level (Table 1), and were used to construct the NiN version 2.2.0 type hierarchy. Local environmental variation is accounted for in NiN by local environmental complex-gradients (LECs), which make up ‘category 0’ of sources of variation (Table S3.4). LECs, named by a two-letter code, are described in Appendix S4. Each LEC is divided into a number of elementary segments that are defined in general terms that apply across major-type groups and major types (section S2.4.5).

Since species compositional turnover is used as criterion for major-type specific divisions of LECs and, subsequently, for partitioning major types into minor types, a large fraction of the variation in species composition is accounted for by the hierarchical type system at the ecosystem level. The main reason why species composition is nevertheless included as source of variation in the attribute system is the frequent need for a more detailed description of species composition, including dominance relationships (e.g. dominant tree species in forests).

Processes are not explicitly addressed by variables in the attribute system in the NiN version 2.2.0 implementation of EcoSyst. Instead, ecological structuring processes are highlighted by the categorisation of LECs into process categories (Box S2.2). Geomorphological processes are highlighted in the categorisation of landforms (section S3.5). The fundamental geological, ecological and evolutionary processes that underlie the observed composition and structure, are not explicitly addressed in NiN.

The standardised variables of the NiN attribute system, sorted on sources of variation with codes from 0 to 9, are described in sections S3.3–S.3.11. For each source of variation, the variables are arranged in a nested, hierarchical manner with up to four levels. This is exemplified by the fourth-level variable 7SB–HI–ÅP–SH, ‘clearcutting’, which can be used to record the fraction of a mapped object that has been subjected to clearcutting. The variable belongs to the level-3 group 7SB–HI–ÅP ‘open selective logging’ in the level-2 group 7SB–HI ‘logging schemes’ which, in turn, belongs to level-1 group ‘forestry’ in source of variation 7, ‘short-term variation’. Variable codes are based upon the Norwegian terms, and hence may provide a link to definitions and extensive descriptions in Halvorsen, Bryn, Erikstad, Bratli, & Lindgaard (2018) and Halvorsen et al. (2019), among others.

**S3.2 | Standardised recording and measurement scales**

The flexible attribute system contains fully standardised and semi-standardised variables. The major-type specific segmentations of LECs by means of compositional turnover are criterion-based and testable. Hence, the LECs are fully standardised (complex-) variables. The other variables of the attribute system are semi-standardised in the sense that each variable is recorded by use of one pre-determined, standard measurement scale. In some cases, two alternative scales are available for the same variable. This ensures that different users of NiN, e.g. different authorities or mapping companies, record all variables in the same way and that data collected by different mappers can be stored in the same database.

Statistical variables of different types are recorded by different measurement scales. Binary variables are recorded as 0 or 1, nominal and ordinal categorical variables are recorded by using numbered factor levels. Discrete, i.e. count, variables, including discretised density and concentration variables, are recorded on ‘T-scales’ (Table S3.5). Discretised proportion variables are recorded on ‘A-scales’ (Figure S3.7). ‘R-scales’ (Figure S3.8) are used for ‘reference variables’, to which a value is assigned by comparison with reference values, ‘states’, that define variable end-points. Other, more specific measurement scales (Table S3.6) are explained together with the variables in question.

|  |  |  |
| --- | --- | --- |
| **TABLE S3.5** Measurement scales for discrete (count, density and concentration) variables. Code = scale code. | | |
| **Code** | **Variable type** | **Description** |
| T1 | Counts | Number of units within a given area |
| T2 | Counts, log scale | Number of units within a given area, given as base-2 logarithm (log2 x), rounded down to the nearest integer. Thus, x = 15 => log2(15) = 3.907 => T2 (15) = 3 |
| T3 | Density or concentration | Number of units per unit area, typically one hectare (10 000 m2) or one decare (1 000 m2) |
| T4 | Density or concentration, log scale | Number of units per unit area, given as base-2 logarithm (log2 x), rounded down to the nearest integer |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Code** | **F** | **> 9/10** | **3/4 – 9/10** | **1/2 – 3/4** | **1/4 – 1/2** | **1/8 – 1/4** | **1/16 – 1/8** | **1/32 – 1/16** | **0 – 1/32** | **0** |
| **P** | **> 90** | **75–90** | **50–75** | **25–50** | **12.5–25** | **6.25–12.5** | **3.125–6.25** | **0–3,125** | **0** |
| A3 | 2 | | | | 1 | 0 | | | | |
| A4 | 3 | | | | 2 | 1 | 0 | | | |
| A4b | 3 | | | | 2 | | | 1 | | 0 |
| A5 | 4 | | | 3 | 2 | 1 | 0 | | | |
| A6 | 5 | | | 4 | 3 | 2 | 1 | 0 | | |
| A7 | 6 | | | 5 | 4 | 3 | 2 | 1 | 0 | |
| A8 | 7 | | | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| A9 | 8 | | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| **FIGURE S3.7** Measurement scales for discretised proportion variables. Code = scale code; F = frequency; P = percent. F and P refer to the intervals on the frequency and percentage scales that correspond to each value on measurement scales A3–A9. For the species-group composition variables (1AG), the modified scale A9b is used. This scale is similar to scale A9, except for interval borders being adapted to the international definition of forest: 4 = 10–25%; 3 = 5–10%; 2 = 2.5–5%; 1 = 0–2.5%. | | | | | | | | | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Definition** | **Measurement scale and ordinal level** | | | | |
| **R4** | **R4b** | **R5** | **R5b** | **R7** |
| Reference for no observable effect on the species composition (‘reference 0’) | 1 | 1 | 1 | 1 | 1 |
| Very weak effect – presence of at least one indicator species, otherwise similar to reference 0 | 2 | 2 | 2 |
| Weak effect – presence of indicators, e.g. several indicator species, compositional similarity with reference 0 clearly larger than the similarity with reference E | 2 | 2 | 3 |
| Moderate effect – presence of indicators, e.g. several indicator species, compositional similarity with reference 0 larger than the similarity with reference E | 3 | 3 | 3 | 4 |
| Strong effect – almost equal compositional similarity with the 0 and E references | 3 | 4 | 4 | 5 |
| Very strong effect – compositional similarity with reference E clearly larger than the similarity with reference 0 | 6 |
| Extreme effect – reference E for maximal effect on the species composition | 4 | 4 | 5 | 5 | 7 |
| **FIGURE S3.8** Measurement scales for variables that describe effects on species composition, relative to two reference conditions. | | | | | |

**S3.3 | Species composition**

|  |  |
| --- | --- |
| **TABLE S3.6** Measurement scale S6 for subplot frequency of ground-dwelling species – generic variable 1AE–MB–XX(XX)yy(yy)–S; marked with \* in Table S3.7. | |
| **Value** | **Frequency** |
| 0 | 0 |
| 1 | < 1/32 |
| 2 | 1/32 – 1/8 |
| 3 | 1/8 – 3/8 |
| 4 | 3/8 – 4/5 |
| 5 | 4/5 – 1 |

Species composition is source of variation category 1 in the attribute system of NiN version 2.2.0. This category contains three level-1 variable groups that enable description of the occurrence, abundance and cover of single species (1AE); functional, structural or taxonomic groups (1AG); and dominance relationships within vertical layers or groups (1AR). An overview of species composition variables is given in Table S3.7.

The single-species cover and abundance variables of group 1AE consists of the generic variable 1AE–ZZ–XX(XX)yy(yy). Here, ZZ can take three values: –MB for ground-dwelling species; –BV for epiphytic and epixylic species; and –MO for mobile species. The last part of the variable code, consisting of ‘XX(XX)’ and ‘yy(yy)’, is included for specification of genus and species, respectively. XX(XX) refers to the name of the genus, abbreviated to four (or, optionally, two) letters and yy(yy) refers to the specific epithet abbreviated to four (or,

**TABLE S3.7** Species-composition variables (source of variation category 1) in the NiN implementation of Ecosyst, version 2.2.0. Level 1, Level 2, Level 3, Level 4 = codes for the up to four levels of the attribute system hierarchy which are concatenated to a variable-specific code. Type = statistical variable type [B – binary; D – density (concentration); F – proportion (fraction); M – multidimensional, consisting of several variables at lower hierarchical levels; N – nominal]. MS = measurement scale (Tn, An and S6 measurement scales are explained in Table S3.5, Figure S3.7 and Table S3.6, respectively). \* refers to generic level-3 variables named ‘–XX(XX)yy(yy)’ in which XX(XX) refers to genus abbreviated to four (two) letters and yy(yy) refers to the specific epithet abbreviated to four (two) letters according to standard lists. The 27 levels of the nominal variable 1AR–A–0 are explained in Table S3.8.

| **Level 1** | **Level 2** | **Level 3** | **Level 4** | **Variable** | **Type** | **MS** |
| --- | --- | --- | --- | --- | --- | --- |
| 1AE |  |  |  | Single-species composition | M |  |
|  | –MB |  |  | Ground-dwelling species1 | M |  |
|  |  | \* |  | Species | M |  |
|  |  |  | –0 | Species presence/absence | B |  |
|  |  |  | –S | Species subplot frequency | F | [S6](#S6) |
|  |  |  | –D | Species cover | F | [A6](#A6) |
|  | –BV |  |  | Bark- and wood-dwelling species (epiphytes and epixyles) | M |  |
|  |  | \* |  | Species | M |  |
|  |  |  | –0 | Species presence/absence | B |  |
|  |  |  | **–**K | Concentration2 | D | [T3](#T3) |
|  | –MO |  |  | Mobile species3 | M |  |
|  |  | \* |  | Species presence/absence | B |  |
| 1AG |  |  |  | Species-group composition | M |  |
|  | –A |  |  | Tree-layer (canopy) cover4 | M |  |
|  |  | –0 |  | Total tree-layer (canopy) cover5 | F | [A9](#A9) |
|  |  | –E |  | Cover of standards6 | F | [A9](#A9) |
|  |  | –G |  | Cover of regrowth successional trees7 | F | [A9](#A9) |
|  |  | –V |  | Cover of stunted trees4 | F | [A9](#A9) |
|  | –B |  |  | Shrub-layer cover8 | F | [A9](#A9) |
|  | –C |  |  | Field-layer cover9 | F | [A9](#A9) |
|  | –D |  |  | Ground-layer cover10 | F | [A9](#A9) |
|  | –E |  |  | Cover of benthic macroalgal canopy layer |  |  |
|  | –F |  |  | Cover of benthic macroalgal understory | F | [A9](#A9) |
|  | –G |  |  | Cover of marine and limnic algal crusts | F | [A9](#A9) |
|  | –H |  |  | Cover of sessile megafauna | F | [A9](#A9) |
| 1AR |  |  |  | Relative species-group composition11 | M |  |
|  | –A |  |  | Relative composition of the tree layer | M |  |
|  |  | -0 |  | Dominance class | N |  |
|  |  | –B |  | Coniferous tree fraction | F | [A5](#A5) |
|  |  | –E |  | Broadleaf deciduous tree fraction | F | [A5](#A5) |
|  |  | –L |  | Boreal deciduous tree fraction | F | [A5](#A5) |
|  |  | –V |  | Poplar and *Salix* tree fraction | F | [A5](#A5) |
|  |  | \* |  | Single-species fraction | F | [A5](#A5) |
|  | –B |  |  | Relative composition of the shrub layer | M |  |
|  |  | –B |  | Coniferous shrub fraction | F | [A5](#A5) |
|  |  | –E |  | Broadleaf deciduous shrub fraction | F | [A5](#A5) |
|  |  | –L |  | Boreal deciduous shrub fraction | F | [A5](#A5) |
|  |  | –V |  | Poplar and *Salix* shrub fraction | F | [A5](#A5) |
|  |  | \* |  | Single-species fraction | F | [A5](#A5) |
|  | –C |  |  | Relative composition of the field layer | M |  |
|  |  | –L |  | Woody-plant fraction | F | [A5](#A5) |
|  |  | –G |  | Graminoid fraction | F | [A5](#A5) |
|  |  | –K |  | Vascular cryptogam fraction | F | [A5](#A5) |
|  |  | –U |  | Herb fraction | F | [A5](#A5) |
|  | –D |  |  | Relative composition of the ground layer | M |  |
|  |  | –M |  | Bryophyte fraction | F | [A5](#A5) |
|  |  | –L |  | Lichen fraction | F | [A5](#A5) |
|  | –G |  |  | Relative composition of standing dead wood | M |  |
|  |  | –B |  | Coniferous fraction | F | [A5](#A5) |
|  |  | –L |  | Deciduous fraction | F | [A5](#A5) |
|  |  | \* |  | Single-species fraction | F | [A5](#A5) |
|  | –H |  |  | Relative composition of sessile megafauna | M |  |
|  |  | –F |  | Sea-pen fraction | F | [A5](#A5) |
|  |  | –H |  | Gorgonian fraction | F | [A5](#A5) |
|  |  | –S |  | Sponge fraction | F | [A5](#A5) |
|  | –L |  |  | Relative composition of downed wood | M |  |
|  |  | –B |  | Coniferous fraction | F | [A5](#A5) |
|  |  | –L |  | Deciduous fraction | F | [A5](#A5) |
|  |  | \* |  | Single-species fraction | F | [A5](#A5) |
| 1plants and other species (including soil-dwelling organisms) with low mobility, the performance of which can be meaningfully recorded for areas of 4 m2 or smaller  2number of trees with presence of the species per decare  3species with high mobility, the performance of which cannot be meaningfully recorded for areas of 4 m2 or smaller  4the tree layer consists of trees, i.e. woody plant with perennial main stem, more than 5 m tall or with potential to reach 5 m height at the site, and individuals of species that under favourable growth conditions may reach 5 m but due to growth-limiting site conditions at a site are, or are expected to be, at least 2.5 m (stunted trees)  5the fraction of a given area that is situated within crown peripheries of trees  6tree left over from an earlier phase in the dynamics of the tree stand or before abandonment of agricultural land-use  7tree established after tree-stand density reduction (e.g. by logging) or after abandonment of agricultural land-use  8woody plant with prennial main stem, between 0.8 and 2 m tall or between 2 and 5 m and belonging to a species which, even under favourable growth conditions, may reach a height of 5 m  9vascular plants other than trees and shrubs  10bryophytes and lichens  11recorded as the fraction of the total abundance (cover, etc.) of the layer in question made up by a given species group | | | | | | |

|  |  |
| --- | --- |
| **TABLE S3–8** Measurement scale N used for assigning dominance class to the tree layer (variable 1AR–A–0). Class codes B, E, L and V refer to the four species groups, coniferous, broadleaf deciduous, boreal deciduous, and poplar and *Salix* trees, respectively. A class code followed by ‘2’ indicates dominance by the group, i.e. a relative canopy cover of > 50%, otherwise the group co-dominates (i.e. has a relative canopy cover of 25–50%). Note that the 1AR–A–0 variable, like other variables of the level-1 group 1AR, address *relative* cover, i.e. the fraction of the total cover in a spatial unit that is attributable to each species group in the tree layer. | |
| **Class** | **Definition** |
| 0 | Open (non-woodland); tree cover < 10% (1AG-A-0 ≤ 3) |
| B2 | Dominance by conifers, no co-dominants |
| B2E | Dominance by conifers, co-dominance by broadleaf deciduous trees |
| B2L | Dominance by conifers, co-dominance by boreal deciduous trees |
| B2V | Dominance by conifers, co-dominance by poplar and *Salix* trees |
| BE | Co-dominance by conifers and broadleaf deciduous trees |
| BL | Co-dominance by conifers and boreal deciduous trees |
| BV | Co-dominance by conifers and poplar and *Salix* trees |
| B | No species group dominates, coniferous trees is the only species group with cover > 25% |
| E2 | Dominance by broadleaf deciduous trees, no co-dominants |
| E2B | Dominance by broadleaf deciduous trees, co-dominance by conifers |
| E2L | Dominance by broadleaf deciduous trees, co-dominance by boreal decidious trees |
| E2V | Dominance by broadleaf deciduous trees, co-dominance by poplar and *Salix* trees |
| EL | Co-dominance by broadleaf deciduous trees and boreal deciduous trees |
| EV | Co-dominance by broadleaf deciduous trees and poplar and *Salix* trees |
| E | No species group dominates, broadleaf deciduous trees is the only species group with cover > 25% |
| L2 | Dominance by boreal deciduous trees, no co-dominants |
| L2B | Dominance by boreal deciduous trees, co-dominance by conifers |
| L2E | Dominance by boreal deciduous trees, co-dominance by boreal decidious trees |
| L2V | Dominance by boreal deciduous trees, co-dominance by poplar and *Salix* trees |
| LV | Co-dominance by boreal deciduous trees and poplar and *Salix* trees |
| L | No species group dominates, boreal deciduous trees is the only species group with cover > 25% |
| V2 | Dominance by poplar and *Salix* trees, no co-dominants |
| V2B | Dominance by poplar and *Salix* trees, co-dominance by conifers |
| V2E | Dominance by poplar and *Salix* trees, co-dominance by broadleaf deciduous trees |
| V2L | Dominance by poplar and *Salix* trees, co-dominance by boreal deciduous trees |
| V | No species group dominates, poplar and *Salix* treesis the only species group with cover > 25% |

optionally, two) letters according to standard lists. For ground-dwelling species, two quantitative variables are used for measurement of subplot frequency and cover in a spatial unit. One of these variables, 1AE–MB–XX(XX)yy(yy)–S, can be used to assign subplot frequency on the standard S6 scale (see Table S3.6) to each species, assuming a virtual division of the spatial unit into 4 m2 (2 × 2 m) subplots.

The nominal variable 1AR–A–0 consists of the 27 possible combinations of tree-layer dominance (i.e. a relative canopy cover of > 50%) and co-dominance (i.e. a relative canopy cover of

25–50%) by the four species groups, coniferous, broadleaf deciduous, boreal deciduous (i.e. *Betula* spp., *Populus tremula*, *Sorbus aucuparia* or *Alnus incana*), and poplar and *Salix* trees.

**S3.4 | Geology**

Geological composition is source of variation category 2 in the attribute system. This category contains five level-1 categories for the occurrence of bedrock, minerals, fossils, surficial deposits and soil types (Table S3.9). Bedrock types (2BE) follow the most recent list provided by the Geological Survey of Norway (NGU). Minerals (2MI) are represented by generic variables of the type 2MI–XXXX, where XXXX is the first four letters in the official Norwegian name of the mineral (<http://www.nags.net/nags/mineraler/mineralside.htm>). Like variables for extant species, variables for fossils (2FO) consist of a generic variable, 2FO–XXXXyyyy where XXXX refers to the name of the genus, abbreviated to four letters and yyyy refers to the specific epithet abbreviated to four letters according to standard lists. The categorisations of surficial deposits (2JA) and (top)soil types (2JM) follow Norwegian SOSI standards.

**TABLE S3.9** Geological composition variables (source of variation category 2) in the NiN implementation of Ecosyst, version 2.2.0. Level 1, Level 2, Level 3 = codes for the up to three levels of the attribute system hierarchy which are concatenated to a variable-specific code. Type = statistical variable type [B – binary; M – multidimensional, consisting of several variables at lower hierarchical levels]. \* refers to generic level-2 variables named ‘–XXXX’ for minerals (2MI) and ‘–XXXXyyyy’ for fossils (2FO) in which XXXX refers to genus abbreviated to four letters and yyyy refers to the specific epithet abbreviated to four letters according to standard lists.

| **Level 1** | **Level 2** | **Level 3** | **Variable** | **Type** |
| --- | --- | --- | --- | --- |
| 2BE |  |  | Bedrock | M |
|  | –1 |  | Plutonic rock | M |
|  |  | –01 | Alkali feldspar granite | B |
|  |  | –02 | Granite | B |
|  |  | –03 | Granodiorite | B |
|  |  | –04 | Tonalite | B |
|  |  | –05 | Trondhjemite | B |
|  |  | –06 | Alkali feldspar syenite | B |
|  |  | –07 | Syenite | B |
|  |  | –08 | Monzonite | B |
|  |  | –09 | Monzodiorite | B |
|  |  | –10 | Larvikite | B |
|  |  | –11 | Quartz diorite | B |
|  |  | –12 | Diorite | B |
|  |  | –13 | Gabbro | B |
|  |  | –14 | Norite | B |
|  |  | –20 | Nephelin-bearing rock | B |
|  |  | –30 | Peridotite | B |
|  |  | –31 | Dunite | B |
|  |  | –32 | Harzburgite | B |
|  |  | –33 | Wehrlite | B |
|  |  | –34 | Lherzolite | B |
|  |  | –35 | Websterite | B |
|  |  | –36 | Pyroksenite | B |
|  |  | –40 | Charnockite | B |
|  |  | –41 | Mangerite | B |
|  |  | –42 | Enderbite | B |
|  |  | –43 | Anorthosite | B |
|  |  | –44 | Carbonatite | B |
|  |  | –50 | Diabase | B |
|  |  | –51 | Lamprophyre | B |
|  |  | –60 | Pegmatite | B |
|  |  | –61 | Aplite | B |
|  | –2 |  | Volcanic rock | M |
|  |  | –01 | Rhyolite | B |
|  |  | –02 | Rhyodacite | B |
|  |  | –03 | Dacite | B |
|  |  | –04 | Intermediate volcanic rock | B |
|  |  | –10 | Trachyte | B |
|  |  | –11 | Rhomb porphyry | B |
|  |  | –12 | Latite | B |
|  |  | –13 | Andesite | B |
|  |  | –14 | Mafic volcanic rock | B |
|  |  | –20 | Basalt | B |
|  |  | –21 | Komatiite | B |
|  |  | –22 | Nepheline-bearing lava | B |
|  |  | –30 | Pyroclastic rock | B |
|  |  | –40 | Volcanic breccia | B |
|  |  | –41 | Lapillituff | B |
|  |  | –42 | Tuff | B |
|  |  | –43 | Rhyolite | B |
|  | –3 |  | Sedimentary rock | M |
|  |  | –01 | Claystone | B |
|  |  | –02 | Mudstone | B |
|  |  | –03 | Siltstone | B |
|  |  | –04 | Sandstone | B |
|  |  | –05 | Greywacke | B |
|  |  | –06 | Arkose | B |
|  |  | –07 | Conglomerate | B |
|  |  | –10 | Sedimentary breccia | B |
|  |  | –11 | Tillite | B |
|  |  | –12 | Diamictite | B |
|  |  | –20 | Marl | B |
|  |  | –21 | Limestone | B |
|  |  | –22 | Dolomite | B |
|  |  | –30 | Dhert | B |
|  |  | –40 | Tuffite | B |
|  |  | –50 | Banded iron formation | B |
|  | –4 |  | Metamorphic rock | M |
|  |  | –01 | Shale | B |
|  |  | –02 | Phyllite | B |
|  |  | –03 | Mica schist | B |
|  |  | –04 | Garnet mica schist | B |
|  |  | –05 | Calcareous phyllite | B |
|  |  | –06 | Calcareous mica schist | B |
|  |  | –07 | Skarn | B |
|  |  | –10 | Hornblende schist | B |
|  |  | –11 | Graphitic schist | B |
|  |  | –15 | Calcite marble | B |
|  |  | –16 | Dolomite marble | B |
|  |  | –20 | Metasandstone | B |
|  |  | –21 | Metagreywacke | B |
|  |  | –22 | Meta-arkose | B |
|  |  | –23 | Quartzite | B |
|  |  | –24 | Quartz schist | B |
|  |  | –25 | Metachert | B |
|  |  | –26 | Mica gneiss | B |
|  |  | –27 | Calc-silicate rock | B |
|  |  | –30 | Granitic gneiss | B |
|  |  | –31 | Granodioritic gneiss | B |
|  |  | –32 | Tonalitic gneiss | B |
|  |  | –33 | Quartz dioritic gneiss | B |
|  |  | –34 | Monzonitic gneiss | B |
|  |  | –35 | Dioritic gneiss | B |
|  |  | –40 | Migmatite | B |
|  |  | –41 | Augengneiss | B |
|  |  | –42 | Banded gneiss | B |
|  |  | –50 | Greenschist | B |
|  |  | –51 | Greenstone | B |
|  |  | –52 | Amphibolite | B |
|  |  | –53 | Garnet amphibolite | B |
|  |  | –54 | Metagabbro | B |
|  |  | –55 | Eclogite | B |
|  |  | –56 | Serpentinite | B |
|  |  | –57 | Soapstone | B |
|  |  | –60 | Albitite | B |
|  |  | –61 | Hydrothermal quartz | B |
|  |  | –70 | Mylonite | B |
|  |  | –71 | Cataclasite | B |
|  |  | –72 | Tectonic breccia | B |
|  |  | –73 | Impact breccia | B |
| 2MI |  |  | Mineral site | M |
|  | \* |  | Mineral | B |
| 2JA |  |  | Surficial deposit | M |
|  | –01 |  | Glacifluvial deposits | B |
|  | –02 |  | Alluvial flood deposits | B |
|  | –03 |  | Debris flow deposit | B |
|  | –04 |  | Fluvial deposit (alluvium) | B |
|  | –05 |  | Weathered material | B |
|  | –06 |  | Marine deposit | B |
|  | –07 |  | Lacustrine deposit | B |
|  | –08 |  | Till | B |
|  | –09 |  | Organic material | B |
|  | –10 |  | Land-levelled material | B |
|  | –11 |  | Avalanche and landslide deposit (collovium) | B |
|  | –12 |  | Marine beach deposit | B |
|  | –13 |  | Aeolian deposit | B |
|  | –14 |  | Landfill | B |
|  | –15 |  | Glacilacustrine deposit | B |
| 2JM |  |  | Soil type | M |
|  | –AB |  | Albeluvisol | B |
|  | –AR |  | Arenosol | B |
|  | –AT |  | Antrosol | B |
|  | –CM |  | Cambisol | B |
|  | –CR |  | Cryosol | B |
|  | –FL |  | Fluvisol | B |
|  | –GL |  | Gleysol | B |
|  | –HS |  | Histosol | B |
|  | –LP |  | Leptosol | B |
|  | –LU |  | Luvisol | B |
|  | –PH |  | Phaeosem | B |
|  | –PZ |  | Podzol | B |
|  | –RG |  | Regosol | B |
|  | –RH |  | Agricultural landfill | B |
|  | –UM |  | Umbrisol | B |
| 2FO |  |  | Fossil site | M |
|  | \* |  | Fossil | B |

**S3.5 | Landforms**

Landforms are source of variation category 3 in the attribute system of NiN version 2.2.0. This category contains variables (Table S3.10) that enable recording of binary presence or absence of geomorphological features (landfoms), each spanning spatial scales from some metres to several kilometres. The 13 level-1 categories (landform groups) into which the individual landform variables are filed, represent major geomorphological processes, e.g. the action of glaciers, rivers, wind, mass transport or peat accumulation.

**TABLE S3.10** Landform presence variables (source of variation category 3) in the NiN implementation of Ecosyst, version 2.2.0. Level 1, Level 2 = codes for the up to two levels of the attribute system hierarchy (landform group and landform, respectively) which are concatenated to a variable-specific code. Type = statistical variable type [B – binary; M – multidimensional, consisting of several variables at lower hierarchical levels]. CSS = Characteristic spatial scale of variation, defined as the estimated median spatial extent of a single landform unit, given on a 2-logarithmic scale and rounded down to the nearest integer. Thus, the value CSS = 6 means that the typical extent of the landform in question is between 26 and 27 (i.e. 64–128) metres.

| **Level 1** | **Level 2** | **Variable** | **Type** | **CSS** |
| --- | --- | --- | --- | --- |
| 3AB |  | Glacial landforms | M |  |
|  | –DG | Kettle hole | B | 7 |
|  | –DI | Dead-ice terrain | B | 12 |
|  | –DR | Drumlin and flutes | B | 8 |
|  | –EN | Terminal or lateral moraine | B | 9 |
|  | –ES | Esker | B | 8 |
|  | –FL | Erratic block | B | 2 |
|  | –IS | Ice-cored moraine | B | 7 |
|  | –RO | Rogen moraine | B | 9 |
| 3AR |  | Alluvial deposits | M |  |
|  | –DE | Delta | B | 11 |
|  | –EB | River bar | B | 5 |
|  | –ES | Alluvial plain (river floodplain) | B | 10 |
|  | –EV | Alluvial fan | B | 8 |
|  | –LS | Terrestrialised marine clay plain | B | 12 |
|  | –LV | Levée | B | 6 |
| 3BF |  | Glaciers | M |  |
|  | –BB | Cirque glacier | B | 11 |
|  | –DB | Valley glacier | B | 12 |
|  | –DS | Ice apron | B | 10 |
|  | –KB | Calving glacier | B | 10 |
|  | –PB | Platau glacier | B | 13 |
|  | –RB | Regenerated glacier | B | 9 |
|  | –SB | Ice field | B | 12 |
| 3EB |  | Glacial erosion landforms | M |  |
|  | –BO | Cirque | B | 11 |
|  | –BR | Chatter mark | B | 0 |
|  | –DE | Trough end | B | 11 |
|  | –DK | Riegel | B | 9 |
|  | –FD | Glacial valley with fjord lake | B | 15 |
|  | –HD | Hanging valley | B | 12 |
|  | –MB | Marine basin | B | 16 |
|  | –PF | P-form | B | –2 |
|  | –RS | Roche moutonée | B | 1 |
|  | –SS | Glacial stria | B | 0 |
|  | –TI | Horn | B | 12 |
|  | –UD | U-shaped valley | B | 14 |
| 3EL |  | Alluvial landforms | M |  |
|  | –BD | Blind valley | B | 7 |
|  | –BK | Ravine | B | 9 |
|  | –FE | Braided stream | B | 11 |
|  | –KR | Oxbow lake | B | 8 |
|  | –ME | Meander | B | 8 |
|  | –UE | Subterranean river | B | 9 |
| 3ER |  | Fluvial erosion landforms | M |  |
|  | –ER | Eroded river bank | B | 6 |
|  | –GJ | Canyon (gorge) | B | 8 |
|  | –JE | Pothole | B | 1 |
|  | –JP | Earth pillar | B | 2 |
|  | –RB | Gully in glacilacustrine sediments | B | 6 |
|  | –RL | Gully in marine clay | B | 6 |
|  | –SP | Meltwater channel | B | 7 |
|  | –VD | V-shaped valley | B | 13 |
| 3FP |  | Periglacial landforms | M |  |
|  | –FB | Block field (autochtonous; originating by weathering) | B | 8 |
|  | –FG | Gravel field (autochtonous; originating by weathering) | B | 9 |
|  | –IP | Ice-wedge polygon | B | 4 |
|  | –OB | Frost-sorted block field (of allochtonous material) | B | 6 |
|  | –PI | Pingo | B | 6 |
|  | –SB | Rock glacier | B | 7 |
|  | –SM | Patterned ground | B | 5 |
| 3IK |  | Igneous and tectonic landforms | M |  |
|  | –GL | Nappe escarpment | B | 9 |
|  | –HA | Black smoker | B | 7 |
|  | –KA | Limestone ridge | B | 9 |
|  | –MD | Mud diapir | B | 8 |
|  | –MV | Mud vulcano | B | 9 |
|  | –SP | Fissure valley | B | 6 |
|  | –UG | Pockmark | B | 4 |
|  | –VU | Volcano | B | 12 |
| 3KJ |  | Karst landforms | M |  |
|  | –DO | Doline | B | 2 |
|  | –DR | Dripstone | B | 0 |
|  | –KG | Limestone cave | B | 6 |
|  | –KO | Karren (karstic surface) | B | 8 |
|  | –KT | Tufa | B | 1 |
| 3KP |  | Coastal landforms | M |  |
|  | –KG | Coastal cave | B | 6 |
|  | –KK | Coastal cliff | B | 9 |
|  | –RA | Sea stack | B | 2 |
|  | –SL | Shoreline | B | 7 |
|  | –SV | Beach ridge | B | 7 |
| 3ML |  | Terrestrial mass movement landforms | M |  |
|  | –FJ | Solifluction lobe | B | 1 |
|  | –FU | Rockslide scree | B | 8 |
|  | –FV | Debris cone | B | 7 |
|  | –JS | Soil landslide | B | 6 |
|  | –LS | Quick clay landslide | B | 5 |
|  | –PT | Protalus rampart | B | 4 |
|  | –SV | Snow avalanche-impacted rampart | B | 3 |
|  | –TA | Talus | B | 7 |
| 3MR |  | Marine landslides and landform shaped by ocean currents | M |  |
|  | –MG | Marine gorge | B | 11 |
|  | –MR | Submarine landslide | B | 14 |
|  | –PS | Iceberg ploughmark | B | 9 |
|  | –VS | Marine sandwave | B | 9 |
| 3TO |  | Mire massif types | M |  |
|  | –BA | Sloping fen | B | 7 |
|  | –BS | String-flark mixed mire | B | 8 |
|  | –BØ | Islet mixed mire | B | 7 |
|  | –DK | Spring fen | B | 2 |
|  | –FA | Flat fen | B | 6 |
|  | –FL | Transgression fen | B | 6 |
|  | –GS | Percolation mire | B | 7 |
|  | –GV | Terrestrialisation fen | B | 6 |
|  | –HA | Atlantic bog | B | 7 |
|  | –HE | Eccentric raised bog | B | 8 |
|  | –HK | Concentric raised bog | B | 8 |
|  | –HN | Ridge raised bog | B | 7 |
|  | –HP | Plateau raised bog | B | 8 |
|  | –PA | Palsa mire | B | 8 |
|  | –PO | Polygon fen | B | 6 |
|  | –ST | String-flark fen | B | 7 |
|  | –TE | Blanket bog | B | 9 |
| 3VI |  | Aeolian landforms | B | 9 |

|  |  |  |
| --- | --- | --- |
| **TABLE S3.11** The D7 measurement scale, used for recording the diameter (at breast height) of trees in NiN version 2. V = value; D = diameter (in cm). | | |
| **V** | **D** | **Term** |
| 0 | < 5 | Very small |
| 1 | 5–10 | Small |
| 2 | 10–20 | Relatively small |
| 3 | 20–30 | Intermediate |
| 4 | 30–40 | Large |
| 5 | 40–80 | Very large |
| 6 | > 80 | Giant |

**S3.6 | Natural objects**

Natural objects is source of variation category 4 in the attribute system of NiN version 2.2.0. This category comprises physically observable objects of limited spatial extent that, fully or partly, consist of natural substrates that are not part of the ground or bottom ecosystem components at the site. This category contains seven level-1 variable groups, each with several variables (see Tables S3.11 and S3.12) that enable description of occurrence patterns for naturally occurring objects, most notably dead wood in forests. The level of detail chosen for the variables reflects the detail required to describe features of known importance for forest biodiversity, requested by users. The single-species variables of groups 4TG (old trees) and 4TS (tree size) consist of the generic variable 4TZ–XX(yy) where Z refers to level-1 group and XX(yy) refers to genus abbreviated to two letters, and, if necessary to make the variables unique, also the specific epithet abbreviated to two letters according to standard lists.

**TABLE S3.12**  Variables describing natural objects (source of variation category 4) in the NiN implementation of Ecosyst, version 2.2.0. Level 1, Level 2, Level 3 = codes for the up to three levels of the attribute system hierarchy which are concatenated to a variable-specific code. Type = statistical variable type [D – density (concentration); M – multidimensional, consisting of several variables at lower hierarchical levels; O – ordinal]. MS = measurement scale (the Tn and D7 measurement scales are explained in Tables S3.5 and S3.11, respectively; ‘T4 (T3)’ means that the continuous T3 scale may optionally be used if a more precise quantification is needed). \* refers to generic level-3 variables named ‘–XX(yy)’ in which XX refers to genus abbreviated to two letters, if necessary also the specific epithet abbreviated to two letters.

| **Level 1** | **Level 2** | **Level 3** | **Variable** | **Type** | **MS** |
| --- | --- | --- | --- | --- | --- |
| 4DG |  |  | Snags (standing dead wood) | M |  |
|  | –0 |  | Snags regardless of size and species | D | [T4](#T4) ([T3](#T3)) |
|  | –M |  | Medium-sized snags (diameter 10–30 cm) | M |  |
|  |  | –0 | Medium-sized snags regardless of species | D | [T4](#T4) ([T3](#T3)) |
|  |  | –B | Medium-sized coniferous snags | D | [T4](#T4) ([T3](#T3)) |
|  |  | –L | Medium-sized deciduous snags | D | [T4](#T4) ([T3](#T3)) |
|  | –S |  | Large snags (diameter > 30 cm) | M |  |
|  |  | –0 | Large snags regardless of species | D | [T4](#T4) ([T3](#T3)) |
|  |  | –B | Large coniferous snags | D | [T4](#T4) ([T3](#T3)) |
|  |  | –L | Large deciduous snags | D | [T4](#T4) ([T3](#T3)) |
| 4DL |  |  | Logs (downed wood) | M |  |
|  | –0 |  | Logs regardless of size, species and decay stage | D | [T4](#T4) ([T3](#T3)) |
|  | –L |  | Logs in early stage of decay regardless of size and species1 | D | [T4](#T4) ([T3](#T3)) |
|  | –S |  | Logs in late stage of decay regardless of size and species1 | D | [T4](#T4) ([T3](#T3)) |
|  | –ML |  | Medium-sized logs (10–30 cm) in early stage of decay | M |  |
|  |  | –0 | Medium-sized logs (10–30 cm) in early stage of decay regardless of species1 | D | [T4](#T4) ([T3](#T3)) |
|  |  | –B | Medium-sized conifer logs (10–30 cm) in early stage of decay1 | D | [T4](#T4) ([T3](#T3)) |
|  |  | –L | Medium-sized deciduous logs (10–30 cm) in early stage of decay1 | D | [T4](#T4) ([T3](#T3)) |
|  | –MS |  | Medium-sized logs (10–30 cm) in late stage of decay | M |  |
|  |  | –0 | Medium-sized logs (10–30 cm) in late stage of decay regardless of species1 | D | [T4](#T4) ([T3](#T3)) |
|  |  | –B | Medium-sized conifer logs (10–30 cm) in late stage of decay1 | D | [T4](#T4) ([T3](#T3)) |
|  |  | –L | Medium-sized deciduous logs (10–30 cm) in late stage of decay1 | D | [T4](#T4) ([T3](#T3)) |
|  | –SL |  | Large logs (10–30 cm) in early stage of decay | M |  |
|  |  | –0 | Large logs (10–30 cm) in early stage of decay regardless of species1 | D | [T4](#T4) ([T3](#T3)) |
|  |  | –B | Large conifer logs (10–30 cm) in early stage of decay1 | D | [T4](#T4) ([T3](#T3)) |
|  |  | –L | Large deciduous logs (10–30 cm) in early stage of decay1 | D | [T4](#T4) ([T3](#T3)) |
|  | –SS |  | Large logs (10–30 cm) in late stage of decay | M |  |
|  |  | –0 | Large logs (10–30 cm) in late stage of decay regardless of species1 | D | [T4](#T4) ([T3](#T3)) |
|  |  | –B | Large conifer logs (10–30 cm) in late stage of decay1 | D | [T4](#T4) ([T3](#T3)) |
|  |  | –L | Large deciduous logs (10–30 cm) in late stage of decay1 | D | [T4](#T4) ([T3](#T3)) |
| 4RV |  |  | Treefall disturbance patches | M |  |
|  | –0 |  | Treefall disturbance patches regardless of size | D | [T4](#T4) ([T3](#T3)) |
|  | –RL |  | Small treefall disturbance patch2 | D | [T4](#T4) ([T3](#T3)) |
|  | –RS |  | Large treefall disturbance patch2 | D | [T4](#T4) ([T3](#T3)) |
| 4TG |  |  | Old trees | M |  |
|  | –0 |  | Old trees regardless of species | D | [T4](#T4) ([T3](#T3)) |
|  | –XX(yy) |  | Old trees of specific species XXyy3 | D | [T4](#T4) ([T3](#T3)) |
| 4TL |  |  | Tree with microhabitat | M |  |
|  | –BS |  | Tree with fire scar | D | [T4](#T4) ([T3](#T3)) |
|  | –HE |  | Tree with pendant lichens | D | [T4](#T4) ([T3](#T3)) |
|  | –HL |  | Hollow deciduous tree | D | [T4](#T4) ([T3](#T3)) |
|  | –RB |  | Tree with nutrient-rich bark4 | D | [T4](#T4) ([T3](#T3)) |
|  | –SB |  | Tree with furrowed bark | D | [T4](#T4) ([T3](#T3)) |
| 4TS |  |  | Tree size | M |  |
|  | –T0 |  | All trees regardless of size and species | D | [T4](#T4) ([T3](#T3)) |
|  | –TS |  | All large trees regardless of species5 | D | [T4](#T4) ([T3](#T3)) |
|  | –XX(yy) |  | Trees of specific species XXyy5 | M |  |
|  |  | –GD | Diameter of trees of species XX(yy) weighted by basal area | O | [D7](#D7) |
|  |  | –D0 | Very small trees (diameter < 5 cm) of species XX(yy) | D | [T4](#T4) ([T3](#T3)) |
|  |  | –D1 | Small trees (diameter 5–10 cm) of species XX(yy) | D | [T4](#T4) ([T3](#T3)) |
|  |  | –D2 | Relatively small trees (diameter 10–20 cm) of species XX(yy) | D | [T4](#T4) ([T3](#T3)) |
|  |  | –D3 | Intermediate-sized trees (diameter 20–30 cm) of species XX(yy) | D | [T4](#T4) ([T3](#T3)) |
|  |  | –D4 | Large trees (diameter 30-40 cm) of species XX(yy) | D | [T4](#T4) ([T3](#T3)) |
|  |  | –D5 | Very large trees (diameter 40–80 cm) of species XX(yy) | D | [T4](#T4) ([T3](#T3)) |
|  |  | –D6 | Tree giants (diameter > 80 cm) of species XX(yy) | D | [T4](#T4) ([T3](#T3)) |
|  |  | –T0 | All trees of species XX(yy) | D | [T4](#T4) ([T3](#T3)) |
|  |  | –TS | Large trees of species XX(yy)5 | D | [T4](#T4) ([T3](#T3)) |
|  |  | –T1 | Trees of species XX(yy) with diameter > 5 cm | D | [T4](#T4) ([T3](#T3)) |
|  |  | –T2 | Trees of species XX(yy) with diameter > 10 cm | D | [T4](#T4) ([T3](#T3)) |
|  |  | –T3 | Trees of species XX(yy) with diameter > 20 cm | D | [T4](#T4) ([T3](#T3)) |
|  |  | –T4 | Trees of species XX(yy) with diameter > 30 cm | D | [T4](#T4) ([T3](#T3)) |
|  |  | –T5 | Trees of species XX(yy) with diameter > 40 cm | D | [T4](#T4) ([T3](#T3)) |
| 1Decay stages follow the five-grade scale of Stokland (2001): 0 – weakened tree; 1 – recently dead tree; 2 – weakly decayed; 3 – medium decayed; 4 – strongly [very] decayed; 5 – almost decomposed. Stages 1–3 are regarded as early stages of decay and stages 4–5 are regarded as late stages of decay.  2Treefall disturbance patches are regarded as small if the area of exposed mineral soil < 2 m2.  3Ages at which trees are regarded as old are species-specific: 200 yrs for *Pinus sylvestris* and *Quercus* spp.; 150 years for *Picea abies* and all broadleaf deciduous tree species except *Quercus* spp., *Betula pendula* and *Alnus glutinosa*; 125 years for *Betula* spp.; 100 years for *Populus tremula* and all coniferous trees except *Pinus* and *Picea*; 75 years for *Alnus glutinosa*, *Salix* spp. and all boreal deciduous trees except *Populus tremula* and *Betula pubescens*.  4Rich-bark species in Norway: *Acer platanoides*, *Fraxinus excelsior*, *Ulmus glabra*, *Populus tremula*, *Tilia cordata.*  5Species-specific D7 size classes (cf. Table S3.11) included in the concept of large tree: 2–6: *Juniperus communis*; 3–6: *Taxus baccata*, boreal deciduous trees other than *Betula* spp., *Sorbus aucuparia*, *Salix* spp. other than *Salix caprea*; 4–6: *Alnus* spp., *Sorbus aucuparia* and *Salix caprea*; 5–6: *Picea abies*, *Pinus sylvestris* and all other coniferous tree species except *Taxus baccata* and *Juniperus communis*; *Populus tremula* and *Betula pubescens*; all broadleaf deciduous tree species except *Alnus glutiosa*. | | | | | |

**S3.7 | Man-made objects**

Man-made objects is source of variation category 5 in the attribute system of NiN version 2.2.0. A man-made object is a physically observable object of limited spatial extent that, fully or partly, consists of strongly modified or synthetic substrates, resulting from human activity. This category contains four level-1 variable groups, each with several variables (see Table S3.13) that enable recording of land-use types (5AB) or the presence or quantity of man-made objects and features such as quarries and buildings (5BY), archaeological sites and artefacts (5KU), and loose objects including trash (5XS). Man-made object variables are largely derived from existing standards. Accordingly, the level-1 group ‘land-use categories’ (5AB) contains the AREALBRUK (land-use SOSI-standard) categories used in official maps and databases for Norway and the content of level-1 group building types (5BY) accords with the standard of the Norwegian Mapping Authority (NS 3457). The long list of variables in the level-2 group ‘archaeological sites’ (5KU–AR) mainly contains categories of the Askeladden database for cultural monuments and heritage sites of the Directorate for Cultural Heritage.

**TABLE S3.13** Variables describing man-made objects (source of variation category 5) in the NiN implementation of Ecosyst, version 2.2.0. Level 1, Level 2, Level 3 = codes for the up to three levels of the attribute system hierarchy which are concatenated to a variable-specific code. Type = statistical variable type [B – binary; C – count (integer) variables; F – proportion (fraction); M – multidimensional, consisting of several variables at lower hierarchical levels]. MS = measurement scale (the An and Tn measurement scales are explained in Figure S3.7 and Table S3.5, respectively). CSS = Characteristic spatial scale of variation, defined as the estimated median spatial extent of a single land form unit, given on a 2-logarithmic scale and rounded down to the nearest integer. Thus, the value CSS = 6 means that the typical extent of the landform in question is between 26 and 27 (i.e. 64–128) metres. Norwegian terms are italicised and given in brackets in cases when precise English translations are not available.

| **Level 1** | **Level 2** | **Level 3** | **Variable** | **Type** | **MS** | **CSS** |
| --- | --- | --- | --- | --- | --- | --- |
| 5AB |  |  | Land-use categories | M |  |  |
|  | –DO |  | Service areas | M |  |  |
|  |  | –FY | Landfill site | B |  | 6 |
|  |  | –GR | Gravel pit | B |  | 5 |
|  |  | –GU | Mine | B |  | 4 |
|  |  | –IO | Industrial area | B |  | 8 |
|  |  | –LT | Clay pit | B |  | 3 |
|  |  | –SB | Quarry | B |  | 8 |
|  |  | –ST | Stone heap | B |  | 5 |
|  |  | –TT | Peat extraction site | B |  | 7 |
|  |  | –TØ | Log pile | B |  | 4 |
|  |  | –XD | Other service area | B |  | 6 |
|  | –FO |  | Recreational areas | M |  |  |
|  |  | –AL | Alpine piste | B |  | 9 |
|  |  | –CA | Camp site | B |  | 8 |
|  |  | –GO | Golf course | B |  | 10 |
|  |  | –LE | Playground | B |  | 4 |
|  |  | –RA | Picnic site | B |  | 3 |
|  |  | –SB | Shooting range | B |  | 6 |
|  |  | –SF | Artillery range | B |  | 12 |
|  |  | –SI | Sports ground | B |  | 6 |
|  |  | –XF | Other recreational area | B |  | 6 |
|  | –KO |  | Settlement areas | M |  |  |
|  |  | –BY | Urban settlement | B |  | 12 |
|  |  | –DM | Arable land | B |  | 8 |
|  |  | –FH | Orchard | B |  | 6 |
|  |  | –GP | Graveyard | B |  | 5 |
|  |  | –GÅ | Farmyard | B |  | 4 |
|  |  | –HY | Cabinfield | B |  | 7 |
|  |  | –LO | Other agricultural area | B |  | 6 |
|  |  | –PA | Park | B |  | 8 |
|  |  | –SE | Summer farmyard | B |  | 5 |
|  |  | –TE | Populated area other than urban settlement | B |  | 8 |
|  |  | –XB | Other artificial, constructed or otherwise developed area | B |  | 6 |
|  | –TO |  | Transportation areas | M |  |  |
|  |  | –FP | Airport | B |  | 10 |
|  |  | –JB | Railway | B |  | 4 |
|  |  | –KG | Antenna | B |  | 2 |
|  |  | –KL | Power line | B |  | 3 |
|  |  | –RG | Pipe trench | B |  | 2 |
|  |  | –SM | Marked trail | B |  | 2 |
|  |  | –SX | Unmarked path | B |  | 1 |
|  |  | –TS | Public transportation station area | B |  | 4 |
|  |  | –VE | European Road | B |  | 7 |
|  |  | –VF | County road | B |  | 4 |
|  |  | –VG | Shared-use path | B |  | 2 |
|  |  | –VK | Municipal road | B |  | 3 |
|  |  | –VP | Private road | B |  | 2 |
|  |  | –VR | State road | B |  | 5 |
|  |  | –VS | Forest truck road | B |  | 2 |
| 5BY |  |  | Building types | M |  |  |
|  | –BO |  | Residences | M |  |  |
|  |  | –EN | Villa and townhouse | C | T1 | 4 |
|  |  | –HY | Cabin | C | T1 | 3 |
|  |  | –KS | Summer farmhouse, logging and hunting cabin | C | T1 | 2 |
|  |  | –SB | Block of flats | C | T1 | 6 |
|  |  | –VÅ | Farmhouse | C | T1 | 4 |
|  | –FB |  | Military, home guard and prison building | C | T1 | 5 |
|  | –HE |  | Health-sector building (hospital, nursing homes etc.) | C | T1 | 6 |
|  | –HR |  | Hotel and restaurant building | C | T1 | 5 |
|  | –IL |  | Industrial, storage and primary sector buildings | M |  |  |
|  |  | –EF | Energy-sector building | C | T1 | 4 |
|  |  | –FL | Fishery and agricultural building | C | T1 | 5 |
|  |  | –IL | Industrial building and storehouse | C | T1 | 6 |
|  |  | –VM | Windmill | C | T1 | 3 |
|  | –KF |  | Office and business building | C | T1 | 6 |
|  | –KB |  | Culture and research buildings | M |  |  |
|  |  | –IB | Sports building | C | T1 | 6 |
|  |  | –KU | Cultural centre | C | T1 | 5 |
|  |  | –RB | Religious building | C | T1 | 5 |
|  |  | –SU | Educational building | C | T1 | 6 |
|  | –SK |  | Communication buildings | M |  |  |
|  |  | –AN | Antenna | C | T1 | 2 |
|  |  | –EB | Terminal and public transportation building | C | T1 | 5 |
|  |  | –FY | Lighthouse | C | T1 | 4 |
|  |  | –GH | Garage or hangar building | C | T1 | 6 |
|  |  | –TK | Telecommunication building | C | T1 | 5 |
|  | –XB |  | Other type of building | C | T1 | 4 |
| 5KU |  |  | Archaeological and historical monuments and sites | M |  |  |
|  | –AR |  | Archaeological sites | M |  |  |
|  |  | –BR | Bridge and abutment | B |  | 4 |
|  |  | –BV | Well and water post | B |  | 1 |
|  |  | –BÅ | Landing place | B |  | 2 |
|  |  | –DA | Dam | B |  | 6 |
|  |  | –DE | Boundary stone, p.p. [*delerøys*] | B |  | 2 |
|  |  | –FA | Hunting pit | B |  | 1 |
|  |  | –FX | Fish trap | B |  | 2 |
|  |  | –GA | Peat hut | B |  | 1 |
|  |  | –GP | Graveyard | B |  | 3 |
|  |  | –GR | Boundary stone, p.p. [*grenserøys*] | B |  | 0 |
|  |  | –GU | Mine | B |  | 4 |
|  |  | –GÅ | Farm mound | B |  | 3 |
|  |  | –HT | Dwelling ruin or site | B |  | 4 |
|  |  | –HV | Sunken lane | B |  | 2 |
|  |  | –KA | Quay | B |  | 4 |
|  |  | –KN | Canal | B |  | 3 |
|  |  | –KO | Lime kiln | B |  | 2 |
|  |  | –KU | Charcoal kiln | B |  | 1 |
|  |  | –LG | Hunting fence | B |  | 2 |
|  |  | –MA | Iron ore storage | B |  | 3 |
|  |  | –ML | Pier | B |  | 4 |
|  |  | –MM | Memorial monument | B |  | 2 |
|  |  | –MO | Blast furnace | B |  | 2 |
|  |  | –MØ | Mill ruin and millstone | B |  | 1 |
|  |  | –NB | Boathouse | B |  | 2 |
|  |  | –NT | Boathouse ruin or site | B |  | 2 |
|  |  | –OV | Furnace (kiln) | B |  | 1 |
|  |  | –PO | Gate | B |  | 2 |
|  |  | –RE | Place of execution | B |  | 3 |
|  |  | –RI | Bridleway | B |  | 2 |
|  |  | –RS | Rock carving | B |  | 0 |
|  |  | –RU | Ruin | B |  | 2 |
|  |  | –RY | Clearance cairn | B |  | 1 |
|  |  | –RØ | Roasting site | B |  | 2 |
|  |  | –SA | Sawmill ruin | B |  | 3 |
|  |  | –SB | Stone cabin | B |  | 1 |
|  |  | –SE | Navigation mark | B |  | 1 |
|  |  | –SG | Stone fence | B |  | 0 |
|  |  | –SJ | Trial pit | B |  | 0 |
|  |  | –SK | Entrenchment | B |  | 5 |
|  |  | –SL | Mining waste site | B |  | 3 |
|  |  | –SP | Barrier fence | B |  | 2 |
|  |  | –ST | Stone quarry | B |  | 4 |
|  |  | –SY | Military trench | B |  | 3 |
|  |  | –TI | Waste heap | B |  | 2 |
|  |  | –TJ | Tar production site | B |  | 1 |
|  |  | –TP | Peat-drying site | B |  | 3 |
|  |  | –TT | Peat extraction site | B |  | 4 |
|  |  | –TU | House foundation remnant | B |  | 2 |
|  |  | –VA | Irrigation system | B |  | 5 |
|  |  | –VO | Moat | B |  | 3 |
|  |  | –VR | Cairn | B |  | 1 |
|  |  | –VV | Road and trace of road | B |  | 2 |
|  | –BE |  | Rock art | B |  | 3 |
|  | –BY |  | SEFRAK-listed building1 | B |  | 3 |
|  | –FA |  | Historical vehicle | B |  | 2 |
|  | –KI |  | SEFRAK-listed church1 | B |  | 5 |
|  | –KV |  | Underwater cultural site | B |  | 4 |
| 5XG |  |  | Other loose object | M |  |  |
|  | –SM |  | Small loose object2,3 | F | [A8](#A8) | 3 |
|  | –ST |  | Large loose object2,3 | F | [A8](#A8) | 4 |
|  | –ST |  | Large loose object2,3 | F | [A8](#A8) | 4 |
| 1SEFRAK is the official Norwegian list of historical buildings and churches ([http://www.riksantikvaren.no/Veiledning/­SEFRAK](http://www.riksantikvaren.no/Veiledning/SEFRAK)) erected before year 1900 (1945 in Finnmark county).  2In order to be large (5XG–ST), loose objects have to a largest length of 2 m or more and/or a mass of 50 kg or more, and an expected duration at the site of 25 year or more in the absence of human intervention.  3Loose objects are recorded as frequency of presence in virtual subplots of 10 × 10 m, into which a spatial unit is divided. | | | | | | |

**S3.8 | Regional environmental variation**

Regional environmental variation is source of variation category 6 in the attribute system of NiN version 2.2.0. This category contains regional environmental complex-variables (RECs); broad-scale parallels to the LECs used to construct EcoSyst hierarchies of ecosystem types (see section S2.2.1 and Figure S2.2). Each of the six RECs (Table S3.14) are divided into elementary segments in the same way as LECs, i.e. without taking the variation in species composition along the REC into account.

**TABLE S3.14** Regional environmental complex-gradients (RECs; source of variation category 6) used in the NiN implementation of EcoSyst (version 2.2.0). Code = code used throughout the NiN documentation. PC = category of structuring process (H – historically conditioned biogeographic pattern; S – environmental stress); PV – pattern of variation (f – factor; g – gradient); ES = number of elementary segments. RECs are sorted alphabetically by code within each process category; CSS = relevant spatial scale, given as the linear dimension at which variation will typically be found, on a 2-logarithmic scale rounded down to the nearest integer. A value of 14 thus indicates that variation is typically found among sites ca. 214 = 16 km apart.

| **Code** | **REC** | **Description** | **PC** | **PV** | **ES** | **CSS** |
| --- | --- | --- | --- | --- | --- | --- |
| 6HF | Historical fresh-water connection to the east | Binary variable which separates the southeastern and northeastern parts of Norway with historical connection to lake *Ancylus* ca. 9 000–8 000 years BP (6HF∙1) from the rest of Norway, which lacked this connection (6HF∙2). The distinction between the two 6HF-segments is still clearly visible in the species composition; many freshwater fish and invertebrate species (and some plant species) are restricted to 6HF∙1. | H | f | 2 | 18 |
| 6KE | Coastal water sections | Variation in coastal waters of South Norway, related to temperature amplitude, salinity and tidal range and running from the west (the North Sea) to the east (Skagerrak). This gradient extends further into the Baltic sea. Two segments are recognised by which the open coastline W of Cape Lindesnes (6KE∙1) is separated from Skagerrak (6KE∙2). | S | g | 2 | 18 |
| 6KO | Coastal water zones | Variation in coastal waters of Norway, related to surface temperature, radiation and day length, running from the south (Nordsjøen and Skagerrak; 6KO∙1), via the North Sea (6KO∙2), South Barents Sea (6KO∙3) and Greenland Sea (6KO∙4) to North Barents Sea and Arctic Ocean (6KO∙5). | S | g | 5 | 19 |
| 6SE | Bioclimatic sections | Variation on land (including freshwater) related to broad-scale differences in humidity from oceanic to continental areas; on the Norwegian mainland from west to east and from midfjord to inland, on Spitsbergen without clear direction. Seven bioclimatic sections are recognised globally, of which five (6SE∙1–5) are recognised on the Norwegian mainland and four are recognised on the Svalbard archipelago (6SE∙3–6). These sections are: strongly oceanic (O3) section (6SE∙1); clearly oceanic (O2) section (6SE∙2); weakly oceanic (O1) section (6SE∙3); transitional (OC) section (6SE∙4); weakly continental (C1) section (6SE∙5); and clearly continental (C2) section (6SE∙6). | S | g | 6 | 15 |
| 6SO | Bioclimatic zones | Variation on land (including freshwater) on the Norwegian mainland and coastal islands related to broad-scale differences in energy supplies (as expressed by warmth sum, summer temperature, annual mean temperature, growing-season length) from the boreo-nemoral zone (6SO∙1), via the south boreal (6SO∙2), middle boreal (6SO∙3) and north boreal (6SO∙4) zones, to the low alpine (6SO∙5), middle alpine (6SO∙6) and high alpine (6SO∙7) zones. | S | g | 7 | 14 |
| 6SX | Bioclimatic zones in the Arctic | Variation in land (including freshwater) in the Arctic, i.e. north of the polar forest line, related to broad-scale differences in energy supplies (as expressed by warmth sum, summer temperature, annual mean temperature, growing-season length) from the Arctic shrub-tundra zone (6SX∙1); via the south Arctic tundra zone (6SX∙2), the middle Arctic tundra zone (6SX∙3) and the north Arctic tundra zone (6SX∙4) to the Arctic polar desert zone (6SX∙5). 6SX∙1 occurs on the Norwegian mainland along the coast of N Finnmark, 6SX∙2 contains no land area under Norwegian jurisdiction, while 6SX∙3–5 occurs on Svalbard. | S | g | 5 | 14 |

**S3.9 | Short-term variation**

Short-term variation is source of variation category 7 in the attribute system of NiN version 2.2.0. This heterogeneous category comprises simple and complex short-term variables that typically bring about successions that are completed in < (100–)200 years. This category includes short-term environmental complex variables (SECs) that are parallels to LECs used to construct EcoSyst hierarchies of ecosystem types (see see section S2.2.1 and Figure S2.2). It also includes short-term species compositional, i.e. successional, gradients with unclear environmental basis and transitions between these extremes. Most variables in category 7 describe a human impact or the effects of a human impact, regardless whether an effect on the species composition is expected or not. This category comprises 17 level-1 short-term variable groups, of which some are divided into elementary segments (gradient levels or classes) like LECs, with or without taking the variation in species composition into account, and some are of the fraction or reference types (see section S3.2 for an account of variable types). Table S3.15 provides an overview of short-term variables in NiN 2.2.0.

**TABLE S3.15** Short-term variables (source of variation category 7) used in the NiN implementation of EcoSyst (version 2.2.0). Level 1, Level 2, Level 3, Level 4 = code for the up to three levels of the attribute system hierarchy which are concatenated to a variable-specific code. SV = source of variation expressed (E – environmental, including impact; S = species compositional, including successional; ES – ecoclinal, i.e. species compositional variation in response to environmental variation. Type = statistical variable type [B – binary; D – density (concentration); F – proportion (fraction); M – multidimensional, consisting of several variables at lower hierarchical levels; N – nominal; O – ordinal]. MS = measurement scale (An, Rn and Tn measurement scales are explained in Figures S3.7–8 and Table S3.5, respectively; Nx refers to a nominal variable with x classes; Ox referes to an ordinal variable with x segments). CSS = relevant spatial scale relevant spatial scale, given as the linear dimension at which variation will typically be found, on a 2-logarithmic scale rounded down to the nearest integer. A value of 6 thus indicates that variation is typically found among sites ca. 26 = 64 m apart .

| **Level 1** | **Level 2** | **Level 3** | **Level 4** | **Variable** | **SV** | **Type** | **MS** | **CSS** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 7BU |  |  |  | Bottom-trawling impact1 | E | A | A4b | 5 |
| 7EU |  |  |  | Eutrophication | ES | R | R7 | 15 |
| 7FA |  |  |  | Alien species | ES | R | R7 | 3 |
| 7GR |  |  |  | Drainage (ditching) | – | M |  |  |
|  | –EG |  |  | Extinction debt after drainage | (E)S | O | O4 | 6 |
|  | –GI |  |  | Drainage intensity | E(S) | O | O5 | 6 |
| 7JB |  |  |  | Agricultural measures | – | M |  |  |
|  | –BA |  |  | Current agricultural land-use intensity | E(S) | O | O8 | 6 |
|  | –BD |  |  | Grazers | – | M |  |  |
|  |  | –FJ |  | Poultry | E | B |  | 6 |
|  |  | –GE |  | Goats | E | B |  | 6 |
|  |  | –GJ |  | Geese | E | B |  | 6 |
|  |  | –GR |  | Pigs | E | B |  | 6 |
|  |  | –HE |  | Horses | E | B |  | 6 |
|  |  | –HJ |  | Red deer | E | B |  | 6 |
|  |  | –RE |  | Reindeer | E | B |  | 6 |
|  |  | –SA |  | Sheep | E | B |  | 6 |
|  |  | –ST |  | Cattle | E | B |  | 6 |
|  |  | –XD |  | Other livestock | E | B |  | 6 |
|  | –BR |  |  | Prescribed burning intensity | E(S) | O | O4 | 6 |
|  | –BT |  |  | Grazing intensity | E(S) | O | O6 | 6 |
|  | –GJ |  |  | Artificial fertilisation intensity | ES | O | O5 | 6 |
|  | –HT |  |  | Tree-layer harvesting | – | M |  |  |
|  |  | –SL |  | Coppicing | E | D | T4 (T3) | 4 |
|  |  | –ST |  | Pollarding | E | D | T4 (T3) | 4 |
|  | –JB |  |  | Tilling intensity | E(S) | O | O6 | 7 |
|  | –KU |  |  | Developmental phases of coastal heath |  | M |  |  |
|  |  | –PI |  | Pioneer phase | S | F | A5 | 5 |
|  |  | –BY |  | Building phase | S | F | A5 | 5 |
|  |  | –MO |  | Mature phase | S | F | A5 | 5 |
|  |  | –DE |  | Degeneration phase | S | F | A5 | 5 |
|  | –SI |  |  | Mowing intensity | E(S) | O | O6 | 6 |
|  | –SP |  |  | Pesticide application intensity | E(S) | O | O4 | 6 |
|  | –SU |  |  | Sowing and planting | E | N | N8 | 6 |
|  | –VA |  |  | Irrigation | E(S) | B |  | 6 |
| 7MG |  |  |  | Contaminants and pollutants | – | M |  |  |
|  | –BI |  |  | Biocide | ES | R | R4 | 20 |
|  | –OL |  |  | Oil spill | ES | R | R4 | 17 |
|  | –OM |  |  | Organic contaminant or micropollutant other than biocides | ES | R | R4 | 20 |
|  | –RF |  |  | Radioactive pollutant | ES | R | R4 | 18 |
|  | –UO |  |  | Inorganic contaminant or micropollutant | ES | R | R4 | 8 |
|  | –XF |  |  | Other pollutant | ES | R | R4 | 8 |
| 7OB |  |  |  | Over-exploitation | ES | O | O4 | 16 |
| 7RA |  |  |  | Rapid succession |  | M |  |  |
|  | –BH |  |  | Regrowth succession in boreal heath | S | R | R4b | 7 |
|  | –SJ |  |  | Regrowth succession on semi-natural and strongly modified cultivated terrestrial land | S | R | R5b | 6 |
|  | –SM |  |  | Regrowth succession on semi-natural cultivated wetland | S | R | R3b | 6 |
|  | –TP |  |  | Rapid succession in tree plantation | S | R | R3b | 7 |
|  | –US |  |  | Rapid succession in natural and strongly modified, uncultivated ecosystems | S | R | R4b | 6 |
| 7SB |  |  |  | Silvicultural measures |  | M |  |  |
|  | –FT |  |  | Reforestation measures |  | M |  |  |
|  |  | –MA |  | Scarification | E | F | A6 | 8 |
|  |  | –NF |  | Natural regeneration | E | F | A6 | 8 |
|  |  | –TS |  | Planting or sowing | E | F | A6 | 8 |
|  | –FY |  |  | Regeneration material |  | M |  |  |
|  |  | –BL |  | Boreal deciduous trees | E | B |  | 8 |
|  |  | –EL |  | Broad-leaved deciduous trees | E | B |  | 8 |
|  |  | –FB |  | Alien coniferous trees | E | B |  | 8 |
|  |  | –GF |  | Native coniferous trees (*Picea abies* and *Pinus sylvestris*) | E | B |  | 8 |
|  | –HI |  |  | Timber harvesting methods |  | M |  | 8 |
|  |  | –GR |  | Repeated clearance cutting | E | A | A6 | 8 |
|  |  | –IH |  | Thinning, cleaning and related measures |  | M |  |  |
|  |  |  | –0 | Unspecified thinning and related silvicultural measures | E | A | A6 | 8 |
|  |  |  | –DH | Firewood harvesting and related cutting for other purposes than silviculture | E | A | A6 | 8 |
|  |  |  | –FR | Cleaning (prior to thinning) | E | A | A6 | 8 |
|  |  |  | –FT | Unspecific thinning | E | A | A6 | 8 |
|  |  |  | –HT | Thinning of older trees | E | A | A6 | 8 |
|  |  |  | –MA | Juvenile spacing | E | A | A6 | 8 |
|  |  | –LG |  | Closed gradual regeneration felling |  | M |  |  |
|  |  |  | –0 | Unspecified closed gradual regeneration felling | E | A | A6 | 8 |
|  |  |  | –GH | Group selection felling | E | A | A6 | 8 |
|  |  |  | –KH | Group selection felling near forest margin | E | A | A6 | 8 |
|  |  |  | –SH | Shelterwood felling | E | A | A6 | 8 |
|  |  | –LS |  | Closed selective felling |  | M |  |  |
|  |  |  | –0 | Unspecified closed selective felling | E | A | A6 | 8 |
|  |  |  | –PH | Plenter-system felling | E | A | A6 | 8 |
|  |  |  | –KH | Selective felling of mature trees | E | A | A6 | 8 |
|  |  | –ÅP |  | Open regeneration felling |  | M |  |  |
|  |  |  | –0 | Unspecified open regeneration felling | E | A | A6 | 8 |
|  |  |  | –FH | Seed-tree felling | E | A | A6 | 8 |
|  |  |  | –SH | Clear felling | E | A | A6 | 8 |
|  | –HS |  |  | Fraction av basal area made up by tree stumps | E | A | A9 | 8 |
|  | –KA |  |  | Catchment liming | E | B |  | 8 |
|  | –UT |  |  | Extraction method |  | M |  |  |
|  |  | –UG |  | Extraction of stem and slash (branches and top) | E | A | A6 | 8 |
|  |  | –US |  | Whole-tree extraction (including roots) | E | A | A6 | 8 |
|  |  | –UT |  | Timber extraction | E | A | A6 | 8 |
|  |  | –XH |  | Slash piling | E | A | A6 | 8 |
| 7SD |  |  |  | Tree-stand dynamics |  | M |  |  |
|  | –0 |  |  | Type of forest dynamics2 | ES | B |  | 7 |
|  | –NS |  |  | Regrowth succession of tree stands3 | ES | O | O5 | 6 |
|  | –NU |  |  | Development phases of near-natural forests |  | M |  |  |
|  |  | –FY |  | Regeneration phase | S | A | A5 | 5 |
|  |  | –OF |  | Optimal phase | S | A | A5 | 5 |
|  |  | –AF |  | Ageing phase | S | A | A5 | 5 |
|  |  | –FF |  | Degeneration phase | S | A | A5 | 5 |
| 7SE |  |  |  | Trampling and associated erosion1 | ES | A | A4b | 5 |
| 7SN |  |  |  | Natural tree-stand mortality |  | M |  |  |
|  | –BE |  |  | Beaver felling | E | A | A9 | 5 |
|  | –BR |  |  | Forest fire | E | A | A9 | 8 |
|  | –HJ |  |  | Mortality caused by moose and other ungulates | E | A | A9 | 4 |
|  | –IN |  |  | Insect attack | E | A | A9 | 4 |
|  | –SN |  |  | Avalanche | E | A | A9 | 6 |
|  | –SO |  |  | Fungal attack | E | A | A9 | 4 |
|  | –TF |  |  | Drought- or flood-related mortality | E | A | A9 | 7 |
|  | –VI |  |  | Storm felling | E | A | A9 | 5 |
|  | –XF |  |  | Other or unknown cause of mortality | E | A | A9 | 5 |
| 7SU |  |  |  | Acidification | ES | R | R7 | 17 |
| 7TK |  |  |  | All-terrain vehicle impact1 | ES | A | A4b | 4 |
| 7UB |  |  |  | Imbalance between trophic levels | S | A | A4b | 13 |
| 7VR |  |  |  | Water regulation |  | M |  |  |
|  | –EG |  |  | Extinction debt in terrestrial ecosystems after regulation | (E)S | O | O4 | 7 |
|  | –RE |  |  | Effect of water regulation on freshwater systems | (E)S | R | R5 | 9 |
|  | –RI |  |  | Regulation intensity | E(S) | O | O5 | 9 |
| 1Recorded as frequency of presence of the impact in question in virtual subplots of 10 × 10 m over the spatial unit.  2This variable separates forests by an explicit set of criteria into two categories; forests with near-natural dynamics (7SD–0∙1) and forests with other, typically successional, dynamics, in most cases due to forestry measures dynamics (7SD–0∙0).  3Five segments corresponding to felling classes 1–5 (recently clear-felled forest stage; thicket stage; young production forest stage; mature production forest stage; old production forest stage). | | | | | | | | |

**S3.10 | Topographic structure**

Topographic structure is source of variation category 8 in the attribute system of NiN version 2.2.0. This category contains five geospatial variables selected among many available variables and indices that may be used to describe the shape of the land surface and the seabed, and that apply to any spatial resolution (Table S3.16). All of these variables are continuous and can be derived from digital elevation models in a geographical information system (GIS). The quality and resolution of the elevation model determines the precision and spatial resultion of the topographic structure variables.

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| --- | --- | --- | --- | --- |
| **TABLE S3.16** Topographic structure variables (source of variation category 8) in the NiN implementation of EcoSyst (version 2.2.0). Code = code used throughout the NiN. Range = the range of valid values for the variable. Unit = unit of measurement. | | | | |
| **Code** | **Variable** | **Explanation** | **Range** | **Unit** |
| 8ER | Aspect | The cardinal direction towards which the vector of maximum inclination through a point points | 0–360 | ° |
| 8RR | Relative relief | The altitudinal difference between the highest- and lowest-situated points within a spatial unit | 0–∞ | m |
| 8TH | Inclination | The angle between the slope vector and the horiziontal plane | 0–180 | ° |
| 8TP | Topographic position | The difference between the altitude of a focal point and the mean altitude in a 1-km2 neighbourhood centered on the focal point | 0–∞ | m |
| 8TU | Terrain ruggedness | The vector ruggedness index of Sappington, Longshore, & Thompson (2007) | 0–1 | (no unit) |

**S3.11 | Spatial structure**

Topographic structure is source of variation category 9 in the attribute system of NiN version 2.2.0. This category contains six variables selected among many available variables and indices that describe observable structural characteristics of spatial units (Table S3.17).

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| --- | --- | --- | --- | --- |
| **TABLE S3–17** Spatial structure variables (source of variation category 9) in the NiN implementation of EcoSyst (version 2.2.0 Code = code used throughout the NiN documentation. Type = statistical variable type [C – continuous; On – ordinal, with n levels];.Unit = unit of measurement. | | | | |
| **Code** | **Variable** | **Explanation** | **Type** | **Unit** |
| 9AR | Surface area | Surface area of a spatial land unit | C | m2 |
| 9NE | Watershed area | Surface area of a watershed, i.e. a spatial unit comprising all points that drain through a focal point | C | km2 |
| 9TD | Threshold depth | Greatest depth of the threshold that separates a fjord from the sea | C | m |
| 9TS | Vertical stratification | Number of well-defined vertical crown layers in a tree stand (levels: 1; 2; > 2) | O3 | – |
| 9VA | Lake surface area | Surface area of a lake at normal water level | C | km2 |
| 9VD | Lake depth | Greatest depth of a lake, measured at normal water level | C | m |

**References**

Halvorsen, R., Bryn, A., Erikstad, L., Bratli, H., & Lindgaard, A. (2018). *Natur i Norge (NiN), version 2.2.0*. Trondheim: Norwegian Biodiversity Information Facility. (http://www.artsdatabanken.no/naturtyper)

Halvorsen, R., et al., [2016] (2019). NiN – typeinndeling og beskrivelsessystem for natursystemnivået. *Natur i Norge (NiN) Systemdokumentasjon*, **3** (Version 2.1.0), 1–525. (<https://www.artsdatabanken.no/Files/14539/Artikkel_3___Natursystemniv_et___typeinndeling_og_beskrivelsessystem_(versjon_2.1.0).pdf)>

Sappington, J. M., Longshore, K. M. & Thompson, D. B. (2007). Quantifying landscape ruggedness for animal habitat analysis: a case study using bighorn sheep in the Mojave Desert. *Journal of Wildlife Management*, **71**, 1419–1426.

Stokland, J. N. (2001). The coarse woody debris profile: an archive of recent forest history and an improved biodiversity indicator. *Ecological Bulletin*, **49**, 71-83.

Towards a systematics of ecodiversity: the EcoSyst framework

**APPENDIX S4 | NiN IMPLEMENTATION: LOCAL ENVIRONMENTAL COMPLEX-GRADIENTS (LECs)**

**S4.0 |** **Contents**

S4.1 | Background and terminology

S4.2 | List of LECs, with descriptions

**S4.1 | Background and terminology**

This appendix gives an overview of all the 57 local environmental complex-variables, herafter referred to as local environmental complex-gradients (LECs), that are used in the NiN implementation of EcoSyst (version 2.2.0) for Norway. The term ‘gradient’ is used here in a wide sense, not only including variation that is strictly gradual (LECs in the strict sense) but also more or less step-wise variation (local environmental complex-factors). The term ‘complex’ is included to make clear that an LEC is an abstract variable that express co-ordinated variation, i.e. a set of more or less strongly correlated single environmental variables. The term ‘local’ makes it clear that relatively fine spatial scales are addressed; typical LECs describe variation on spatial scales between 1 and 100 m, occasionally up to 1000 m, which, in the absence of changes in fundamental environmental conditions, is expected to persist for more than 100(–200) years. LECs and their relationship to other categories of environmental variation is treated in greater detail in Sections S2.2.1 and S2.2.2.

Different LECs represent different environmental structuring processes. The division of LECs according to structuring process is central to their role in EcoSyst type-hierarchy construction (see section S2.2.3). In particular, the division into process categories is important (Box S2.2). Terms used to distinguish between process categories are listed with definitions in Box S4.4.

The hierarchical type system at the ecosystem level addresses variation along LECs (the key source of variation), using variation in species composition (the key characteristic) as indicator of the importance of each LEC (see S2 for details). Two segmentations exist for each LEC. The elementary segments, which are the smallest segments into which a complex-gradient is divided, are defined by universal criteria that apply across all major types. The standard segments, on the other hand, are specific to each major type and made up by one, two or more elementary segments. Each standard segment comprises at least 1 ecodiversity distance unit (EDU) of variation in the key characteristic within the major type in question (see section S2.4 for a detailed description of methods, and S5 for a complete overview of ecosystem types in NiN version 2.2.0). The elementary segments represent variation along complex-gradients as such while the standard segments represent variation along ecoclines, i.e. the parallel, more or less gradual, co-variation of species composition (a coenocline) along a major complex-gradient (Whittaker, 1967; Halvorsen, 2012).

This appendix contains information about the division of LECs into elementary segments, often labelled by small letters starting with a. The number of elementary segments into which each LEC is divided depends on the amount of compositional turnover along the LEC in *any* major type. In cases where the lower end of an LEC represents a situation where the process in question has no impact, the elementary segment in question is labelled ‘0’. Similarly, the upper-end LEC segment is labelled ‘¤’ when the process has a disruptive effect. The term disruptive is used for situations with strongly reduced number of species or no species permanently present, caused by strong impact of an LEC. The label ‘+’ is used to indicate that an LEC ‘continues’ into another LEC, characterised by another, related but qualitatively different process.

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| **BOX S4.4** Terms used to characterise LECs according to ecological structuring process.  *active disturbance* – disturbance process with expected frequency above zero and a pattern of variation in the degree of disturbance impact that is known  *anthropogenic disturbance –* disturbance (unpredictable or predictable) process that results from human activity  *destabilising disturbance* – disturbance process that, at intermediate intensities, impacts the species composition relatively rarely, but each time with considerable effect on the species composition and initiating a succession that, if not interrupted, will last for many years if not interrupted  *disturbance* – reduction of the biomass at a site by a process that causes complete or partial destruction of living organisms  *environmental stress* – process by which production of organic matter is constantly limited by one or more resources in short supply  *historical disturbance* – previous, comprehensive disturbance event that is not expected to recur, with observable legacies in the species composition, structure and ecological processes of the affected ecosystem  *land management* – recurrent man-made activity that maintains specific ecosystem types by disturbance, alone or in combination with efforts to increase agricultural production; activities and impacts that are included in the concept of land management are: hay-making, grazing and trampling by domestic animals, prescribed burning, ploughing, clearance of shrubs and trees, pesticide spraying, manuring, coppicing, sowing and watering  *rapid succession* – succession that is expected to reach a post-successional stage in (100–)200 years  *regulating disturbance* – disturbance process that, at intermediate intensities, impacts the species composition relatively frequently, each time neither with considerable effects on the species composition nor initiating a succession that lasts for many years  *slow succession* *–* succession that is not expected to reach a post-successional stage in (100–)200 years |

**S4.2 | List of LECs, with descriptions**

Table S4.18 provides a systematic overview of LECs in NiN version 2.2.0. Detailed descriptions in Norwegian can be found in Halvorsen et al., (2019).

**TABLE S4.18** Local environmental complex-gradients (LECs) used in the NiN implementation of EcoSyst (version 2.2.0) for Norway, with short descriptions. Code = two-letter code that is used throughout the NiN documentation. PC = process category (D – destabilising disturbance; R – regulating disturbance; S – environmental stress; L = slow succession; see section S2.2.2 and Box S2.3). PV – pattern of variation (f = factor; g – gradient, ga – gradient that ends in a species-thinning situation at high intensity). CSS = relevant spatial scale (given as the linear dimension at which variation will typically be found, on a 2-logarithmic scale rounded down to the nearest integer. A value of 5 thus indicates that variation is typically found among sites 25 = 32 m apart. ES = elementary segments. MG and MT = major-type group(s) and major type(s) in which the LEC is used for division into minor types or as a subordinate LEC, i.e. to describe observable variation in species composition. Codes for major-type groups and major types are in accordance with Tables S5.20 and S5.21, respectively. LECs are sorted alphabetically by code within each process category.

| **Code** | **LEC** | **Description** | | **PC** | **PV** | **CSS** | **ES** | **MG** | **MT** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ER | Erosion intensity | Variation in the intensity of water-mediated disturbance on river beds and the adjacent flooded ground, in sites where erosion clearly dominates over sedimentation (e.g. along seasonal meltwater rivers with negligible sediment transport); ends in a species-thinning situation | D | | ga | 8 | 0,a–b,¤ | T | T30 |
| HI | Land manage-ment intensity | Variation in the intensity of agricultural land mana-gement activities, including related anthropogeneous impacts not intended to increase production; running from natural sites with no traces of management, via extensively managed (e.g. by grazing, haymaking or prescribed burning), semi-natural sites to intensively managed sites (by ploughing, fertilisation, treatment with herbicides and sowing of crops) | D | | g | 6 | 0,a–j | T,V | T2–T4,T7,T8, T12,T15,T16, T18,T21,T29–T34,T41, T43,T45;  V9,V10 |
| HR | Semi-natural land manage-ment regime | Binary variable that distinguishes between two fundamentally different land management regimes on semi-natural ground: grazing and/or haymaking which results in grassland vs prescribed burning which results in heathland | D | | f | 7 | 0,a | T | T34 |
| IF | Ice-scouring disturbance | Variation in the intensity of freezing and ice scouring on littoral belts of coastal and inland lake sites and flooded ground along rivers, and in kettle holes, e.g. affecting the establishment of perennial plants; ends in a species-thinning situation | D | | ga | 2 | 0,a,b,¤ | M,L,T | M1,M3; L1,L2,L4; T1,T6,T18,T20 |
| IO | Organic matter content | Variation in the substrate’s content of organic matter ranging from predominantly inorganic (<10% organic matter) to predominantly organic substrates (<10% inorganic matter) | D | | g | 3 | 0,a,b,¤ | M,L, T,V | M4,M5,M8; L2–L4; T9,T23,T24; V6,V10,V13 |
| JF | Solifluction | Variation in topsoil stability, i.e. the tendency of soil to become saturated with water during snowmelt and subsequently move downslope; high intensity of solifluction typically results in formation of soli-fluction lobes at which woody plants are lacking and small bryophytes and lichens dominates on fine soil | D | | g | 3 | 0,a,b | T | T22 |
| MB | Topsoil tilling | Binary variable that separates intensively managed land into two categories; land that is not regularly ploughed (i.e. subjected to topsoil tilling) and land that is regularly ploughed (and, in addition to tilling, often fertilised and/or treated with herbicides) | D | | f | 6 | 0,+ | T | T40–T45 |
| MX | Category of anthropo-genic disturbance | Binary variable separating semi-natural ground characterised by moderate anthropogenic disturbance processes but not contingent upon land management, from corresponding natural ground | D | | f | 7 | 0,a | T | T31 |
| OF | Cryotur-bation | Variation in the intensity of disturbance by frost processes, from stable ground via sites slightly affected by frost heaving, to sites strongly disturbed by frost processes on fine soil typically dominated by small bryophytes | D | | g | 2 | 0,a,b | T | T19 |
| SE | Sedimen-tation intensity | Variation in the intensity of sedimentation in freshwater and marine sites where decelerating river water loses its mass transportation capacity and sedimentation regularly dominates over erosion, typically found in the outer parts of deltas; at high intensity ending in a species-thinning situation | D | | ga | 6 | 0,a,b,¤ | M,L | M4,M9; L2 |
| SS | Sand stabilisation | Variation in sand-dune stability, brought about by the tendency of sand to become more stable at increasing distances from the sand source (typically the coastline); LEC SS runs from naked sand-dominated littoral seabeds via active sand-dune systems to forests on stabilised sand and thus is a primary successional gradient starting with vascular plants colonising naked sand (in contrast to primary successions on rock substrates, which start with colonisation by mosses and lichens and continues with slow soil accumulation) | D | | gs | 3 | 0,a–k,+ | T | T4,T21,T32, T40 |
| SU | Landslide intensity | Variation in the intensity of disturbance by landslides in clay- to gravel-dominated quaternary deposits; the term ‘landslide’ is used for situations where a part of the substrate with its biomass is detached and new mineral material is exposed; ends in a species-thinning situation at which a primary succession is initiated after each landslide event | D | | ga | 4 | 0,a–c,¤ | T | T4,T17 |
| SX | Categories of strongly modified ground | Complex environmental factor that sorts ground or bottom strongly modified by anthropogenic disturbances (but not contingent on historical land management) into categories such as: sites with upper layer removed, sites where a new substrate is deposited, e.g. resulting from regulation of watercourses or construction | D | | f | 7 | 0,a–0 | M,L,  T,V | M14,M15;  L7,L8;  T35–T45;  V11–V13 |
| SY | Categories of strongly modified water masses | Complex environmental factor that sorts water masses strongly modified by anthropogenic disturbances such as physical, chemical or biological interventions, and/or new water masses (artificial lakes, pools, etc.), into categories | D | | f | 10 | 0,a–d | H,F | H4;  F4,F5 |
| UE | Risk of desiccation | Variation in air humidity near the ground at the end of long-lasting dry periods, primarily relevant for poikilohydric species such as bryophytes and lichens, growing on rock; ranges from shaded sites with constant, high air humidity to open, sun-exposed slopes; factors affecting desiccation risk are canopy cover, topographic position and aspect | D | | g | 2 | 0,a–g | T | T1,T4,T5,T13, T27 |
| UF | Risk of drought | Variation in the risk of damage during periods with exceptionally low soil moisture content, i.e. the most severe drought spells in 50–100 years; variation along LEC UF is affected by topographic position and soil depth; herbs, grasses, deciduous dwarf shrubs and mosses dominate at low drought risk, while at high drought risk evergreen dwarf shrubs and lichens dominate | D | | g | 4 | a–h | T | T2–T4,T8,T16, T31,T34,T40 |
| VF | Water-mediated disturbance intensity | Variation in the intensity of water-mediated distur-bance in marine, freshwater and adjacent littoral and flooded-ground systems; from protected sites (still waters, slow-flowing rivers) to strongly exposed sites (large, fast-flowing rivers and strong tidal currents) where not even stone-dominated substrates are stable | D | | ga | 3 | 0,a–h,¤ | M,L,  T,F | M1–M3,M5,  M14;  L1,L2,L5; T1,T6,T18, T24,T30,T32;  F1,F4 |
| VI | Wind-mediated disturbance intensity | Variation in the intensity of wind-mediated disturbance in open sites such as sand dunes and alpine ridges; ending in a species-thinning situation at disruptively wind-deflated sites; moderately wind-disturbed alpine ridges have a characteristic species composition dominated by yellow lichens | D | | ga | 3 | 0,a–c,¤ | T,V | T1,T10,T13, T14,T16,T21, T27, T29;  V3 |
| FR | Flooding regime | Binary variable that separates a 'normal' flooding regime typically with a seasonal peak discharge in spring due to snowmelt and shorter peaks after intense rain storms, from a regime characterised by prolonged inundation (for months) by stagnant water, e.g. in flooded kettle holes after snowmelt | R | | f | 10 | 0,a | T | T18 |
| HF | Slope-related disturbance intensity | Variation in the inclination of rock substrates (submerged or terrestrial); with increasing slope the tendency to loss of sessile organisms’ biomass increases due to strengthening of downward forces (water erosion, transport of snow, ice, soil etc.) | R | | g | 1 | 0,a,b,+ | M,T | M1–M3; T1,T6 |
| RU | Avalanche intensity | Variation in the intensity of regulating disturbance caused by large masses of snow, ice, soil or water moving over a sloping surface; typically bringing about removal of biomass in small patches that are laid open for colonization; at very high frequency ending in a species-thinning situation without perennial vegetation cover | R | | ga | 5 | 0,a–e,¤ | M,T | M1–M3; T3,T4,T13,T16 |
| SH | Categories of ground character-ized by historical environ-  mental stress or distur-bance | Complex environmental factor that sorts ground characterised by historic disruptive stress and/or disturbance processes into categories with substantially different species composition; examples of categories are: landslide areas, glacier forelands, blockfields, polar deserts and pebble beaches | R | | f | 8 | 0,a–e | T | T25–T29 |
| SM | Size-related environ-mental variation in marine and freshwater systems | Complex-gradient that expresses co-ordinated variation in environmental variables related to the surface area and depth of water masses, such as annual temperature amplitude (and, accordingly, the risk of overheating and freezing), hypersalinity, hypoxia and anoxia; the LEC covers variation from the open sea and large lakes to temporary pools which may lack persistent populations and thus represent a species-thinning situation | R | | ga | 10 | 0,a–i,¤ | M,H,F | M9;  H2–H4;  F2,F5 |
| SP | Hay-meadow character | Binary variable that separates hayfields from pastures; hayfields are cultivated areas with haymaking, periodic harvesting of biomass (up to three times a year) with no nutrient return; pastures are areas characterised by livestock grazing, trampling, manuring and continuous, selective removal of biomass | R | | t | 6 | 0,a | T | T32,T33,T40, T41,T45;  V9,V10 |
| S1 | Particle size | Dominant grain size class in the substrate; ranging from bedrock (> 4096 mm) via blocks, stones, pebbles, sand and silt to clay (< 1/512 mm) | R | | f |  | 0,a–i | M,T | M1–M3; T4,T7,T10–T12,T17,T18, T25–T27, T29,T30,T33, T35,T44,T45 |
| TE | Peat- producing ability | Fine-scaled variation in the rate of peat production (and peat accumulation), from low (‘regressive’ mire sites dominated by liverworts, lichens and weakly peat-producing mosses) to high (‘progressive’ mire sites dominated by actively growing *Sphagnum* spp.) | R | | g | –1 | 0,a–c | V | V1,V3 |
| VR | Water-mediated disturbance regime | Binary variable that, for marine sites with high water-mediated disturbance intensity (high water energy), distinguishes between two disturbance regimes: the less predictable action of waves and the more predictable action of strong tidal currents | R | | f | 7 | a,b | M,T | M1,M3;  T2,T3 |
| VS | Water-spray impact | Variation in the impact of water spray from water-falls and large, fast-flowing rivers, typically forming a distinct zonation of vegetation by gradual loss of woody plants and other frost-sensitive, perennial species that do not tolerate encapsulation in ice crust during wintertime; towards the water source the physical characteristics of the supplied water (from mist via small and large droplets to large drops) changes and the supplied amounts of water increases strongly, ending in absence of soil forma-tion and a species-thinning situation even on rock | R | | g | 3 | 0,a–e,¤ | T | T1,T4,T15 |
| AS | Arid terrestrial salinity | Variation from 'normal' ground with predominantly downward water flow and maximal pH (in mineral soil rich in lime) around 8.0, to ground with predominantly upward water flow and salt precipitated as a white topsoil crust and pH up to 10.5; salt-enriched soils are typical for deserts and steppes but also occur locally in Arctic climates (e.g. at Svalbard) in sites characterised by a combination of extreme rain-shadow effect and dry winds | S | | t | 5 | 0,a | T | T10 |
| BK | Categories of bedrock with deviating chemical compo-sition | Complex environmental factor that separates four categories of bedrock with systematically deviating elemental composition from 'normal' bedrock: ultramafic rock (rich in heavy metals); acidic sulphide mineral- and iron-rich rocks; less acidic sulphide mineral- and copper-rich rocks; and lava | S | | f | 4 | 0,a–d | M,T | M2; T1–T5, T13,T16,T27, T31,T34 |
| DD | Depth-related variation in deep fjords | Depth-related variation in the deepest fjords (> 700 m), which differs from the general pattern of depth-related environmental variation in open sea (addressed by LEC DM) in the occurrence of Atlantic water masses (with temperatures rarely falling below 4 °C) to the greatest depths in these fjords | S | | g | 9 | 0,a | M | M2,M5 |
| DL | Depth-related light attenuation | Reduction of radiation intensity with water depth due to diffusion by light-absorbing particles and water molecules;. the rate of light attenuation depends on wavelength and the compensation depth, below which respiration exceeds production and photosynthesising organisms cannot maintain stable populations | S | | g | 5 | 0,a–e,+ | M,L | M1,M4,  M13–M15; L1,L2,L7,L8 |
| DM | Depth-related environ-mental stabilisation | The gradual stabilisation of marine environments with increasing depth, reflected in reduced amplitudes of temperature, salinity and kinetic energy; depths > 2000 m are characterised by constant temperature < –0.5°C, food shortage and high hydrostatic pressure | S | | g | 9 | 0,a–f | M,H | M2,M5,M6, M10–M12;  H1 |
| FK | Categories of fresh-water with deviating chemical composition | Complex environmental factor that separates from 'normal', circulating freshwater masses five categories of non-circulating water masses that have been found in meromictic lakes with systematically deviating elemental composition, e,g., high concen-trations of seasalt, iron, calcium and/or humus | S | | f | 10 | 0,a–e | F | F3 |
| GS | Cave-induced sheltering | Light attenuation and reduced amplitudes of temperature and air humidity along the physical gradient from open ground via overhanging rocks to the interior of deep caves, ending in a species-thinning situation | S | | ga | 3 | 0,a–d,¤ | M,T | M10;  T5 |
| HU | Freshwater humus content | Variation in the concentration of particulate and dissolved organic matter in water, from oligohumous and transparent (<2 mg TOC/L; TOC = total organic carbon) via mesohumous to polyhumous, dark-coloured (> 15 mg TOC/L) | S | | g | 10 | 0,a–d | L,F | L1,L2; F1,F2,F4,F5 |
| JV | Geothermal influence | Variation in geothermal energy supplies, carried by water or gas, ranging from no influence on the species composition via increasing dominance by specialist organisms (bacteria are typical), at >100 °C ending in a species-thinning situation; no sessile organism maintains persistent populations in such sites | S | | ga | 6 | 0,a–e,¤ | M,V,H | M12;  V5;  H1 |
| KA | Lime richness | Co-ordinated variation in many chemical charac-teristics of soil and water, such as alkalinity (pH) and availability of micro- and macronutrients such as Ca, K, Na, Mg, often also N and P, which regulate many important biological processes; position along KA is influenced by the mineral composition of bedrock, parallelling a gradient from silicate-rich to carbonate-rich bedrock with different weathering properties | S | | g | 7 | a–i | M,L,  T,V,F | M4,M5;  L1–L6;  T1–T9,T12–T20,T22,T25–T28,T30–T36, T40,T41,T43–T45; V1,V2,V4,V6–V13; F1,F2,F4,F5 |
| KI | Strength of spring-water influence | Variation in the degree to which the water supplied to terrestrial, wetland, limnic or marine systems have characteristics of spring water (rheogenous water), i.e. constancy throughout the year of flow and chemical composition of water including high concentrations of dissolved O2, and temperature near the annual mean temperature of the area. In wetlands, spring-water influence increases from a level (topogeneous) to a sloping (soligenous) ground-water table. | S | | g | 1 | 0,a–f,¤ | M,L,  T,V | M11,M12;  L5; T3,T4,T7,T8, T15–T18,T25, T26,T30–T32; V1,V2,V4–V6, V9,V10;  F2,F5 |
| KO | Connec-tivity | Binary variable that separates isolated water bodies from water bodies that are part of more or less extensive watercourse networks; connectedness increases species richness of organisms with dispersal limitations such as fish, larger molluscs and crustaceans | S | | f | 9 | 0,¤ | F | F2,F5 |
| KT | Spring category | Complex environmental factor by which springs are sorted by ecological context into six categories: peaty spring, spring without peat formation; spring in river or lake, cold marine water and gas spring, cold marine mud spring, and marine magma spring | S | | f | 7 | a–f | M,L,V | M11;  L5;  V4 |
| KY | Coastal water character | Variation in the degree to which marine water bodies have properties of coastal vs oceanic water masses; characteristics of the former are: more strongly fluctuating temperature and salinity throughout the year and larger supplies of river-transported sediments, organic material and nutrients | S | | g | 10 | 0,a | M,H | M6;  H1 |
| MF | Mire expanse character | Gradient in the species composition of mires, from sites close to adjacent non-wetland ground or with shallow peat typically dominated by generalist and forest species, to sites with deep peet in the interior parts of wetland massifs typically dominated by mire specialist species; the environmental basis of LEC MF is insufficiently understood, variables such as annual range of ground water fluctuations, drainage, peat aeration, nutrient turnover and light have been mentioned as potentially important | S | | g | 5 | 0,a–f | V | V1,V3 |
| NG | Natural manuring | Variation in the amounts of nitrogen and phosporus supplied (to the ground) by wild animals, e.g. seabirds, geese and reindeer; ends in a species-thinning situation typically with a few plant species that tolerate hypertrophic conditions | S | | ga | 1 | 0,a–d,¤ | T | T8,T9 |
| OM | Oxygen deficiency | Variation in the intensity (duration and frequency) of hypoxic (<2 ml O2/L) and anoxic conditions in freshwater and marine water bodies; ending with a species-thinning situation in permanently anoxic waters | S | | g | 10 | 0,a,b,¤ | M,L,  H,F | M13;  L6;  H3;  F3 |
| OR | Supply of trickling surface water | Variation in the intensity (duration and frequency)  of irrigation of bare rock by moving surface water, e.g. expressed by the length of the period a rock surface remains moist after rainfall, snowmelt etc. | S | | g | 0 | 0,a–c | T | T1 |
| PF | Permafrost | Binary variable that separates arctic-alpine ecosystems without and with permafrost, the latter typically with a shallow active topsoil layer that thaws in summer; both categories may or may not be influenced by solifluction and/or cryoturbation | S | | f | 7 | 0,a | T,V | T9,T19,T28; V7 |
| SA | Marine salinity | Variation in salinity (halinity), i.e. the concentration of salts, in water-mass and bottom and ground ecosystems in contact with or otherwise influenced by seasalt-enriched water; this LEC runs from hypohaline (fresh) water, defined as water with salinity < 0.5‰, via oligohaline, mesohaline, poly-haline and euhaline waters to metahaline ocean wa-ter with salinity typically in the range 34.2–35.5‰ | S | | g | 4 | 0,a–f,+ | M,T,  V,H | M1–M4,M7, M8,M14,M15; T4,T6,T12, T24,T30,T33,T40;  V1,V8;  H1,H4;  F5 |
| SF | Littoral hyper-salinity | Variation in the extent to which seasalt concentrations in geolittoral and supralittoral soils are elevated above normal levels due to evaporation from stagnant saline water, e.g. in temporal tidal pools and depressions in tidal meadows; ends in a species-thinning situation characterised by a few, halophyte specialists | S | | ga | 2 | 0,a,b,¤ | T | T11 |
| SV | Growing-season reduction due to prolonged snow cover | Variation in the extent to which the growing-season is reduced due to long-lasting snow cover; from normal growing-season length given the prevailing climatic conditions via moderate, late, extreme and vegetation-free snowbeds to permanent snow and ice; ends in a species-thinning situation | S | | ga | 4 | 0,a–g,¤ | T,V | T1,T7,T22,  T26,T27;  V6 |
| TU | Turbidity | Variation in the content of suspended inorganic material in water, e.g. glacial rivers, which reduces light penetration, causes mechanical abrasion of the substrate and ends in a species-thinning situation | S | | g | 9 | 0,a | F | F1,F2,F4,F5 |
| TV | Duration of period without inundation | Variation in duration of the period in which the ground surface emerges above water vs. is immersed in water; used to characterise variation across river banks, lake shores, tidal belts and in wetlands; in the littoral belt of lake and sea shores divided into hydro-, geo-, supra- and epilitoral belts, in mires divided into carpets, lawns and hummocks | S | | g | 0 | 0,a–l,¤ | M,T,V | M3,M4,M7–M9; T6,T11,T12, T23,T24,T29,T33;  V1–V3,V7,V9 |
| VM | Water saturation | Variation in normal (median) soil moisture, from well-drained via periodically moist to moist soil; transgressing into LEC TV, ‘Duration of period without inundation’; VM addresses soil moisture content under ‘normal’ situations, e.g. as reflected in the abundance of *Sphagnum* spp. in forests, while LEC UF addresses the risk of extreme drought spells | S | | g | 1 | 0,a,b,+ | T | T2–T4,T7,T9, T12,T16,T21, T22,T24,T26, T31–T34,T40, T41,T43–T45 |
| VT | Categories of prevailing water supply | Complex environmental factor that sorts wetlands into four categories by prevailing water supply: ombrogenous (water from precipitation only), geogenous or minerogenous (some of the supplied water has been in contact with mineral soil), limno-topogenous (lake water), and limno-soligenous (river water) | S | | f | 8 | 0,a–c | L,V | L2; V1,V3,V8 |
| LA | Slow primary succession | Stages along a primary succession that takes more than 100–200 years to complete, from the initial, pioneer stage, via colonization, establishment and consolidation stages to the post-successional stage in which species composition is in a dynamic equilibrium with the environment; rapid successions, lasting <100 years, are considered as short-term environmental variation | L | | gs | 6 | 0,a–f,+ | T | T1,T5,T26, T27,T29,T39 |
| LK | Slow secondary succession on coral reefs | Binary variable that separates two distinct stages in the development of coral reefs: young reefs dominated by living corals and aging reefs dominated by dead corals | L | | f | 5 | 0,+ | M | M6 |
| S3 | Sediment sorting | Complex environmental variable consisting of three single LECs: erosion resistance (NiN code S3E; running from suspended material with no resistance to erosion, to bedrock); fine-matter content (S3F; the fraction of substrate made up by silt and clay); and special sediments (S3S; a categorical variable that includes, e.g. shellsand, coral gravel and submerged peat) | R&S | | mf | 6 | – | M,L | M4,M5,M7, M15;  L2,L4,L5 |

**References**

Halvorsen, R. (2012). A gradient analytic perspective on distribution modelling. *Sommerfeltia*, **35**, 1–165.

Halvorsen, R., et al., [2016] (2019). NiN – typeinndeling og beskrivelsessystem for natursystemnivået. *Natur i Norge (NiN) Systemdokumentasjon*, **3** (Version 2.1.0), 1–525. (<https://www.artsdatabanken.no/Files/14539/Artikkel_3___Natursystemniv_et___typeinndeling_og_beskrivelsessystem_(versjon_2.1.0).pdf)>

Whittaker, R. H. (1967). Gradient analysis of vegetation. *Biological Review of the Cambridge Philosophical Society*, **42**, 207–264.

Towards a systematics of ecodiversity: the EcoSyst framework

**APPENDIX S5 | NiN IMPLEMENTATION: ECOSYSTEM TYPES**

This appendix gives an overview of the type hierarchy at the ecosystem level in the NiN implementation of EcoSyst (version 2.2.0) for Norway. The type hierarchy, which contains 7 major-type groups with 92 major types and 741 minor types, is constructed in accordance with the principles and methods explained in section S2.2, by use of the local environmental complex-gradients (LECs) described in Appendix S4 as key source of variation. Terms used to characterise the different roles played by LECs in type-hierarchy construction are explained in Box S5.5.

Table S5.19 gives an overview of major-type groups, major types and the LECs used to define the major and minor types. Table S5.20 provides descriptions of major-type groups, Table S5.21 provides descriptions of major types, and Table S5.22 provides a full list of the 741 minor types, including an account of minor-type definitions in terms of mLECs and iLECs. Full, detailed type descriptions in Norwegian can be found in Halvorsen et al. (2019).

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| **BOX S5.5**  Categories of LECs based on their role in ecosystem type-hierarchy construction.  *defining LEC* (= *dLEC*) – sLEC that forms the basis for separating a special major type from normal variation within a major-type group  *major LEC* (= *mLEC*) – LEC associated with gradient lengths that exceed 3 EDU–E (‘considerable variation’) within a major-type  *minor LEC* (= *iLEC*) – LEC associated with gradient lengths between 2 and 3 EDU–E (‘substantial variation’) within a major-type  *normal LEC* (= *nLEC*) – LEC associated with more than 2 EDU–E of compositional variation between endpoints, within the normal variation in a major-type group  *special LEC* (= *sLEC*) – LEC associated with more than 2 EDU–E of compositional variation between extremes, of which one endpoint lies within normal variation in an ecosystem while the other endpoint does not  *subordinate LEC* (= *uLEC*) – LEC associated with gradient lengths between 1 and 2 EDU–E (‘observable variation’) within a major-type |

**TABLE S5.19** Overview of major-type groups (in bold), major types and the LECs used to define major and minor types in the NiN implementation of EcoSyst for Norway, version 2.2.0. The role of LECs in each major type is indicated as follows: dLEC: dark red colour (‘SM∙g+’ and ‘TV∙k–’ means that the elementary segments g and higher, or k and lower, are included in the special major-types defined by LECs SM and TV, respectively); mLEC: red color (LEC code followed by the number of major-type specific, standard segments and, within square brackets, how the elementary segments are aggregated into standard segments, separated by |); iLEC: orange colour; uLEC: gray colour. The LEC codes refer to names and explanations in Table S5.18. Normal major types, major types defined by structuring species group, and normal major types defined by structuring species group, are indicated by (N), (S) and (NS), respectively. Code = type code; #MiT = number of minor types

| **Code** | **Major-type group and major type** | **LECs** | **#MiT** |
| --- | --- | --- | --- |
| **M** | **Marine seabed systems** |  |  |
| M1 | Euphotic marine rock | (N) VF4[0ab|cd|ef|gh] DL3[a|bc|d] SA3[a|bc|def] HF[0ab|+] S1[a|b] IF[0ab|¤] VR RU | 29 |
| M2 | Aphotic marine rock | (N) DM5[0|a|b|cd|ef] VF[a|bc] HF[0ab|+] BK[0|a] SA S1 RU DD | 20 |
| M3 | Littoral rock | (N) VF4[0ab|cd|efg|h] TV3[ab|cde|fgh] SA3[a|bc|def] HF[0ab|+] IF[0ab|¤] S1 VR RU | 19 |
| M4 | Euphotic marine sediment | (N) S3[E,F,S] DL[abc|d] SA[abc|de] TV[0|ab] IO[0ab|¤] KA[efg|hi] SE[oab|¤] | 44 |
| M5 | Aphotic marine sediment | (N) S3[E,F,S] DM5[0|a|b|cd|ef] IO[0ab|¤] VF DD | 38 |
| M6 | Coral reef seabed | (NS) KY[0|a] LK DM | 2 |
| M7 | Seagrass bed | (NS) SA[abc|def] TV[0|ab] S3 | 4 |
| M8 | Tidal swamp | (NS) SA IO TV | 1 |
| M9 | Tidal rockpool seabed | (SM∙g+) SM3[gh|i|¤] TV3[cdefgh|ij|k] SE[0a|b] | 9 |
| M10 | Marine cave and overhang | (GS∙a+) DL3[0|abcd|e+] GS[ab|cd¤] | 5 |
| M11 | Marine cold seep | (KI∙e+) DM3[0|a|bcdef] KI[e|¤] KT[d|e] | 7 |
| M12 | Hydrothermal vent | (KI∙e+ JV∙a+) JV3[ab|cd|e¤] DM3[0|a|bcdef] | 7 |
| M13 | Anoxic marine sediment | (OM∙b+) OM[b|¤] DL[abcd|e¤] | 4 |
| M14 | Strongly altered or artificial hard marine substrate | (SX∙a) DL3[0|abcd|e+] VF SA | 3 |
| M15 | Strongly altered or artificial marine sediment | (SX∙b) S3[E,F] HS\* DL SA | 4 |
| **H** | **Marine waterbody systems** |  |  |
| H1 | Oceanic waterbody | (N) DM4[0|a|bcd|ef] KY[0|a] JV | 5 |
| H2 | Circulating fjord, estuary, lagoon and rock pool waterbody | (SM∙a+) SM6[a|bc|def|gh|i|¤] SA[abc|def] | 8 |
| H3 | Anoxic marine waterbody | (OM∙¤) 0 | 1 |
| H4 | Strongly altered or artificial marine waterbody | (SY∙abcd) SY4[a|b|c|d] SM SA | 4 |
| **L** | **Freshwater bottom systems** |  |  |
| L1 | Euphotic freshwater rock | (N) KA3[abc|def|ghi] VF[0abcde|fgh¤] HU[0|abcd] DL IF | 7 |
| L2 | Euphotic freshwater sediment | (N) S3[E,F,S] KA3[abc,def,ghi] IO[0a|b¤] VT[ab|c] SE[0ab|¤] VF HU DL IF | 19 |
| L3 | Aphotic freshwater sediment | (N) KA[abcde|fghi] IO | 2 |
| L4 | Freshwater swamp | (NS) KA3[abc|def|ghi] S3 IO IF | 3 |
| L5 | Freshwater spring | (KI∙e+) KT3[a|b|c] KA[cde|fghi] S3 VF | 4 |
| L6 | Anoxic freshwater sediment | (OM∙b+) OM[b|¤] KA | 2 |
| L7 | Strongly altered or artificial hard freshwater substrate | (SX∙c) HS\*3 DL | 3 |
| L8 | Strongly altered or artificial freshwater sediment | (SX∙d) HS\*8 DL | 8 |
| **F** | **Limnic waterbody systems** |  |  |
| F1 | River and stream waterbody | (N)VF[bcde|fgh¤] HU[0a|bcd] KA[abcde|fghi] TU | 6 |
| F2 | Circulating lake waterbody | (N) SM4[bc|def|ghi|¤] KA3[abc|def|ghi] HU TU KO | 21 |
| F3 | Anoxic lake waterbody | (OM∙¤) FK | 1 |
| F4 | Strongly altered or artificial river waterbody | (SY∙abc) SY3[a|b|c] VF HU KA TU | 3 |
| F5 | Strongly altered or artificial lake waterbody | (SY∙abcd) SY4[a|b|c|d] SM KU HU TU KO | 4 |
| **T** | **Terrestrial systems** |  |  |
| T1 | Bare rock | (N) KA5[ab|cd|ef|gh|i] UE4[0a|bc|de|fg] OR3[0|ab|c] HF[0ab|+] VF[a|bcdef] VS[0abcd|e] LA[0abcd|ef+] NG[0a|bcd¤] VI[0a|bc] SV[0|abcd] IF BK | 85 |
| T2 | Open shallow-soil ground | (N) KA4[abc|de|fg|hi] UF[def|gh] VM BK HI | 8 |
| T3 | Arctic-alpine heath and lee side | (N) KA4[abc|de|fg|hi] UF3[bc|de|fg] KI[0a|bc] BK HI RU VM | 14 |
| T4 | Forest | (NS) UF4[ab|cd|ef|gh] KA4[abc|de|fg|hi] KI[0a|bc] BK HI SU RU SS S1 VM VS UE | 20 |
| T5 | Cave and overhang | (GS∙a+) GS3[a|bcd|¤] KA3[abc|defg|hi] UE[0abc|defg] BK LA | 10 |
| T6 | Rocky shore | (TV∙k– SA∙a+) TV3[i|j|k] KA[bcde|fghi] VF[0abcde|fgh¤] HF[0ab|+] IF[0ab|¤] | 7 |
| T7 | Snowbed | (SV∙a+) KA5[a|bc|de|fg|hi] SV4[ab|cd|ef|g] KI[0a|bc] VM HI S1 | 14 |
| T8 | Bird-cliff meadow | (NG∙a+) NG[ab|cd|¤] KI[0a|bc] UF[abcd|efgh] KA HI | 5 |
| T9 | Moss tundra | (NG∙ab PF∙a IO∙b¤) KA[cde|fghi] VM | 2 |
| T10 | Arctic steppe | (AS∙a) VI[0|abc] | 2 |
| T11 | Hypersaline tidal marsh | (TV∙k– SF∙b+) TV[cdefgh|ijk] S1[de|hi] | 3 |
| T12 | Tidal meadow | (TV∙k– SA∙a+) TV4[cd|ef|gh|ijk] SA HI S1 VM KA | 4 |
| T13 | Bare talus slope | (RU∙b+) KA3[abc|defg|hi] S1∙3[b|c|def] UE[abc|defg] RU[bcde|¤] BK VI | 18 |
| T14 | Exposed ridge | (VI∙a+) VI[abc|¤] KA[abcde|fghi] | 3 |
| T15 | Waterfall-sprayed meadow | (VS∙bcd) KA[cde|fgh] VS HI KI | 2 |
| T16 | Talus-slope heath and meadow | (RU∙b+) KA4[abc|de|fg|hi] RU[bc|de] KI[0a|bc] UF HI BK VI VM | 7 |
| T17 | Open active landslide | (SU∙bc) S1∙4[0|de|fg|hi] SU KA KI | 4 |
| T18 | Open alluvial sediment | (VF∙f+) S1∙3[cde|fg|hi] VF[f|gh¤] KA[bcde|fgh] FR[0|a] IF KI HI | 6 |
| T19 | Patterned ground | (PF∙a OF∙a) S1[cd|h] KA[bcde|fgh] | 3 |
| T20 | Kettle-hole frost heath | (IF∙b) KA[cde|fgh] | 2 |
| T21 | Sand dune | (SS∙i–) SS6[a|bc|d|ef|gh|i] VI[abc|¤] VM[0|ab] HI | 8 |
| T22 | Arctic-alpine dry-grass heath | (JF∙ab) KA[bcde|fgh] SV[0|ab] VM | 4 |
| T23 | Freshwater driftline | (TV∙k– IO∙¤) | 1 |
| T24 | Coastal driftline | (TV∙k– IO∙¤ SA∙a+) VF3[cd|e|f] VM | 3 |
| T25 | Open historical landslide | (SH∙a) S1∙4[0|de|fg|hi] KA KI | 4 |
| T26 | Glacier foreland | (SH∙b) S1∙3[cd|efg|hi] SV[0|abcd] VM[0a|b] LA[0ab|cdef] KA KI | 7 |
| T27 | Boulder field | (SH∙c) SV3[0|abcdefd|g] KA[abcde|fghi] VI[0a|bc] LA[0abcd|ef+] BK S1 UE | 8 |
| T28 | Polar desert | (SH∙d PF∙a) KA3[abc|defg|hi] | 3 |
| T29 | Coastal shingle beach | (SH∙e) S1∙3[c|de|j] LA[0ab|cdef] VI[abc|¤] TV[ijk|l+] HI | 10 |
| T30 | Alluvial forest | (S VF∙bcde) S1[cde|fghi] VF[bc|de] KI[0a|bc] ER[0a|b] KA HI SA | 7 |
| T31 | Boreal heath | (MX∙a) KA4[abc|de|fg|hi] UF3[bc1|de|fgh] KI[0a|bc] BK HI VM | 14 |
| T32 | Semi-natural grassland | (HI∙bcde) KA4[bc|de|fg|hi] HI3[b|cd|e] KI[0a|bc] UF[ab|cde] SS[fghi|jk+] SP VM | 21 |
| T33 | Semi-natural tidal and salt meadow | (HI∙bcde TV∙k– SA∙a+) TV[fgh|ijk] SA SP VM S1 HI KA | 2 |
| T34 | Coastal heath | (HI∙bcde HR∙a) KA4[abc|de|fg|hi] UF3[bc|de|fgh] VM[0a|b] BK | 12 |
| T35 | Wasteland, extracted or deposited surficial deposit | (SX∙e) S1∙4[0|cde|fg|hi] KA | 4 |
| T36 | Drained wetland and terrestrialised freshwater sediment | (SX∙f) HS\*3 KA | 3 |
| T37 | Artificial soft substrate | (SX∙g) HS\*3 | 3 |
| T38 | Tree plantation | (SX∙e) UF KA | 1 |
| T39 | Strongly altered or artificial hard substrate | (SX∙h) HS\*4 LA[0ab|cdef] | 8 |
| T40 | Strongly altered ground with semi-natural grassland character | (SX∙i MB∙0) KA UF SP VM SS SA | 1 |
| T41 | Agriculturally improved grassland with semi-natural character | (SX∙j MB∙+) KA HI SP VM | 1 |
| T42 | Landscaped patch or field | (SX∙k MB∙0) 0 | 1 |
| T43 | Landscaped grassland | (SX∙k MB∙+) KA HI VM | 1 |
| T44 | Arable field | (SX∙l MB∙0) KA S1 VM | 1 |
| T45 | Agriculturally improved grassland | (SX∙l MB∙+) HI3[fg|hi|j] SP[0|a] KA S1 VM | 4 |
| **V** | **Wetland systems** |  |  |
| V1 | Open fen | (N) KA5[ab|cd|ef|gh|i] TV5[cd|ef|gh|ij|k] MF[cd|ef] KI[0a|bc] SA[0a|bcd] VT TE | 32 |
| V2 | Mire and swamp forest | (NS) KA3[abcd|ef|ghi] TV[cdef|ghijk] KI[0a|bc] | 8 |
| V3 | Bog | (VT∙c) TV5[cd|ef|gh|ij|k] MF[cd|ef] VI[0|ab] TE | 7 |
| V4 | Spring | (KI∙d+) KA3[cd|ef|ghi] KI[de|¤] KT[a|b] | 9 |
| V5 | Thermal spring | (KI∙d+ JV∙a+) JV[a|b] | 2 |
| V6 | Wet snow-bed and snowbed spring | (SV∙a+ IO∙0a) SV3[ab|cd|ef] KA[cdef|ghi] KI[bc|de] | 9 |
| V7 | Arctic permafrost wetland | (PF∙a) KA[cdef|ghi] TV | 2 |
| V8 | Tidal and alluvial swamp forest | (VT∙a) KA[cde|fgh] SA[0a|bcd] | 3 |
| V9 | Semi-natural fen | (HI∙bcde) KA3[bcd|ef|ghi] TV KI SP | 3 |
| V10 | Semi-natural wet meadow | (HI∙bcde IO∙0a) KA[cde|fgh] KI[0a|bc] SP | 3 |
| V11 | Peat quarry | (SX∙m) KA[abcd|efghi] | 2 |
| V12 | Drained mire | (SX∙n) VT[0|c] KA[abcd|efgh] | 3 |
| V13 | Artificial wetland | (SX∙o) HS\*4 IO[0a|b¤] KA | 8 |
| **I** | **Snow and ice systems** |  |  |
| I1 | Permanent snow and ice | (N) | 1 |
| I2 | Polar sea-ice | (N) | 1 |

**TABLE S5.20** Short descriptions of major-type groups in the NiN implementation of EcoSyst for Norway, version 2.2.0. Code = major-type group code.

| **Code** | **Major-type group** | **Description** |
| --- | --- | --- |
| M | Marine seabed systems | Marine seabed systems comprise all ecosystems in, on or closely associated with the bottom or sea-floor in oceans, fjords, coastal lagoons and littoral rock pools. By definition, the salinity of adjoining marine waterbodies is 0.5 ppt or higher, and seabed differs from terrestrial systems by being immersed in water for more than 50 % of the time. |
| H | Marine waterbody systems | Marine waterbody systems comprise all waterbodies with salinity of 0.5 ppt or higher regardless of depth, also including enclosed coastal waterbodies. |
| L | Freshwater bottom systems | Freshwater bottom, or limnic bottom, ecosystems consist of all ecosystems in, on or closely associated with the bottom of rivers, lakes and ponds. The salinity of the adjoining water is 0.5 ppt or less and the bottom is covered with water for more than 50 % of the time. |
| F | Limnic waterbody systems | Limnic waterbody systems comprise freshwater masses regardless of origin and properties such as standing or running, natural, man-made or highly modified (e.g. artificially created ponds, reservoirs etc.). |
| T | Terrestrial systems | Terrestrial ecosystems comprise ecosystems on land with ground neither permanently waterlogged nor covered with water for more than 50 % of the time. |
| V | Wetland systems | Wetland systems, as defined in NiN, contain permanently waterlogged ecosystems on land, e.g. fens, bogs, mire and swamp forests and springs, with a surface that is immersed in water for less than 50% of the time. |
| I | Snow and ice systems | Snow and ice systems comprise parts of the Earth’s surface (land or sea) that are covered more or less permanently by perennial snow or ice, e.g. glaciers, perennial snow-patches and polar sea-ice. |

**TABLE S5.21** Short descriptions of major types in the NiN implementation of EcoSyst for Norway, version 2.2.0. Code = major-type code.

| **Code** | **Major type** | **Description** |
| --- | --- | --- |
| **M** | **Marine seabed systems** | |
| M1 | Euphotic marine rock | Euphotic marine rock includes marine rockwalls, outcrops and stable boulder- and stone-beds in the euphotic belt, which consists of three sub-belts: the sublittoral fringe, the infralittoral belt and the upper circalittoral belt. The latter extends downwards to the compensation point. Green algae and sessile animals dominate in the sublittoral fringe, kelp communities in the infralittoral zone while red algae dominate in the upper circalittoral zone. This major type comprises variation from sheltered via moderately to strongly exposed hard substrates. |
| M2 | Aphotic marine rock | Aphotic marine rock comprises hard substrates below the compensation point, i.e. where light intensities are too low for positive net photosynthesis. Algae are absent; various animal communities dominate. Sponges (Porifera) are common. The species composition varies with depth, temperature and nutrient supply. The major type comprises variation from sheltered via moderately to strongly exposed hard substrates, while strongly exposed substrates are rarely found. |
| M3 | Littoral rock | Littoral rock includes rockwalls, outcrops and stable boulders in the tidal belt, delimited upwards by the shift from dominance by saltwater-adapted organisms (e.g. the barnacle *Semibalanus balanoides* and the winkle *Littorina littorea*) to dominace by terrestrial organisms, typically the lichen *Verrucaria maura*. Littoral rock extends downwards to the low- tide level. This major type includes the upper infralittoral zone, comprises communities from both salt and brackish water, as well as variation from sheltered via moderately to strongly exposed hard substrates. |
| M4 | Euphotic marine sediment | Euphotic marine sediment comprises soft substrates in the marine hydrolittoral and euphotic sublittoral belts, extending down to the compensation point. Euphotic marine sediment is found on sites protected from the action of strong waves and currents, typically dominated by sand and silt or, on more exposed sites, by gravel and pebbles. The organic matter content varies a lot, from pure mineral to pure organic substrates. Special substrates such as dy, gyttja, shellbeds and maerlbeds belong here, as well as the large mudflats that can be seen many places along the coast of Norway, exposed at low tide. |
| M5 | Aphotic marine sediment | Aphotic marine sediment comprises all soft substrates below the compensation point, where the light intensity is too low to support photosynthesis. Algae are absent; various animal communities dominate. Species richness generally decreases towards greater depths. Aphotic marine sediment is typically found on sites protected from the action of strong waves and currents, dominated by sand and silt, but special substrates such as dy, gyttja, shellbeds, sponge spicule beds and coral gravel beds also belong to this major type. |
| M6 | Coral reef seabed | Coral reef seabed is built by the activity of reef-building stone corals over hundreds and thousands of years. The stone coral *Lophelia pertusa* is quantitatively most important, another common species is the zigzagcoral *Madrepora oculata*. The coral reefs of Norway are cold-water reefs which lack the symbiotic algae of tropical coral reefs and, accordingly, occur in the aphotic belt on the Norwegian continental shelf at depths from ca. 40 to ca. 600 m, associated with Atlantic watermasses. |
| M7 | Seagrass bed | Seagrass bed includes soft marine sediments dominated by eelgras (*Zostera marina*) and other hydrophytic vascular halophytes in the hydrolittoral belt and in shallow waters of the sublittoral belts. Green and brown algae may co-occur with the vascular plants, forming a three-dimensional community rich in microhabitats and, hence, in associated species. |
| M8 | Tidal swamp | Tidal swamp comprises dense, macrohelophyte-dominated stands in the hydrolittoral tidal belt, also including extensions of the helophyte belt downwards into the sublittoral belt and upwards into the geolittoral belt. Communities dominated by one single species, e.g. *Phragmites australis*, *Schoenoplectus tabernaemontani* and *Bolboschoenus maritimus*, are common. Tidal swamps are typically found on fine sediments in sheltered sites, such as estuaries and narrow bays. Freshwater supplies from the land-side are common. |
| M9 | Tidal rockpool seabed | Tidal rockpools are pools on rocky substrate in bedrock depressions the upper part of the tidal zone. Physically delimited from the sea, tidal rockpools typically receive sea-water supplies at high tide. Rock pools in the supralittoral belt, that are only supplied with salt water during spring tide, are considered tidal rockpools as long as the average salinity of their water is 0.5 ppt or higher. Tidal rockpools are marine exclaves in a terrestrial matrix, typically surrounded by the rocky shore (T6) major type. Temperature and salinity may vary considerably throughout the year, more in smaller than in larger rock pools and more in rock pools with infrequent sea-water supplies. Salinity decreases when freshwater is supplied by precipitation or melting snow, but increases after periodic seawater supply. Periodic hypersalinity may occur near the end of long, dry summer periods. |
| M10 | Marine cave and overhang | Marine caves are natural cavities in bedrock, situated in the tidal belt or below the low-tide level. Overhangs are rock walls with inclination > 90°. The surface of caves and overhangs receive less incident radiation and have more stable environmental conditions than marine rock at similar depths. |
| M11 | Marine cold seep | Marine cold seeps are soft seabeds influenced by seepage of water and/or gases, e.g. hydrogen sulphide or methane. The fluid has the same temperature or is only slightly warmer than the adjacent water. Marine cold seeps vary from temporal and unstable pockmarks to stable cold seeps and also includes mud volcanoes, formed by emergence of gas-filled mud. |
| M12 | Hydrothermal vent | Hydrothermal vents are fissures in rocky seabed in volcanically active areas from which geothermally heated water, e.g. water that has been in contact with volcanic lava, emerges. When hot, mineral-rich water meets the cold ambient seawater, dissolved minerals may precipitate to form new hard-substrate structures. Hydrothermal vents are found in volcanically active areas, e.g. along the North Atlantic ridge north east of Jan Mayen. Hydrothermal vents are biologically productive ecosystems which host specialised communities of chemosynthetic bacteria. |
| M13 | Anoxic marine sediment | Anoxic marine sediment occurs in fjords and estuaries where restricted water exchange, often also lack of circulation, results in periodically (hypoxic) or permanently oxygen-free (anoxic) conditions near the bottom. Organisms adapted to anaerobic conditions prevail. |
| M14 | Strongly altered or artificial hard marine substrate | Strongly altered or artificial hard marine substrate includes a variety of substrates that are altered by human intervention and new substrates, e.g. concrete, glass and steel. This major type includes permanent structures such as constructed port facilities and temporary installations such as oil rigs, pipelines and offshore wind-power farms. |
| M15 | Strongly altered or artificial marine sediment | Strongly altered or artificial marine sediment includes soft seabeds that are altered by human intervention as well as new sediments. Sediments that belong to this major type may result from, e.g. deposition of sewage sludge and industrial, mining or other wastes, construction of artificial sand beaches and exposure of new sediments by dredging. |
| **H** | **Marine waterbody systems** | |
| H1 | Oceanic waterbody | Oceanic marine waterbodies are directly connected to the World’s large oceans, without being physically separated from the latter by a threshold. This major type comprises water masses that are connected to, part of, or strongly influenced by, the Earth’s large circulation systems. |
| H2 | Circulating fjord, estuary, lagoon and rock pool waterbody | This major type includes waterbodies of fjords, estuaries, lagoons and rock pools, i.e. waters that are physically separated from oceanic marine waterbodies by a threshold and have a circulation system resembling that of lakes. |
| H3 | Anoxic marine waterbody | Anoxic marine waterbodies comprise the non-circulating, permanently stagnant, oxygen-free waters at the bottom of some fjords, estuaries and lagoons, often characterised by strongly restricted seasonal exchange of water. |
| H4 | Strongly altered or artificial marine waterbody | Strongly altered or artificial marine waterbodies comprise physically delimited marine water-bodies that are changed by human activity, such as pollution. |
| **L** | **Freshwater bottom systems** | |
| L1 | Euphotic freshwater rock | Euphotic freshwater rock includes rockwalls, outcrops and stable boulder- and stone-beds in rivers and the euphotic belt of lakes. Mosses and liverworts (Bryophyta), benthic macroscopic and microscopic green algae and several animal groups, such as dayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera), are dominant organism groups. |
| L2 | Euphotic freshwater sediment | Euphotic freshwater sediment comprises soft sediments in rivers and lakes, ranging from predominantly inorganic (clay, silt, sand and gravel, in fast-flowing rivers also stone- and boulder-beds) to predominantly organic (dy and gyttja at the bottom of small tarns, and peat at the bottom of flark pools and hollow pools in mires). Vascular plants may occur, but sites dominated by macrohelophytes constitute a separate major type (L4). A considerable diversity of animal communities is found in this major type. |
| L3 | Aphotic freshwater sediment | Aphotic freshwater sediment comprises soft sediments, often with high organic matter content, below the compensation point of lakes. Plants are absent, various animal communities may occur. Animal species richness is lower than in the euphotic belt. |
| L4 | Freshwater swamp | Freshwater swamp comprises dense, macrohelophyte-dominated stands in shallow lakes and slow-flowing rivers, also including extensions of the helophyte belt upwards into the adjacent geolittoral belt. Communities dominated by one single species, e.g. *Phragmites australis*, *Schoenoplectus lacustris*, *Typha* spp. and *Carex* spp., are common. |
| L5 | Freshwater spring | Freshwater spring includes bottoms of springs, streams, rivers and lakes that are clearly influenced by supply of oxygen-rich (rheogenous) water, i.e. water with nearly constant temperature, chemical composition and flow rates throughout the day and the year, housing distinctive communities. |
| L6 | Anoxic freshwater sediment | Anoxic freshwater sediment borders on oxygen-free, stagnant bottom waters of deep meromictic lakes. Sediments adjacent to periodically anoxic or oxygen-reduced (hypoxic) bottom waters, which also have a species composition that differs substantially from that of normal, circulating (mictic) lakes, are also included in this major type. While anoxia causes a general reduction of species richness, some organisms, e.g. sulphur bacteria, are adapted to life in oxygen-poor environments. |
| L7 | Strongly altered or artificial hard freshwater substrate | Strongly altered or artificial hard freshwater substrate includes substrates that are altered by human actions or new, e.g. concrete, glass and steel. This major type includes permanent or temporary constructions such as quays, piers, hydropower dams and plants and bridge foundations and irreversibly changed former terrestrial land such as reservoir embankments. |
| L8 | Strongly altered or artificial freshwater sediment | Strongly altered or artificial freshwater sediment includes soft substrates in lakes and rivers that are altered by human intervention as well as new soft substrates, e.g. in artificial lakes and farm ponds constructed on former wetland or terrestrial land. Sediments that belong to this major type may result from landfill operations, regulation of rivers and lakes, deposition of sewage sludge and industrial, mining or other wastes. |
| **F** | **Limnic waterbody systems** | |
| F1 | River and stream waterbody | This major type includes waterbodies of rivers and streams, i.e. running water. In contrast to lake water, running water is inherently dynamic and lacks permanent populations of species without swimming abilities such as planctonic crustaceans. |
| F2 | Circulating lake waterbody | Circulating lake waterbodies include waters of mictic lakes, tarns and ponds, with their pelagic communities. Most Norwegian lakes above a certain minimum size are dimictic, i.e. with full circulation of water masses every spring and autumn. |
| F3 | Anoxic lake waterbody | Anoxic lake waterbodies comprise the non-circulating, permanently stagnant, oxygen-free waters at the bottom of meromictic lakes (monimolimnion). Meromictic lakes are lakes with a permanent and stable vertical stratification (no seasonal mixing of water between strata under normal conditions). Anoxic waterbodies have characteristic, deviant, chemical composition compared to normal, oxic waters; high concentrations of CO2, CH4, Ca, Fe and/or Mn are typical. Bacteria tend to dominate the species-poor communities. |
| F4 | Strongly altered or artificial river waterbody | Strongly altered or artificial river waterbodies are characterised by irreversibly altered species composition and ecological function, brought about by human activities such as water regulation, contamination, irreversible eutrophication, chemical treatment against parasites and introduction of exotic species. Thus, the impacts may be physical, chemical or biological. |
| F5 | Strongly altered or artificial lake waterbody | Strongly altered or artificial lake waterbodies are characterised by irreversibly altered species composition and ecological function, brought about by human activities similar to those listed for rivers (F4). This major type also includes artificial waterbodies such as water reservoirs and farm ponds. |
| **T** | **Terrestrial systems** |  |
| T1 | Bare rock | Bare rock includes rock surfaces without soil cover or with a soil cover too thin to support vascular plants. Bare rock may lack vegetation or support lichen- and/or moss-dominated communities. Bare rock comprises rock walls, rock pavements and rock outcrops. Lime richness and risk of desiccation are the most important LECs; other important LECs are supply of trickling water and slope-related disturbance intensity. Bare rock also includes specialised ecosystems in the spray zone near waterfalls, in snowbeds, on wind-exposed rock outcrops and ornitocoprophilic communities on bird perching stones. |
| T2 | Open shallow-soil ground | Open shallow-soil ground includes ecosystems below the timberline which are naturally open (treeless) because of the shallow soil cover *as such* and not because of specific disturbance processes. Lime richness and risk of drought are important LECs. This major type often occurs as narrow border zones (ecotones) between bare rock and forest, e.g. along the coast. |
| T3 | Arctic-alpine heath and lee side | Arctic-alpine heath and lee side includes naturally open ecosystems above or north of the climatic forest limit. Sites below the timberline with environmental conditions that resemble those of arctic-alpine areas (wind-swept ridges, frost-exposed depressions) also belong to this major type. The Arctic-alpine heath and lee side major-type occupies a distinct intermediate position along the topographical ‘ridge-snowbed gradient’, between wind-exposed ridge (T14) which lacks permanent snow cover in winter and snowbed (T7) which is characterised by growing-season reduction due to prolonged snow cover. Dwarf shrubs (*Betula nana, Salix* spp. and ericaceous species) and lichens characterise the vegetation towards the ridges while herbs, graminoids and bryophytes are typical of lee sides, which border on snowbeds. Like in forest (T4), lime richness and risk of drought are the most important LECs. |
| T4 | Forest | The forest major type comprises all terrestrial ‘normal variation’ below the alpine and polar forest limits, characterised by trees as structuring species group. Forests are characterised by long-term presence of trees that, at maturity, make up a stand characterised by vertical projection of tree crowns occupying more than 10 % of the area. Clear-cuts are included in the forest major type if replanted or naturally regenerated without delay. Trees are woody plants more than 5 m tall or that may grow to heights of at least 5 m, or, under growth-reducing conditions, more than 2 m. All non-wetland terrestrial land which meets these criteria, except alluvial forests which make up a major type on its own (T30), is included in the forest (T4) major type. Semi-natural and strongly altered land that meets the demand of forests for tree stand density are, by definition, not included in the concept of forest but in NiN characterised as woodland and included in the respective major types. Lime richness and risk of drought are most important LECs in this major type. |
| T5 | Cave and overhang | Cave and overhang include the variation from overhangs, i.e. rock walls with inclination > 90°, to deep caves. An overhang becomes a cave when the cavity is five or more metres deep. Caves are formed by chemical weathering of limestone or coastal processes like wave erosion. LEC cave-induced sheltering expresses the gradual fading of light and stabilisation of environmental conditions such as temperature and moisture with increasing distance from the cave entrance. Caves may harbour specialised organisms. |
| T6 | Rocky shore | The rocky shore major type comprises bare rock in the geolittoral belt and supralittoral belts of the tidal belt, distinctly influenced by sea salt. The lower limit of T6 is the limit between the marine seabed (M) and terrestrial (T) major-type groups, indicated by the shift from dominance by saltwater-adapted organisms (e.g. the barnacle *Semibalanus balanoides* and the winkle *Littorina littorea*) to dominance by terrestrial organisms, typically the lichen *Verrucaria maura*. Upwards, the rocky shore major type (T6) extends as far as the vegetation retains a prominent signal from salt-tolerant or salt-preferring species and lacks species with low tolerance for sea-salt spray (e.g. ericaceous species). Salt-tolerant mosses and lichens may occur. Patches of salt-tolerant vascular plants, which may occupy crevices, represent mosaic elements of tidal salt meadow (T12) in a rocky shore matrix. |
| T7 | Snowbed | Snowbeds occupy the lower part of the topographical ‘ridge-snowbed gradient’ in alpine and arctic areas, as a result of recurrent prevailing wind direction and snow distribution patterns over years. Snowbeds are characterised by a combination of shortened growing seasons due to prolonged snow cover and, at the same time, shelter against low temperatures and wind abrasion during winter. The variation in snowbeds ranges from moderate snowbeds (facing lee sides) via late and extreme snowbeds to vegetation-free snowbeds where the snow does not melt every year. Lime-richness and water supply are other important LECs in this major type. |
| T8 | Bird-cliff meadow | Bird-cliff meadow comprises naturally open (treeless), graminoid- or herb-dominated sites manured by birds, typically found on slopes underneath or adjacent to bird cliffs along the western and northern coast of Norway. Bird-cliff meadows receive high nitrogen and phosphorus supplies and are typically dominated by nitrophilous species. At intermediate levels of natural manuring, bird-cliff meadows are highly productive, while productivity as well as species richness decreases towards supraoptimal nutrient concentrations. This major type also includes bird-perching tops, which are found in open, elevated sites in the landscape where birds rest, sit watching and leave excrements behind. |
| T9 | Moss tundra | Moss tundra includes moss-dominated land on permafrost in the Arctic, more or less influenced by lightly manuring by birds and/or Svalbard reindeer. Typically, moss tundra has a continuous layer of large, relatively fast-growing mosses that grow directly on top of permafrost layers. Moss tundra often occurs on slopes adjacent to bird cliffs. |
| T10 | Arctic salt-enriched ground | Arctic salt-enriched ground comprises graminoid-dominated sites with salt-enriched topsoil brought about by upward water transport in summer. Topsoil pH is usually in the range 8.5–10.5. This major type is confined to the ‘Arctic steppe’ of the continental inner parts of Wijdefjorden, N Spitsbergen. |
| T11 | Hypersaline tidal marsh | Hypersaline tidal marsh occurs in the upper part of the tidal belt, in sites where evaporation of stagnant sea water causes salt enrichment of topsoils (salt pans). Hypersaline tidal marsh is species poor; single-species communities dominated by *Salicornia* spp. or other specialised short-lived succulents are common. Vegetation-free patches occur frequently in this major type. |
| T12 | Tidal meadow | The tidal meadow major type includes naturally open (treeless), sea salt-influenced graminoid- and herb-dominated meadows. Typically, a distinct zonation can be observed along the vertical gradient from the lower geolittoral to (and including) the supralittoral belt. This major type typically occurs in sheltered sites with fine sediments. |
| T13 | Bare talus slope | Bare talus slope comprises sparsely vegetated or barren ground dominated by rock fragments and/or finer material resulting from physical and chemical weathering and erosion of rock faces above. During downward transport, the material is sorted with the largest fragments at the base of the talus slope and finer material near the top. The inclination of talus slopes increases from ca. 25° near the base when dominated by large boulders to ca. 37° in middle parts and more than 40° at the top. Grain size and lime richness are important LECs in this major type. |
| T14 | Exposed ridge | Exposed ridge comprises the upper end of the topographical ‘ridge-snowbed gradient’ in alpine and arctic areas where this type is confined to convex terrain. Ecologically, this major type is characterised by lack of permanent snow cover in winter, periods with extremely low temperatures, freeze-drying conditions and physical wind abrasion. The specialised composition of stress-tolerant species is dominated by chionophobic yellow or dark lichens with scattered mosses and vascular plants. Deflation patches with exposed mineral soil (gravel or sand) may occur on the most strongly wind-exposed ridges. |
| T15 | Waterfall-sprayed meadow | Waterfall-sprayed meadow includes naturally open (treeless), meadow-like sites in the spray zone of waterfalls and larger streams. The vegetation is lush and mostly characterised by moisture-demanding vascular plants and bryophytes. The almost constant spray of water creates a characteristic environmental regime with lower temperatures, higher humidity and stronger winds than the surroundings. The physical properties of the spray water changes from large drops via droplets to mist and fog with increasing distance from the waterfall. Waterfall-sprayed meadows remain treeless because woody plants do not tolerate coverage by massive ice in winter, resulting from deposition of freezing waterfall spray. |
| T16 | Talus-slope heath and meadow | Talus-slope heath and meadow comprises naturally open (treeless) sites in talus slopes with more or less continuous vegetation cover. The dominating plant groups shift from ericaceous species in lime-poor sites (heaths) to herbs and graminoids in lime-rich sites (meadows). Establishment of trees is prevented by relatively high snow avalanche disturbance intensity. |
| T17 | Open active landslide | The open active landslide major type includes steep slopes at sites where active mass transportation processes are strong enough to prevent establishment of forest. The substrate is unstable and dominated by soil or fine mineral material (gravel, sand, silt or clay). The major type is most commonly found along rivers and streams that run through thick fluvial or glacifluvial deposits, e.g. ravines, where landslide processes are kept active by riverbank erosion. The vegetation is sparse, consisting of a bryophyte- or lichen-dominated crust, a meadow-like sward or low thickets. |
| T18 | Open alluvial sediment | Open alluvial sediment includes naturally open (treeless), periodically flooded banks of rivers and lakes. The major type is conditioned on water-mediated disturbance with intensity high enough to prevent establishment of trees. Alluvial processes (in rivers) and wave action (in lakes) regulate the composition of the sediment by balancing sedimentation and erosion. The dominant grain size varies from clay to stone, depending on disturbance intensity. |
| T19 | Patterned ground | Patterned ground consists of regular rings, polygons or stripes of coarse mineral material which alternate with fine, predominantly silt-dominated material. This major type, which is conditioned on strong frost-mediated disturbance (cryoturbation), is typically found in relatively flat areas with permafrost and high groundwater table in the middle and high alpine bioclimatic zones and in the Arctic. |
| T20 | Kettle-hole frost heath | Kettle-hole frost heath includes naturally open (treeless) heath-like vegetation in the bottom of well-drained terrain depressions, most typically found in kettle-holes formed in thick glacifluvial deposits. The typical occurrence of hummocks without peat formation suggests that frost processes are important, most likely conditioned on influx of surface water on frozen ground in the autumn or early winter. Frost heath is typically found in continental climates in the middle and north boreal, and low alpine bioclimatic zones. |
| T21 | Sand dune | The sand-dune major type comprises all naturally open (treeless) parts of sand-dune systems, from unstable, bare sand to established dune meadows and heaths. Sand dunes are dynamic ecosystems formed when strong winds provide continuous supply of sand from an extensive sand source, most often marine sediments near the coast. Accordingly, sand dunes are found along the coast in moderately exposed sites, occasionally also along large rivers that run through sand-dominated glacifluvial deposits. With increasing distance from the sand source the substrate gradually stabilizes due to reduced wind speed and reduced sand supplies. Accordingly, a distinct vegetation zonation is formed, when fully developed comprising bare sandy shore, embryonal, primary, white, gray and brown dunes and dune heath. Dune slacks may arise after erosion of dune meadows down to the groundwater table. |
| T22 | Arctic-alpine dry-grass heath | Arctic-alpine dry-grass heath comprises land in the mountains and in the Arctic dominated by graminoids like *Juncus trifidus*, *Festuca ovina* and *Carex bigelowii* with a bottom layer dominated by *Cetraria islandica* and *Stereocaulon* spp. *Juncus trifidus*, which is the major dominant, gives this major type a distinctive reddish brown colour in late summer and fall. Arctic-alpine dry-grass heath typically replaces the arctic-alpine heath and lee-side major type (T3) at the transition from the low-alpine to the middle-alpine bioclimatic zone, when dominant species of T3 such as *Vaccinium myrtillus* reach their altitudinal limit and/or give in to unstable soils. Solifluction is assumed to be an important conditioning factor; the major type is also found at lower elevations in sites with unstable soils. |
| T23 | Freshwater driftline | Freshwater driftline comprises the rarely occurring, more or less permanent accumulations of coarse organic matter in the upper ge littoral and surpralittoral belts along large lakes. |
| T24 | Coastal driftline | Coastal driftline comprises accumulated organic matter, mostly sea weed and kelp, in the upper geolittoral and supralittoral belts on exposed shores. Coastal driftlines may support a vegetation of annual or perennial plants. Soil layers may be shallow or thick, consisting mainly of organic matter with high nitrogen and phosphorus contents. |
| T25 | Open historical landslide | Open historical landslide includes naturally open (treeless) sites, typically formed by a single landslide event that took place less than 100 years ago and that is not expected to recur before the succession, e.g. into forest, is completed. Most often, the major type arises due to quick clay slides, but landslides in soil, silt, sand or gravel also occur. |
| T26 | Glacier foreland | Glacier foreland includes the land between the current leading edge of glaciers and their maximum extent, typically demarcated by the terminal and/or lateral moraines of the Little Ice Age maximum which at the Norwegian mainland took place ca. year 1750 (later in the Norwegian Arctic). Because soil development and other ecosystem-forming processes are slow in alpine and arctic climates, glacier foreland still undergoes differentiation into other major types, primarily arctic-alpine heath and lee-side, snowbed, fen, spring and (below the timberline) forest, without yet having reached the post-successional stage. |
| T27 | Boulder field | Boulder fields are areas dominated by coarse mineral material, mostly boulders but occasionally also stone or gravel. Soil is lacking or sparsely present in crevices on or between boulders. Boulder fields are typically formed in cold climates of the arctic and alpine bioclimatic zones by mechanical weathering during freeze-thaw periods or by frost upheaval that brings larger blocks to the surface. Coarse glacial deposits (Rogen moraines) are also included in this major type. Vegetation is typically restricted to saxicolous lichens, sometimes also mosses, or may be absent. |
| T28 | Polar desert | Polar desert comprises gravel- and stone-dominated areas in the Arctic polar desert zone, formed by frost weathering. Material finer than gravel may be present. The vegetation is scattered and dominated by species with a high-arctic distribution. |
| T29 | Coastal shingle beach | Coastal shingle beach comprises naturally open (treeless) land along the coast, dominated by gravel, stones, boulders or shell deposits. This major type occurs in the geolittoral and supralittoral tidal belts but also includes open historical shorelines further inland that have not yet reached a successional end-point. The vegetation varies from barren mineral material via scattered plants to shrub-dominated patches in late-successional stages. |
| T30 | Alluvial forest | Alluvial forest includes periodically flooded, non-wetland forest (see T4 for definition of forest) on banks of rivers and lakes, impacted by water-mediated disturbance. Alluvial processes in rivers and wave action in lakes regulates the composition of the sediment by balancing sedimentation and erosion. The dominant grain size varies from clay to stone, depending on disturbance intensity. This major type also includes sea water-influenced forests in the upper part of the tidal belt. |
| T31 | Boreal heath | Boreal heath includes open, semi-natural land below the climatic timberline, formed by deforestation, primarily as a result of summer farming and mining, in the 17th, 18th and 19th centuries. After deforestation, a distinctive ecosystem was formed by actively keeping the land open by clearance of shrubs and trees and low-intensity livestock grazing. The variation in species composition parallels that of forest (T4), with lime richness and risk of drought as the most important LECs, but shade-tolerant and litter-dwelling species are less prominent in boreal heath and mycorrhizal partners of forest trees are lacking. Boreal heath covers large areas in the north boreal bioclimatic zone, with decreasing areal importance towards warmer zones. Over the last decades, the management that kept boreal heaths open has ceased and boreal heaths in various stages of succession towards forest occur abundantly. |
| T32 | Semi-natural grassland | Semi-natural grassland includes meadows formed by forest clerarance followed by livestock grazing and/or haymaking, subject to the additional condition of neither being ploughed nor seeded nor heavily fertilised. The vegetation is dominated by graminoids and herbs, while nitrophilous species are not prominent. Semi-natural grassland may be open (treeless) or, also when actively managed, have an open tree layer (wooded or coppice meadows). Land management intensity, lime richness and risk of drought are the most important LECs. Since the middle of the 20th century, traditional use of semi-natural grasslands has decreased and conversion into arable fields, agriculturally improved grassland or abandonment has taken place. |
| T33 | Semi-natural tidal and salt meadow | Semi-natural tidal and salt meadow comprises open (treeless), sea water-influenced graminoid- and herb-dominated meadows in the upper geolittoral and supralittoral tidal belts. This major type is developed from tidal and salt meadows (T12) by extensive long-term management, typically livestock grazing, which has prevented regrowth succession into forest. With decreasing sea-salt influence during land upheaval, this major type gradually transgresses into semi-natural grassland (T32). |
| T34 | Coastal heath | Coastal heath includes open coastal land, mostly dominated by *Calluna vulgaris* but occasionally dominated by other ericaceous species such as *Empetrum nigrum* and *Erica tetralix*. Coastal heath is conditioned on a long-term management regime that includes prescribed burning, often in combination with all-year livestock grazing and in former times also haymaking. Coastal heaths are confined to areas with a mild winter climate. Since the middle of the 20th century, traditional use of coastal heaths has decreased and extensive areas have been abandoned or replanted with trees. |
| T35 | Wasteland, extracted or deposited surficial deposit | Wasteland, extracted or deposited surficial deposit includes ground that is strongly altered by human actions, dominated by relatively fine-grained material such as soil, gravel, sand, silt and clay. The fine substrate facilitates rapid succession, starting with pioneer vegetation dominated by ruderal species. This major type includes, e.g. sand pits and gravel pits, timber storage sites, deposits of gravel and unsorted fine materials. |
| T36 | Drained wetland and terrestrialised freshwater sediment | Drained wetland and terrestrialised freshwater sediment includes terrestrial ground originating by drainage of fens, bogs and mire and swamp forests, or by terrestrialisation of former sediment-beds of rivers and lakes. After establishment, drained wetland and terrestrialised freshwater sediment typically undergo rapid succession. |
| T37 | Artificial soft substrate | Artificial soft substrate includes household waste deposits, spoil heaps and soft plastic and other synthetic substrates which facilitate rapid succession from pioneer vegetation dominated by ruderal species. |
| T38 | Tree plantation | Tree plantation includes land with tree monocultures intensively managed for production of wood, e.g. by soil scarification, application of fertiliser and/or pesticides and/or planting of exotic tree species or native species out of their natural range, typically in so dense stands that understorey vegetation cover is substantially reduced or the ground entirely covered with needles or leaves. |
| T39 | Strongly altered or artificial hard substrate | Strongly altered or artificial hard substrate includes quarries, buildings and other surfaces composed of natural or artificial, e.g. synthetic, hard substrates on which colonisation proceeds slowly and is expected to continue for > 150 years. Examples of synthetic hard materials are aluminum, iron and steel, glass, some hard plastics and reinforced concrete. |
| T40 | Strongly altered ground with semi-natural grassland character | Strongly altered ground with semi-natural grassland character comprises surficial soil, gravel, silt, sand or clay deposits (typically belonging to T35) which, after several decades of grazing, hay-making or similar extensive management has developed visual similarity with, and a species composition that contains many species typical of, semi-natural grassland (T32). |
| T41 | Agriculturally improved grassland with semi-natural character | Agriculturally improved grassland with semi-natural character comprises old fields, i.e. former fields (T44) and agriculturally improved grassland (T45) that, due to extensive management (livestock grazing, haymaking etc.) for several decades have developed a superficial visual similarity with, and a species composition that contains many species typical of, semi-natural grassland (T32). |
| T42 | Landscaped patch or field | Landscaped patch or field includes flowerbeds and other regularly cultivated ground with bare soil not used for agricultural production. |
| T43 | Landscaped grassland | Landscaped grassland includes road verges, embankments, lawns, parks and similar artificial, regularly cultivated ground with a continuous grass sward, not used for agricultural production. |
| T44 | Arable field | Arable field includes tilled and seeded farmland, typically with monocultures of harvested crops such as cereals, oil-seed plants, legumes and potatoes. Commercial fertiliser, slurry and/or pesticides are often applied. In addition to sown plants, annual weeds occur frequently. |
| T45 | Agriculturally improved grassland | Agriculturally improved grassland includes more or less permanent grassland, managed for fodder production by regular resowing, application of commercial fertiliser, slurry and/or pesticides. Ploughing may be carried out at irregular intervals. A natural flora of perennial and annual weeds typically occurs. |
| **V** | **Wetland systems** |  |
| V1 | Open fen | Open fen comprises all open (treeless) mires that, in addition to rainwater, is supplied with minerogenous (geogenous) water, i.e. water that has been in contact with mineral soil. Peat-forming *Sphagnum* species dominate the ground layer in lime-poor or intermediately lime-rich fens while mosses other than *Sphagnum* (‘brown mosses’) dominate in lime-rich fens. Other important LECs are duration of period without inundation (inversely related to depth from the ground surface to the water-table), which expresses variation from carpets via lawns to hummocks, the variation from mire margin to mire expanse, and the variation in strength of springwater character of the supplied water, separating spring fens from other open fens. |
| V2 | Mire and swamp forest | Mire and swamp forest comprises wetland forest (see T4 for definition of forest) supplied with minerogenous (geogenous) water. Important LECs are lime richness, duration of period without inundation and strength of spring-water character of the supplied water. |
| V3 | Bog | Bog comprises all mires in which the uppermost peat layer is exclusively supplied with ombrogenous water (rainwater). Bog peat is inherently nutrient-poor and the main gradient in species composition is related to duration of period without inundation (inversely related to depth from the ground surface to the water-table), which expresses variation from carpets via lawns to hummocks. Furthermore, a gradient from mire margin to mire expanse is recognised. The bog major type also includes sites with a tree layer that satisfies the definition of forest (more than 10 % of the area within the vertical projection of tree crowns). |
| V4 | Spring | Spring comprises wetlands characterized by strong spring-water influence (constancy throughout the year of flow and chemical composition of water with high concentration of dissolved O2 and temperature near the annual mean temperature of the area). In addition to the strength of spring-water influence, springs show variation related to lime richness. Springs can be divided into two categories; peaty springs and shallow springs without peat formation. |
| V5 | Thermal spring | Thermal springs differ from (cold) springs (V4) by the continuous flow of geothermally heated groundwater, i.e. water with sufficiently high average annual water temperature compared to the adjacent soils that a substantial difference in species composition results. In areas under Norwegian jurisdiction, thermal springs occur only in a few places on Spitsbergen. |
| V6 | Wet snowbed and snowbed spring | Wet snowbed and snowbed spring comprises wetlands above and north of the timberline, characterised by shortened growing season due to prolonged snow cover *and* influence by spring water (see V4). This major type typically occurs near the bottom of slopes under late-melting snow patches that provide ample supplies of meltwater far into the growing season. |
| V7 | Arctic permafrost wetland | Arctic permafrost wetland is dependent on permafrost, occurring only in the middle arctic tundra zone on Svalbard. This major type is found on level ground and in shallow depressions that are filled with stagnant water during thawing of the active layer. The water-table is level with, or situated just above, the moss layer for most of the summer. The vegetation is dominated by mosses and a few, specialised vascular plants that tolerate the combination of low temperatures, occasional freezing in ice and standing water. |
| V8 | Tidal and alluvial swamp forest | Tidal and alluvial swamp forest (see T4 for definition of forest) comprises swamp forests along lakes and seashores that are inundated during flooding events or spring tides. This major type differs from alluvial forest (T30) by the permanently waterlogged soil and from mire and swamp forest (V2) by being supplied with stagnant lake or tidal (limno-topogenous) water. In contrast, swamp forests receive minerogenous water. |
| V9 | Semi-natural fen | Semi-natural fen comprises open (treeless) peat-forming mires that are characterised by livestock grazing and/or haymaking, sometimes also clearance of shrubs and trees. The species composition resembles that of fens with similar lime richness and depth to the water-table. Hay-making fens tend to be more productive than comparable unmanaged fens, with higher cover of graminoids and herbs. Grazing fens tend to contain a distinct element of nitrophilous species. Traditional use of semi-natural fens for hay-making (cutting by scythe) required removal of tussocks, either by controlled flooding or physical destruction. Accordingly, extensive, almost plane lawns are a distinctive feature of intact hay-making fens. Use of fens for fodder collection decreased in the first half of the 20th century and ceased almost entirely after World War II. Few decades after abandonment, a hay-making fen will have lost its semi-natural character. The successional end-point (V1 or V2) has been reached when an uneven surface has been re-established and shrub and tree encroachment has taken place. |
| V10 | Semi-natural wet meadow | Semi-natural wet meadow comprises graminoid-dominated land more or less without peat formation, shaped by livestock grazing and/or haymaking. Semi-natural wet meadows are most often found on periodically flooded river or stream banks or along lakes. While formerly used for hay-making and/or grazing, semi-natural wet meadows are now, with few exceptions, either abandoned or used as pastures. The vegetation is dominated by graminoids and herbs and the bottom layer is poorly developed. |
| V11 | Peat quarry | Peat quarries are mires (fens or bogs) subjected to harvesting of the upper peat layer for use as fuel or soil improvement. The surface of peat quarries therefore consists of exposed, old peat. Peat extraction sites are often recognized as rectangular pits with more or less straight edges. Water-filled peat quarries belong to the excavated freshwater sediment major-type (L8). |
| V12 | Drained mire | Drained mire comprises fens and bogs drained (ditched) for agricultural or forestry purposes, but that have not (yet) been fully terrestrialised and therefore still belongs to the wetland major-type group. |
| V13 | Artificial wetland | Artificial wetland includes new wetland originating by paludification of previous non-wetland sites by human intervention, e.g. road construction. |
| **I** | **Snow and ice systems** |  |
| I1 | Permanent snow and ice | Permanent snow and ice comprises ground that is snow and ice-covered for several years, including glaciers and snowdrifts. |
| I2 | Polar sea-ice | Polar sea-ice comprises the surface of the Arctic Ocean that is permanently covered with ice, including the species that live on or in it or that have immediate contact with the lower side of the sea ice. |

**TABLE S5.22** List of minor types (codes and names) in the NiN implementation of EcoSyst for Norway, version 2.2.0. Code = combination of one-letter major-type group code (see Table S5.20), the one- or two digit major-type code (see Table S5.21), a hyphen (-) and consecutive numbers within each major type. Definition = definition of each minor type as a combination of standard segments along relevant LECs (see Table S5.19 for definition of standard segments in terms of elementary segments and Table S4.18 for description of LECs).

| **Code** | **Minor type** | **Definition** |
| --- | --- | --- |
| M1-1 | Sheltered marine rock | SA∙3&HF∙1&VF∙1&DL∙1,2 |
| M1-2 | Moderately sheltered to moderately exposed upper circalittoral rock | SA∙3&HF∙1&VF∙2,3&DL∙1 |
| M1-3 | Moderately sheltered infralittoral rock | SA∙3&HF∙1&VF∙2&DL∙2 |
| M1-4 | Moderately sheltered sublittoral fringe rock | SA∙3&HF∙1&VF∙2&DL∙3 |
| M1-5 | Moderately exposed infralittoral rock | SA∙3&HF∙1&VF∙3&DL∙2 |
| M1-6 | Moderately exposed sublittoral fringe rock | SA∙3&HF∙1&VF∙3&DL∙3 |
| M1-7 | Strongly exposed euphotic rock | SA∙3&HF∙1&VF∙4&DL1∙3 |
| M1-8 | Sheltered, moderately brackish rock with algal deposits | SA∙2&HF∙1&VF∙1&DL∙2,3 |
| M1-9 | Moderately sheltered to moderately exposed, moderately brackish upper circalittoral rock | SA∙2&HF∙1&VF∙2,3&DL∙1 |
| M1-10 | Moderately sheltered, moderately brackish infralittoral rock | SA∙2&HF∙1&VF∙2&DL∙2 |
| M1-11 | Moderately sheltered, moderately brackish sublittoral fringe rock | SA∙2&HF∙1&VF∙2&DL∙3 |
| M1-12 | Moderately exposed, moderately brackish infralittoral rock | SA∙2&HF∙1&VF∙3&DL∙2 |
| M1-13 | Moderately exposed, moderately brackish sublittoral fringe rock | SA∙2&HF∙1&VF∙3&DL∙3 |
| M1-14 | Sheltered brackish rock with algal deposits | SA∙1&HF∙1&VF∙1&DL∙2,3 |
| M1-15 | Moderately sheltered to moderately exposed, brackish kelp forest | SA∙1&HF∙1&VF∙2,3&DL∙2,3\* |
| M1-16 | Sheltered sublittoral rock wall | SA∙3&HF∙2&VF∙1&DL∙2,3 |
| M1-17 | Moderately sheltered to moderately exposed upper circalittoral rock wall | SA∙3&HF∙2&VF∙2,3&DL∙1 |
| M1-18 | Moderately sheltered to moderately exposed infralittoral and sublittoral fringe rock wall | SA∙3&HF∙2&VF∙2,3&DL∙2,3 |
| M1-19 | Strongly exposed euphotic rock wall | SA∙3&HF∙2&VF∙4&DL∙1∙3 |
| M1-20 | Sheltered brackish euphotic rock wall | SA∙2&HF∙2&VF∙1&DL∙2,3 |
| M1-21 | Moderately sheltered to moderately exposed, brackish upper circalittoral rock wall | SA∙2&HF∙2&VF∙2,3&DL∙1 |
| M1-22 | Moderately sheltered to moderately exposed, brackish infralittoral and sublittoral fringe rock wall | SA∙2&HF∙2&VF∙2,3&DL∙2,3 |
| M1-23 | Strongly brackish rock wall | SA∙1&HF∙2&VF∙1∙3&DL∙2,3\* |
| M1-24 | Strongly sheltered euphotic boulders | SI∙B&SA∙3&HF∙2&VF∙1&DL∙2,3 |
| M1-25 | Moderately sheltered to moderately exposed upper circalittoral boulders | SI∙B&SA∙3&HF∙2&VF∙2,3&DL∙1 |
| M1-26 | Moderately sheltered to moderately exposed infralittoral and sublittoral fringe boulders | SI∙B&SA∙3&HF∙2&VF∙2,3&DL∙2,3 |
| M1-27 | Strongly exposed euphotic boulders | SI∙B&SA∙3&HF∙2&VF∙4&DL∙1∙3 |
| M1-28 | Moderately sheltered to moderately exposed, moderately brackish infralittoral and sublittoral fringe boulders | SI∙B&SA∙2&HF∙2&VF∙2,3&DL∙1 |
| M1-29 | Ice-scoured boulders | IF∙B&VF∙1∙4&DL∙1∙3 |
| M2-1 | Strongly sheltered aphotic epipelagial rock | HF∙1&DM∙1&VF∙1 |
| M2-2 | Strongly sheltered aphotic mesopelagial rock | HF∙1&DM∙2&VF∙1 |
| M2-3 | Strongly sheltered aphotic upper bathypelagial rock | HF∙1&DM∙3&VF∙1 |
| M2-4 | Strongly sheltered aphotic lower bathypelagial rock | HF∙1&DM∙4&VF∙1 |
| M2-5 | Strongly sheltered aphotic abyssopelagial rock | HF∙1&DM∙5&VF∙1 |
| M2-6 | Moderately sheltered aphotic epipelagial rock | HF∙1&DM∙1&VF∙2 |
| M2-7 | Moderately sheltered aphotic mesopelagial rock | HF∙1&DM∙2&VF∙2 |
| M2-8 | Moderately sheltered aphotic upper bathypelagial rock | HF∙1&DM∙3&VF∙2 |
| M2-9 | Moderately sheltered aphotic lower bathypelagial rock | HF∙1&DM∙4&VF∙2 |
| M2-10 | Moderately sheltered aphotic abyssopelagial rock | HF∙1&DM∙5&VF∙2 |
| M2-11 | Moderately sheltered aphotic mesopelagial ultramafic rock | HF∙1&DM∙2&VF∙2&BK∙2 |
| M2-12 | Moderately sheltered aphotic abyssopelagial ultramafic rock | HF∙1&DM∙5&VF∙2&BK∙2 |
| M2-13 | Strongly sheltered aphotic epipelagial rock wall | HF∙2&DM∙1&VF∙1 |
| M2-14 | Moderately sheltered aphotic epipelagial rock wall | HF∙2&DM∙1&VF∙2 |
| M2-15 | Strongly sheltered aphotic mesopelagial rock wall | HF∙2&DM∙2&VF∙1 |
| M2-16 | Moderately sheltered aphotic mesopelagial rock wall | HF∙2&DM∙2&VF∙2 |
| M2-17 | Strongly sheltered aphotic upper bathypelagial rock wall | HF∙2&DM∙3&VF∙1 |
| M2-18 | Moderately sheltered aphotic upper bathypelagial rock wall | HF∙2&DM∙3&VF∙2 |
| M2-19 | Aphotic lower bathypelagial rockwall | HF∙2&DM∙4&VF∙1,2 |
| M2-20 | Aphotic lower abyssopelagial rockwall | HF∙2&DM∙5&VF∙1,2 |
| M3-1 | Strongly sheltered hydrolittoral rock | HF∙1&SA∙3&VF∙1&TV∙1 |
| M3-2 | Strongly sheltered lower geolittoral rock | HF∙1&SA∙3&VF∙1&TV∙2 |
| M3-3 | Strongly sheltered upper geolittoral rock | HF∙1&SA∙3&VF∙1&TV∙3 |
| M3-4 | Sheltered hydrolittoral rock | HF∙1&SA∙3&VF∙2&TV∙1 |
| M3-5 | Sheltered lower geolittoral rock | HF∙1&SA∙3&VF∙2&TV∙2 |
| M3-6 | Sheltered upper geolittoral rock | HF∙1&SA∙3&VF∙2&TV∙3 |
| M3-7 | Exposed hydrolittoral rock | HF∙1&SA∙3&VF∙3&TV∙1 |
| M3-8 | Exposed lower geolittoral rock | HF∙1&SA∙3&VF∙3&TV∙2 |
| M3-9 | Exposed upper geolittoral rock | HF∙1&SA∙3&VF∙3&TV∙3 |
| M3-10 | Strongly exposed tidal rock | HF∙1&SA∙3&VF∙4&TV∙1∙3 |
| M3-11 | Sheltered brackish hydrolittoral rock | HF∙1&SA∙2&VF∙1,2&TV∙1 |
| M3-12 | Sheltered brackish geolittoral rock | HF∙1&SA∙2&VF∙1,2&TV∙2,3 |
| M3-13 | Sheltered, strongly brackish tidal rock | HF∙1&SA∙1&VF∙1,2&TV∙1∙3 |
| M3-14 | Strongly sheltered hydrolittoral rock wall | HF∙2&SA∙3&VF∙1&TV∙1 |
| M3-15 | Strongly sheltered geolittoral rock wall | HF∙2&SA∙3&VF∙1&TV∙1,2 |
| M3-16 | Moderately sheltered littoral rock | HF∙2&SA∙3&VF∙2&TV∙1∙3 |
| M3-17 | Exposed littoral rock | HF∙2&SA∙3&VF∙3,4&TV∙1∙3 |
| M3-18 | Wasteland, extraction site and artificial surficial deposit | HF∙2&SA∙2&VF∙1,2&TV∙1∙3 |
| M3-19 | Ice-scoured littoral rock | VF∙1∙3&TV1∙3&IF∙B |
| M4-1 | Strongly modified and new artificial surficial deposit | DL∙1&SA∙2&TV∙1&S3∙E∙ab&S3∙F∙0a |
| M4-2 | Sublittoral fringe to infralittoral unconsolidated mud | DL∙1&SA∙2&TV∙1&S3∙E∙0a&S3∙F∙¤ |
| M4-3 | Sublittoral fringe to infralittoral gravel seabed | DL∙1&SA∙2&TV∙1&S3∙E∙c&S3∙F∙0a |
| M4-4 | Sublittoral fringe to infralittoral mixed sand and fine sediment sea-bed | DL∙1&SA∙2&TV∙1&S3∙E∙bc&S3∙F∙bc |
| M4-5 | Sublittoral fringe to infralittoral soft fine-sediment seabed | DL∙1&SA∙2&TV∙1&S3∙E∙bcd&S3∙F∙¤ |
| M4-6 | Sublittoral fringe to infralittoral gravel and stone seabed | DL∙1&SA∙2&TV∙1&S3∙E∙de&S3∙F∙0a |
| M4-7 | Sublittoral fringe to infralittoral muddy gravel | DL∙1&SA∙2&TV∙1&S3∙E∙d&S3∙F∙bc |
| M4-8 | Sublittoral fringe to infralittoral consolidated clay | DL∙1&SA∙2&TV∙1&S3∙E∙e&S3∙F∙¤ |
| M4-9 | Sublittoral fringe to infralittoral algal gyttja | DL∙1&SA∙2&TV∙1&S3∙E∙0a&S3∙F∙¤&IO∙2 |
| M4-10 | Sublittoral fringe to infralittoral shell-bed | DL∙1&SA∙2&TV∙1&S3∙S∙a |
| M4-11 | Sublittoral fringe to infralittoral maerl-bed | DL∙1&SA∙2&TV∙1&S3∙S∙b |
| M4-12 | Upper circalittoral sand | DL∙2&SA∙2&S3∙E∙ab&S3∙F∙0a |
| M4-13 | Upper circalittoral unconsolidated mud | DL∙2&SA∙2&S3∙E∙0a&S3∙F∙¤ |
| M4-14 | Upper circalittoral gravel and stone | DL∙2&SA∙2&S3∙E∙cde&S3∙F∙0a |
| M4-15 | Upper circalittoral mixed sediment | DL∙2&SA∙2&S3∙E∙bcd&S3∙F∙bc |
| M4-16 | Upper circalittoral mud | DL∙2&SA∙2&S3∙E∙bcd&S3∙F∙¤ |
| M4-17 | Upper circalittoral consolidated clay | DL∙2&SA∙2&S3∙E∙e&S3∙F∙¤ |
| M4-18 | Upper circalittoral algal gyttja | DL∙2&SA∙2&S3∙E∙0a&S3∙F∙¤&IO∙2 |
| M4-19 | Upper circalittoral shell-bed | DL∙2&SA∙2&S3∙S∙a |
| M4-20 | Upper circalittoral maerl-bed | DL∙2&SA∙2&S3∙S∙b |
| M4-21 | Brackish euphotic sand | DL∙1∙2&SA∙1&TV∙1&S3∙E∙ab&S3∙F∙0a |
| M4-22 | Brackish euphotic unconsolidated mud | DL∙1∙2&SA∙1&TV∙1&S3∙E∙0a&S3∙F∙¤ |
| M4-23 | Brackish euphotic sandy mud | DL∙1∙2&SA∙1&TV∙1&S3∙E∙bc&S3∙F∙bc |
| M4-24 | Brackish euphotic mud and consolidated clay | DL∙1∙2&SA∙1&TV∙1&S3∙E∙bcde&S3∙F∙¤ |
| M4-25 | Brackish euphotic gravel and stone | DL∙1∙2&SA∙1&TV∙1&S3∙E∙cde&S3∙F∙0a |
| M4-26 | Brackish euphotic muddy gravel | DL∙1∙2&SA∙1&TV∙1&S3∙E∙d&S3∙F∙bc |
| M4-27 | Brackish euphotic algal gyttja | DL∙1∙2&SA∙1&TV∙1&S3∙E∙0a&S3∙F∙¤&IO∙2 |
| M4-28 | Brackish euphotic calcite-bed | DL∙1∙2&SA∙1&TV∙1&S3∙E∙0a&S3∙F∙¤&&KA∙2 |
| M4-29 | Hydrolittoral sand | DL∙1&SA∙2&TV∙2&S3∙E∙ab&S3∙F∙0a |
| M4-30 | Hydrolittoral unconsolidated mud | DL∙1&SA∙2&TV∙2&S3∙E∙0a&S3∙F∙¤ |
| M4-31 | Hydrolittoral mixed sediment | DL∙1&SA∙2&TV∙2&S3∙E∙bc&S3∙F∙bc |
| M4-32 | Hydrolittoral mud | DL∙1&SA∙2&TV∙2&S3∙E∙bc&S3∙F∙¤ |
| M4-33 | Hydrolittoral gravel | DL∙1&SA∙2&TV∙2&S3∙E∙c&S3∙F∙0a |
| M4-34 | Hydrolittoral stone | DL∙1&SA∙2&TV∙2&S3∙E∙de&S3∙F∙0a |
| M4-35 | Hydrolittoral consolidated clay | DL∙1&SA∙2&TV∙2&S3∙E∙d&S3∙F∙¤ |
| M4-36 | Hydrolittoral algal gyttja | DL∙1&SA∙2&TV∙2&S3∙E∙0a&S3∙F∙¤&IO∙2 |
| M4-37 | Hydrolittoral shell-bed | DL∙1&SA∙2&TV∙2&S3∙S∙a |
| M4-38 | Brackish hydrolittoral sand | DL∙1&SA∙1&TV∙2&S3∙E∙ab&S3∙F∙0a |
| M4-39 | Brackish hydrolittoral unconsolidated mud | DL∙1&SA∙1&TV∙2&S3∙E∙0a&S3∙F∙¤ |
| M4-40 | Brackish hydrolittoral sandy mud | DL∙1&SA∙1&TV∙2&S3∙E∙bc&S3∙F∙bc |
| M4-41 | Brackish hydrolittoral mud | DL∙1&SA∙1&TV∙2&S3∙E∙bc&S3∙F∙¤ |
| M4-42 | Brackish hydrolittoral consolidated clay | DL∙1&SA∙1&TV∙2&S3∙E∙d&S3∙F∙¤ |
| M4-43 | Brackish hydrolittoral algal gyttja | DL∙1&SA∙1&TV∙2&S3∙E∙0a&S3∙F∙¤&IO∙2 |
| M4-44 | Euphotic seabed with disruptive sedimentation | DL∙1∙2&SA∙1∙2&S3∙E∙abcde&S3∙F∙0abc&SE∙B |
| M5-1 | Upper sublittoral sand | DM∙1&S3∙E∙ab&S3∙F0a |
| M5-2 | Upper sublittoral unconsolidated mud | DM∙1&S3∙E∙0a&S3∙F∙¤ |
| M5-3 | Upper sublittoral gravel and stone | DM∙1&S3∙E∙cde&S3∙F∙0a |
| M5-4 | Upper sublittoral mixed sediment | DM∙1&S3∙E∙bcd&S3∙F∙bc |
| M5-5 | Upper sublittoral mud | DM∙1&S3∙E∙bcd&S3∙F∙¤ |
| M5-6 | Upper sublittoral consolidated clay | DM∙1&S3∙E∙e&S3∙F∙¤ |
| M5-7 | Upper sublittoral algal gyttja | DM∙1&S3∙E∙0a&S3∙F∙¤&IO∙2 |
| M5-8 | Upper sublittoral shell-bed | DM∙1&S3∙S∙a |
| M5-9 | Upper sublittoral sponge-bed | DM∙1&S3∙S∙c |
| M5-10 | Upper sublittoral coral-gravel bed | DM∙1&S3∙S∙d |
| M5-11 | Mesopelagic sand | DM∙2&S3∙E∙ab&S3∙F0a |
| M5-12 | Mesopelagic unconsolidated mud | DM∙2&S3∙E∙0a&S3∙F∙¤ |
| M5-13 | Mesopelagic gravel and stone | DM∙2&S3∙E∙cde&S3∙F∙0a |
| M5-14 | Mesopelagic mixed sediment | DM∙2&S3∙E∙bcd&S3∙F∙bc |
| M5-15 | Mesopelagic mud | DM∙2&S3∙E∙bcd&S3∙F∙¤ |
| M5-16 | Mesopelagic consolidated clay | DM∙2&S3∙E∙e&S3∙F∙¤ |
| M5-17 | Mesopelagic algal gyttja | DM∙2&S3∙E∙0a&S3∙F∙¤&IO∙2 |
| M5-18 | Mesopelagic sponge-bed | DM∙2&S3∙S∙c |
| M5-19 | Mesopelagic coral-gravel bed | DM∙2&S3∙S∙d |
| M5-20 | Upper bathypelagic sand | DM∙3&S3∙E∙ab&S3∙F0a |
| M5-21 | Upper bathypelagic unconsolidated mud | DM∙3&S3∙E∙0a&S3∙F∙¤ |
| M5-22 | Upper bathypelagic gravel and stone | DM∙3&S3∙E∙cde&S3∙F∙0a |
| M5-23 | Upper bathypelagic mixed sediment | DM∙3&S3∙E∙bcd&S3∙F∙bc |
| M5-24 | Upper bathypelagic mud | DM∙3&S3∙E∙bcd&S3∙F∙¤ |
| M5-25 | Upper bathypelagic consolidated clay | DM∙3&S3∙E∙e&S3∙F∙¤ |
| M5-26 | Upper bathypelagic sponge-bed | DM∙3&S3∙S∙c |
| M5-27 | Lower bathypelagic sand | DM∙4&S3∙E∙ab&S3∙F0a |
| M5-28 | Lower bathypelagic unconsolidated mud | DM∙4&S3∙E∙0a&S3∙F∙¤ |
| M5-29 | Lower bathypelagic gravel and stone | DM∙4&S3∙E∙cde&S3∙F∙0a |
| M5-30 | Lower bathypelagic mixed sediment | DM∙4&S3∙E∙bcd&S3∙F∙¤ |
| M5-31 | Lower bathypelagic consolidated clay | DM∙4&S3∙E∙e&S3∙F∙¤ |
| M5-32 | Lower bathypelagic sponge-bed | DM∙4&S3∙S∙c |
| M5-33 | Abyssal sand | DM∙5&S3∙E∙ab&S3∙F0a |
| M5-34 | Abyssal unconsoidated mud | DM∙5&S3∙E∙0a&S3∙F∙¤ |
| M5-35 | Abyssal gravel and stone | DM∙5&S3∙E∙cde&S3∙F∙0a |
| M5-36 | Abyssal mud | DM∙5&S3∙E∙bcd&S3∙F∙¤ |
| M5-37 | Abyssal consolidated clay | DM∙5&S3∙E∙e&S3∙F∙¤ |
| M5-38 | Abyssal sponge-bed | DM∙5&S3∙S∙c |
| M6-1 | Coastal coralline seabed | KY∙A |
| M6-2 | Oceanic coralline seabed | KY∙B |
| M7-1 | Brackish hydrolittoral seagrass bed | SA∙1&TV∙1 |
| M7-2 | Brackish sublittoral seagrass bed | SA∙1&TV∙2 |
| M7-3 | Hydrolittoral seagrass bed | SA∙2&TV∙1 |
| M7-4 | Sublittoral seagrass bed | SA∙2&TV∙2 |
| M8-1 | Tidal swamp |  |
| M9-1 | Large geolittoral rockpool | SM∙1&TV∙1 |
| M9-2 | Large lower to middle supralittoral rockpool | SM∙1&TV∙2 |
| M9-3 | Large upper supralittoral rockpool | SM∙1&TV∙3 |
| M9-4 | Small geolittoral rockpool | SM∙2&TV∙1 |
| M9-5 | Small lower to middle supralittoral rockpool | SM∙2&TV∙2 |
| M9-6 | Small upper supralittoral rockpool | SM∙2&TV∙3 |
| M9-7 | Temporary supralittoral rockpool | SM∙3&TV∙2,3 |
| M9-8 | Large geolittoral rockpool sediment | SM∙1&TV∙1&SE∙2 |
| M9-9 | Small geolittoral rockpool sediment | SM∙2&TV∙1&SE∙2 |
| M10-1 | Tidal cave entrance and overhang | DL∙1&GS∙1 |
| M10-2 | Marine euphotic cave entrance and overhang | DL∙2&GS∙1 |
| M10-3 | Marine aphotic cave | DL∙3&GS∙1,2 |
| M10-4 | Tidal cave interior | DL∙1&GS∙2 |
| M10-5 | Marine euphotic cave interior | DL∙2&GS∙2 |
| M11-1 | Upper sublittoral pockmark | DM∙1&KI∙1 |
| M11-2 | Upper sublittoral cold seep | DM∙1&KI∙2 |
| M11-3 | Lower sublittoral pockmark | DM∙2&KI∙1 |
| M11-4 | Lower sublittoral cold seep | DM∙2&KI∙2 |
| M11-5 | Bathypelagic and abyssal pockmark | DM∙3&KI∙1 |
| M11-6 | Bathypelagic and abyssal cold seep | DM∙3&KI∙2 |
| M11-7 | Bathypelagic and abyssal mud vulcano | DM∙3&KI∙2&KT∙B |
| M12-1 | Upper sublittoral hydrothermal vent | JV∙1&DM∙1 |
| M12-2 | Lower sublittoral hydrothermal vent | JV∙1&DM∙2 |
| M12-3 | Bathypelagic and abyssal hydrothermal vent | JV∙1&DM∙3 |
| M12-4 | Upper sublittoral hot hydrothermal vent | JV∙2&DM∙1 |
| M12-5 | Lower sublittoral hot hydrothermal vent | JV∙2&DM∙2 |
| M12-6 | Bathypelagic and abyssal hot hydrothermal vent | JV∙2&DM∙3 |
| M12-7 | Extremely hot hydrothermal vent | JV∙3&DM∙1∙3 |
| M13-1 | Euphotic periodically anoxic marine sediment | OM∙1&DL∙1 |
| M13-2 | Aphotic periodically anoxic marine sediment | OM∙1&DL∙2 |
| M13-3 | Euphotic anoxic marine sediment | OM∙2&DL∙1 |
| M13-4 | Aphotic anoxic marine sediment | OM∙2&DL∙2 |
| M14-1 | Tidal strongly modified and new marine hard substrate | DL∙1 |
| M14-2 | Euphotic strongly modified and new marine hard substrate | DL∙2 |
| M14-3 | Aphotic strongly modified and new marine hard substrate | DL∙3 |
| M15-1 | Strongly modified and new marine sand and gravel | S3∙E∙1&S3∙F∙1 |
| M15-2 | Strongly modified and new marine mud and clay | S3∙E∙1&S3∙F∙2 |
| M15-3 | Strongly modified and new stone-dominated substrate | S3∙E∙3&S3∙F∙1 |
| M15-4 | Strongly modified contaminated marine sediment | S3∙E∙1&S3∙F∙2&HS∙B |
| H1-1 | Epipelagic waterbody | DM∙1&KY∙1 |
| H1-2 | Mesopelagic waterbody | DM∙2&KY∙1 |
| H1-3 | Bathypelagic waterbody | DM∙3&KY∙1 |
| H1-4 | Abyssopelagic waterbody | DM∙4&KY∙1 |
| H1-5 | Epipelagic coastal waterbody | DM∙1&KY∙2 |
| H2-1 | Fjord waterbody | SA∙2&SM∙1 |
| H2-2 | Large lagoon waterbody | SA∙2&SM∙2 |
| H2-3 | Small and medium-sized lagoon waterbody | SA∙2&SM∙3 |
| H2-4 | Large rockpool waterbody | SA∙2&SM∙4 |
| H2-5 | Small rockpool waterbody | SA∙2&SM∙5 |
| H2-6 | Temporal rockpool | SA∙2&SM∙6 |
| H2-7 | Large brackish lagoon waterbody | SA∙1&SM∙2 |
| H2-8 | Small and medium-sized brackish lagoon waterbody | SA∙1&SM∙3 |
| H3-1 | Anoxic marine waterbody |  |
| H4-1 | Marine waterbody of strongly modified sites | SY∙A |
| H4-2 | Marine waterbody with strongly modified chemical composition | SY∙B |
| H4-3 | Marine waterbody with strongly modified biological composition | SY∙C |
| H4-4 | New marine waterbody | SY∙D |
| L1-1 | Lime-poor low to moderate-energy freshwater rock | HU∙1&KA∙1&VF∙1 |
| L1-2 | Intermediately lime-poor low- to moderate-energy freshwater rock | HU∙1&KA∙2&VF∙1 |
| L1-3 | Lime-rich low to moderate-energy freshwater rock | HU∙1&KA∙3&VF∙1 |
| L1-4 | Lime-poor high-energy freshwater rock | HU∙1&KA∙1&VF∙2 |
| L1-5 | Intermediately lime-poor high-energy freshwater rock | HU∙1&KA∙2&VF∙2 |
| L1-6 | Lime-rich high-energy freshwater rock | HU∙1&KA∙3&VF∙2 |
| L1-7 | Freshwater rock in humus-rich water | HU∙2&KA∙1&VF∙1 |
| L2-1 | Lime-poor freshwater sand and gravel | KA∙1&S3∙E∙1,2&S3∙F∙1 |
| L2-2 | Lime-poor freshwater clay, silt and muddy sand | KA∙1&S3∙E∙1&S3∙F∙2 |
| L2-3 | Lime-poor freshwater stone | KA∙1&S3∙E∙3&S3∙F∙1 |
| L2-4 | Lime-poor freshwater dy | KA∙1&S3∙E∙1&S3∙F∙2&IO∙2 |
| L2-5 | Lime-poor fen-pool peat | KA∙1&S3∙S∙A&S3∙F∙2 |
| L2-6 | Bog-pool peat | KA∙1&S3∙S∙A&S3∙F∙2&VT∙B |
| L2-7 | Intermediately lime-poor freshwater sand and gravel | KA∙2&S3∙E∙1,2&S3∙F∙1 |
| L2-8 | Intermediately lime-poor freshwater clay, silt and muddy sand | KA∙2&S3∙E∙1&S3∙F∙2 |
| L2-9 | Intermediately lime-poor freshwater muddy gravel and stone | KA∙2&S3∙E∙2&S3∙F∙2 |
| L2-10 | Intermediately lime-poor freshwater gravel and stone | KA∙2&S3∙E∙3&S3∙F∙1 |
| L2-11 | Intermediately lime-poor freshwater dy | KA∙2&S3∙E∙1&S3∙F∙2&IO∙2 |
| L2-12 | Intermediately lime-poor fen-pool peat | KA∙2&S3∙S∙A&S3∙F∙2 |
| L2-13 | Lime-rich freshwater sand and gravel | KA∙3&S3∙E∙1,2&S3∙F∙1 |
| L2-14 | Lime-rich freshwater clay, silt and muddy sand | KA∙3&S3∙E∙1&S3∙F∙2 |
| L2-15 | Lime-rich freshwater muddy gravel and stone | KA∙3&S3∙E∙2&S3∙F∙2 |
| L2-16 | Lime-rich freshwater gravel and stone | KA∙3&S3∙E∙3&S3∙F∙1 |
| L2-17 | Lime-rich freshwater gyttja | KA∙3&S3∙E∙1&S3∙F∙2&IO∙2 |
| L2-18 | Lime-rich fen-pool peat | KA∙3&S3∙S∙A&S3∙F∙2 |
| L2-19 | Freshwater-bed with disruptive sedimentation | KA∙1,2&S3∙E∙1,2&S3∙F∙1&SE∙B |
| L3-1 | Lime-poor and intermediately lime-rich aphotic freshwater sediment | KA∙1 |
| L3-2 | Lime-rich aphotic freshwater sediment | KA∙2 |
| L4-1 | Lime-poor freshwater swamp | KA∙1 |
| L4-2 | Intermediately lime-rich freshwater swamp | KA∙2 |
| L4-3 | Lime-rich freshwater swamp | KA∙3 |
| L5-1 | Intermediately lime-rich spring bottom without peat formation | KA∙1&KT∙A |
| L5-2 | Intermediately lime-rich peaty spring bottom | KA∙1&KT∙B |
| L5-3 | Intermediately lime-rich river and lake spring | KA∙1&KT∙C |
| L5-4 | Lime-rich spring bottom | KA∙2&KT∙A |
| L6-1 | Periodically anoxic freshwater sediment | OM∙1 |
| L6-2 | Anoxic freshwater sediment | OM∙2 |
| L7-1 | Strongly modified lake rock | SX∙c&HS∙A |
| L7-2 | Strongly modified river rock | SX∙c&HS∙B |
| L7-3 | Submerged, formerly terrestrial rock | SX∙c&HS∙C |
| L8-1 | Strongly modified and new lake sediment | SX∙d&HS∙A |
| L8-2 | Strongly modified and new river sediment | SX∙d&HS∙B |
| L8-3 | Strongly modified, contaminated freshwater sediment | SX∙d&HS∙C |
| L8-4 | Strongly modified spring bottom | SX∙d&HS∙D |
| L8-5 | Regulated lake-bed | SX∙d&HS∙E |
| L8-6 | Regulated river-bed | SX∙d&HS∙F |
| L8-7 | Submerged, formerly terrestrial sediments | SX∙d&HS∙G |
| L8-8 | Submerged former wetland | SX∙d&HS∙H |
| F1-1 | Lime-poor humus-poor low-energy river waterbody | KA∙1&VF∙1&HU∙1 |
| F1-2 | Lime-poor humus-rich low-energy waterbody | KA∙1&VF∙1&HU∙2 |
| F1-3 | Lime-poor humus-poor high-energy river waterbody | KA∙1&VF∙2&HU∙1 |
| F1-4 | Lime-poor humus-rich high-energy river waterbody | KA∙1&VF∙2&HU∙2 |
| F1-5 | Lime-rich humus-poor river waterbody | KA∙2&VF∙1&HU∙1 |
| F1-6 | Lime-rich humus-rich river waterbody | KA∙2&VF∙1&HU∙2 |
| F2-1 | Lime-poor circulating deep-lake waterbody | HU∙1&SM∙1&KA∙1 |
| F2-2 | Intermediately lime-rich circulating deep-lake waterbody | HU∙1&SM∙1&KA∙2 |
| F2-3 | Lime-rich circulating deep-lake waterbody | HU∙1&SM∙1&KA∙3 |
| F2-4 | Lime-poor waterbody in small or shallow lake | HU∙1&SM∙2&KA∙1 |
| F2-5 | Intermediately lime-rich waterbody in small or shallow lake | HU∙1&SM∙2&KA∙2 |
| F2-6 | Lime-rich waterbody in small or shallow lake | HU∙1&SM∙2&KA∙3 |
| F2-7 | Lime-poor pond waterbody | HU∙1&SM∙3&KA∙1 |
| F2-8 | Intermediately lime-rich pond waterbody | HU∙1&SM∙3&KA∙2 |
| F2-9 | Lime-rich pond waterbody | HU∙1&SM∙3&KA∙3 |
| F2-10 | Temporary pond waterbody | HU∙1&SM∙4&KA∙1∙3 |
| F2-11 | Lime-poor turbid circulating deep-lake waterbody | HU∙1&SM∙1&KA∙1&TU∙2 |
| F2-12 | Lime-poor turbid waterbody in small or shallow lake | HU∙1&SM∙2&KA∙1&TU∙2 |
| F2-13 | Lime-poor humus-rich circulating deep-lake waterbody | HU∙2&SM∙1&KA∙1 |
| F2-14 | Intermediately lime-rich humus-rich circulating deep-lake waterbody | HU∙2&SM∙1&KA∙2 |
| F2-15 | Lime-rich humus-rich circulating deep-lake waterbody | HU∙2&SM∙1&KA∙3 |
| F2-16 | Lime-poor humus-rich waterbody in small or shallow lake | HU∙2&SM∙2&KA∙1 |
| F2-17 | Intermediately lime-rich humus-rich waterbody in small or shallow lake | HU∙2&SM∙2&KA∙2 |
| F2-18 | Lime-rich humus-rich waterbody in small or shallow lake | HU∙2&SM∙2&KA∙3 |
| F2-19 | Lime-poor humus-rich pond waterbody | HU∙2&SM∙3&KA∙1 |
| F2-20 | Intermediately lime-rich humus-rich pond waterbody | HU∙2&SM∙3&KA∙2 |
| F2-21 | Lime-rich humus-rich pond waterbody | HU∙2&SM∙3&KA∙3 |
| F3-1 | Anoxic lake waterbody |  |
| F4-1 | River waterbody of strongly modified sites | SY∙A |
| F4-2 | River waterbody with strongly modified chemical composition | SY∙B |
| F4-3 | River waterbody with strongly modified biological composition | SY∙C |
| F5-1 | Lake waterbody of strongly modified sites | SY∙A |
| F5-2 | Lake waterbody with strongly modified chemical composition | SY∙B |
| F5-3 | Lake waterbody with strongly modified biological composition | SY∙C |
| F5-4 | New lake waterbody | SY∙D |
| T1-1 | Lime-poor hardly desiccation-prone rock wall | OR∙1&HF∙2&KA∙1&UE∙1 |
| T1-2 | Lime-poor somewhat desiccation-prone rock wall | OR∙1&HF∙2&KA∙1&UE∙2 |
| T1-3 | Lime-poor moderately desiccation-prone rock wall | OR∙1&HF∙2&KA∙1&UE∙3 |
| T1-4 | Lime-poor strongly desiccation-prone rock wall | OR∙1&HF∙2&KA∙1&UE∙4 |
| T1-5 | Weakly intermediately lime-rich hardly desiccation-prone rock wall | OR∙1&HF∙2&KA∙2&UE∙1 |
| T1-6 | Weakly intermediately lime-rich somewhat desiccation-prone rock wall | OR∙1&HF∙2&KA∙2&UE∙2 |
| T1-7 | Weakly intermediately lime-rich moderately desiccation-prone rock wall | OR∙1&HF∙2&KA∙2&UE∙3 |
| T1-8 | Weakly intermediately lime-rich strongly desiccation-prone rock wall | OR∙1&HF∙2&KA∙2&UE∙4 |
| T1-9 | Strongly intermediately lime-rich hardly desiccation-prone rock wall | OR∙1&HF∙2&KA∙3&UE∙1 |
| T1-10 | Strongly intermediately lime-rich somewhat desiccation-prone rock wall | OR∙1&HF∙2&KA∙3&UE∙2 |
| T1-11 | Strongly intermediately lime-rich moderately desiccation-prone rock wall | OR∙1&HF∙2&KA∙3&UE∙3 |
| T1-12 | Strongly intermediately lime-rich strongly desiccation-prone rock wall | OR∙1&HF∙2&KA∙3&UE∙4 |
| T1-13 | Moderately lime-rich hardly desiccation-prone rock wall | OR∙1&HF∙2&KA∙4&UE∙1 |
| T1-14 | Moderately lime-rich somewhat desiccation-prone rock wall | OR∙1&HF∙2&KA∙4&UE∙2 |
| T1-15 | Moderately intermediately lime-rich moderately desiccation-prone rock wall | OR∙1&HF∙2&KA∙4&UE∙3 |
| T1-16 | Moderately intermediately lime-rich strongly desiccation-prone rock wall | OR∙1&HF∙2&KA∙4&UE∙4 |
| T1-17 | Extremely lime-rich hardly desiccation-prone rock wall | OR∙1&HF∙2&KA∙5&UE∙1 |
| T1-18 | Extremely lime-rich somewhat desiccation-prone rock wall | OR∙1&HF∙2&KA∙5&UE∙2 |
| T1-19 | Extremely lime-rich moderately desiccation-prone rock wall | OR∙1&HF∙2&KA∙5&UE∙3 |
| T1-20 | Extremely lime-rich strongly desiccation-prone rock wall | OR∙1&HF∙2&KA∙5&UE∙4 |
| T1-21 | Lime-poor hardly desiccation-prone rock with periodic surface waterflow | OR∙2&KA∙1&UE∙12 |
| T1-22 | Lime-poor somewhat desiccation-prone rock with periodic surface waterflow | OR∙2&KA∙1&UE∙3 |
| T1-23 | Lime-poor moderately desiccation-prone rock with periodic surface waterflow | OR∙2&KA∙1&UE∙4 |
| T1-24 | Weakly intermediately lime-rich hardly desiccation-prone rock with periodic surface waterflow | OR∙2&KA∙2&UE∙1,2 |
| T1-25 | Weakly intermediately lime-rich somewhat desiccation-prone rock with periodic surface waterflow | OR∙2&KA∙2&UE∙3 |
| T1-26 | Weakly intermediately lime-rich moderately desiccation-prone rock with periodic surface waterflow | OR∙2&KA∙2&UE∙4 |
| T1-27 | Strongly intermediately lime-rich hardly desiccation-prone rock with periodic surface waterflow | OR∙2&KA∙3&UE∙1,2 |
| T1-28 | Strongly intermediately lime-rich somewhat desiccation-prone rock with periodic surface waterflow | OR∙2&KA∙3&UE∙3 |
| T1-29 | Strongly intermediately lime-rich moderately desiccation-prone rock with periodic surface waterflow | OR∙2&KA∙3&UE∙4 |
| T1-30 | Lime-rich hardly desiccation-prone rock with periodic surface waterflow | OR∙2&KA∙4,5&UE∙1,2 |
| T1-31 | Lime-rich somewhat desiccation-prone rock with periodic surface waterflow | OR∙2&KA∙4,5&UE∙3 |
| T1-32 | Lime-rich moderately desiccation-prone rock with periodic surface waterflow | OR∙2&KA∙4,5&UE∙4 |
| T1-33 | Lime-poor somewhat desiccation-prone rock with frequent surface waterflow | OR∙3&KA∙1&UE∙1,2 |
| T1-34 | Lime-poor desiccation-prone rock with frequent surface waterflow | OR∙3&KA∙1&UE∙3,4 |
| T1-35 | Weakly intermediately lime-rich somewhat desiccation-prone rock with frequent surface waterflow | OR∙3&KA∙2&UE∙1,2 |
| T1-36 | Weakly intermediately lime-rich desiccation-prone rock with frequent surface waterflow | OR∙3&KA∙2&UE∙3,4 |
| T1-37 | Strongly intermediately lime-rich somewhat desiccation-prone rock with frequent surface waterflow | OR∙3&KA∙3&UE∙1,2 |
| T1-38 | Strongly intermediately lime-rich desiccation-prone rock with frequent surface waterflow | OR∙3&KA∙3&UE∙3,4 |
| T1-39 | Lime-rich somewhat desiccation-prone rock with frequent surface waterflow | OR∙3&KA∙4,5&UE∙1,2 |
| T1-40 | Lime-rich desiccation-prone rock with frequent surface waterflow | OR∙3&KA∙4,5&UE∙3,4 |
| T1-41 | Lime-poor hardly desiccation-prone rock outcrop | OR∙1&HF∙1&KA∙1&UE∙1 |
| T1-42 | Lime-poor somewhat desiccation-prone rock outcrop | OR∙1&HF∙1&KA∙1&UE∙2 |
| T1-43 | Lime-poor moderately desiccation-prone rock outcrop | OR∙1&HF∙1&KA∙1&UE∙3 |
| T1-44 | Lime-poor strongly desiccation-prone rock outcrop | OR∙1&HF∙1&KA∙1&UE∙4 |
| T1-45 | Weakly intermediately lime-rich hardly desiccation-prone rock outcrop | OR∙1&HF∙1&KA∙2&UE∙1 |
| T1-46 | Weakly intermediately lime-rich somewhat desiccation-prone rock outcrop | OR∙1&HF∙1&KA∙2&UE∙2 |
| T1-47 | Weakly intermediately lime-rich moderately desiccation-prone rock outcrop | OR∙1&HF∙1&KA∙2&UE∙3 |
| T1-48 | Weakly intermediately lime-rich strongly desiccation-prone rock outcrop | OR∙1&HF∙1&KA∙2&UE∙4 |
| T1-49 | Strongly intermediately lime-rich hardly desiccation-prone rock outcrop | OR∙1&HF∙1&KA∙3&UE∙1 |
| T1-50 | Strongly intermediately lime-rich somewhat desiccation-prone rock outcrop | OR∙1&HF∙1&KA∙3&UE∙2 |
| T1-51 | Strongly intermediately lime-rich moderately desiccation-prone rock outcrop | OR∙1&HF∙1&KA∙3&UE∙3 |
| T1-52 | Strongly intermediately lime-rich, strongly desiccation-prone rock outcrop | OR∙1&HF∙1&KA∙3&UE∙4 |
| T1-53 | Moderately lime-rich hardly desiccation-prone rock outcrop | OR∙1&HF∙2&KA∙4&UE∙1 |
| T1-54 | Moderately lime-rich somewhat desiccation-prone rock outcrop | OR∙1&HF∙2&KA∙4&UE∙2 |
| T1-55 | Moderately lime-rich moderately desiccation-prone rock outcrop | OR∙1&HF∙2&KA∙4&UE∙3 |
| T1-56 | Moderately lime-rich strongly desiccation-prone rock outcrop | OR∙1&HF∙2&KA∙4&UE∙4 |
| T1-57 | Extremely lime-rich hardly desiccation-prone rock outcrop | OR∙1&HF∙2&KA∙5&UE∙1 |
| T1-58 | Extremely lime-rich somewhat desiccation-prone rock outcrop | OR∙1&HF∙2&KA∙5&UE∙2 |
| T1-59 | Extemely lime-rich moderately desiccation-prone rock outcrop | OR∙1&HF∙2&KA∙5&UE∙3 |
| T1-60 | Extremely lime-rich strongly desiccation-prone rock outcrop | OR∙1&HF∙2&KA∙5&UE∙4 |
| T1-61 | Lime-poor alluvial rock outcrop | VF∙2&KA∙1&HF∙1 |
| T1-62 | Lime-poor alluvial rock wall | VF∙2&KA∙1&HF∙2 |
| T1-63 | Weakly intermediately lime-rich alluvial rock outcrop | VF∙2&KA∙2&HF∙1 |
| T1-64 | Weakly intermediately lime-rich alluvial rock wall | VF∙2&KA∙2&HF∙2 |
| T1-65 | Strongly intermediately lime-rich alluvial rock outcrop | VF∙2&KA∙3&HF∙1 |
| T1-66 | Strongly intermediately lime-rich alluvial rock wall | VF∙2&KA∙3&HF∙2 |
| T1-67 | Lime-rich alluvial rock outcrop | VF∙2&KA∙4,5&HF∙1 |
| T1-68 | Lime-rich alluvial rock wall | VF∙2&KA∙4,5&HF∙2 |
| T1-69 | Lime-poor water-sprayed rock outcrop | VS∙2&KA∙1&HF∙1 |
| T1-70 | Lime-poor water-sprayed rock wall | VS∙2&KA∙1&HF∙2 |
| T1-71 | Weakly intermediately lime-rich water-sprayed rock outcrop | VS∙2&KA∙2&HF∙1 |
| T1-72 | Weakly intermediately lime-rich water-sprayed rock wall | VS∙2&KA∙2&HF∙2 |
| T1-73 | Strongly intermediately lime-rich water-sprayed rock outcrop | VS∙2&KA∙3&HF∙1 |
| T1-74 | Strongly intermediately lime-rich water-sprayed rock wall | VS∙2&KA∙3&HF∙2 |
| T1-75 | Lime-rich water-sprayed rock outcrop | VS∙2&KA∙4,5&HF∙1 |
| T1-76 | Lime-rich water-sprayed rock wall | VS∙2&KA∙4,5&HF∙2 |
| T1-77 | Lime-poor hardly to somewhat desiccation-prone pioneer-phase rock | KA∙1,2&UE∙1,2&LA∙1 |
| T1-78 | Lime-poor desiccation-prone pioneer-phase rock | KA∙1,2&UE∙3,4&LA∙1 |
| T1-79 | Lime-rich hardly to somewhat desiccation-prone pioneer-phase rock | KA∙3∙5&UE∙1,2&LA∙1 |
| T1-80 | Lime-rich desiccation-prone pioneer-phase rock | KA∙3∙5&UE∙3,4&LA∙1 |
| T1-81 | Lime-poor snowbed rock | KA∙1,2&UE∙1∙4&SV∙2 |
| T1-82 | Lime-rich snowbed rock | KA∙3∙5&UE∙1∙4&SV∙2 |
| T1-83 | Lime-poor wind-exposed rock | KA∙1,2&UE∙1∙4&VI∙2 |
| T1-84 | Lime-rich wind-exposed rock | KA∙3∙5&UE∙1∙4&VI∙2 |
| T1-85 | Perching stone and bird cliff | KA∙1∙5&UE∙1∙4&NG∙2 |
| T2-1 | Lime-poor open subxeric shallow-soil ground | KA1&UF1 |
| T2-2 | Lime-poor open xeric shallow-soil ground | KA1&UF2 |
| T2-3 | Intermediately lime-rich open subxeric shallow-soil ground | KA2&UF1 |
| T2-4 | Intermediately lime-rich open xeric shallow-soil ground | KA2&UF2 |
| T2-5 | Moderately lime-rich open subxeric shallow-soil ground | KA3&UF1 |
| T2-6 | Moderately lime-rich open xeric shallow-soil ground | KA3&UF2 |
| T2-7 | Strongly lime-rich open subxeric shallow-soil ground | KA4&UF1 |
| T2-8 | Strongly lime-rich open xeric shallow-soil ground | KA4&UF2 |
| T3-1 | Lime-poor alpine lee side | KA1&UF1 |
| T3-2 | Lime-poor alpine subxeric heath | KA1&UF2 |
| T3-3 | Lime-poor alpine xeric heath | KA1&UF3 |
| T3-4 | Intermediately lime-rich alpine lee side | KA2&UF1 |
| T3-5 | Intermediately lime-rich alpine subxeric heath | KA2&UF2 |
| T3-6 | Intermediately lime-rich alpine xeric heath | KA2&UF3 |
| T3-7 | Moderately lime-rich alpine lee-side | KA3&UF1 |
| T3-8 | Moderately lime-rich alpine subxeric heath | KA3&UF2 |
| T3-9 | Moderately lime-rich alpine xeric heath | KA3&UF3 |
| T3-10 | Strongly lime-rich alpine lee-side | KA4&UF1 |
| T3-11 | Strongly lime-rich alpine subxeric heath | KA4&UF2 |
| T3-12 | Strongly lime-rich alpine xeric heath | KA4&UF3 |
| T3-13 | Intermediately lime-rich alpine tall-herb meadow | KA2&UF3&KI∙2 |
| T3-14 | Lime-rich alpine tall-herb meadow | KA3,4&UF3&KI∙2 |
| T4-1 | Lime-poor submesic forest | UF∙1&KA∙1 |
| T4-2 | Intermediately lime-rich submesic forest | UF∙1&KA∙2 |
| T4-3 | Moderately lime-rich submesic forest | UF∙1&KA∙3 |
| T4-4 | Strongly lime-rich submesic forest | UF∙1&KA∙4 |
| T4-5 | Lime-poor submesic to subxeric forest | UF∙2&KA∙1 |
| T4-6 | Intermediately lime-rich submesic to subxeric forest | UF∙2&KA∙2 |
| T4-7 | Moderately lime-rich submesic to subxeric forest | UF∙2&KA∙3 |
| T4-8 | Strongly lime-rich submesic to subxeric forest | UF∙2&KA∙4 |
| T4-9 | Lime-poor subxeric forest | UF∙3&KA∙1 |
| T4-10 | Intermediately lime-rich subxeric forest | UF∙3&KA∙2 |
| T4-11 | Moderately lime-rich subxeric forest | UF∙3&KA∙3 |
| T4-12 | Strongly lime-rich subxeric forest | UF∙3&KA∙4 |
| T4-13 | Lime-poor xeric forest | UF∙4&KA∙1 |
| T4-14 | Intermediately lime-rich xeric forest | UF∙4&KA∙2 |
| T4-15 | Moderately lime-rich xeric forest | UF∙4&KA∙3 |
| T4-16 | Strongly lime-rich xeric forest | UF∙4&KA∙4 |
| T4-17 | Intermediately lime-rich tall-herb forest | UF∙1&KA∙2&KI∙2 |
| T4-18 | Strongly lime-rich tall-herb forest | UF∙1&KA∙34&KI∙2 |
| T4-19 | Strongly lime-rich submesic tall-herb forest | UF∙2&KA∙34&KI∙2 |
| T4-20 | Strongly lime-rich subxeric tall-herb forest | UF∙3&KA∙34&KI∙2 |
| T5-1 | Lime-poor overhang | GS∙1&KA∙1 |
| T5-2 | Intermediately lime-rich to moderately lime-rich overhang | GS∙1&KA∙2 |
| T5-3 | Strongly lime-rich overhang | GS∙1&KA∙3 |
| T5-4 | Lime-poor to moderately lime-rich cave entrance | GS∙2&KA∙1,2 |
| T5-5 | Lime-rich cave entrance | GS∙2&KA∙3 |
| T5-6 | Lime-poor to moderately lime-rich cave interior | GS∙3&KA∙1,2 |
| T5-7 | Lime-rich cave interior | GS∙3&KA∙3 |
| T5-8 | Lime-poor desiccation-prone overhang | GS∙1&KA∙1&UE∙2 |
| T5-9 | Intermediately lime-rich to moderately lime-rich desiccation-prone overhang | GS∙1&KA∙2&UE∙2 |
| T5-10 | Lime-rich desiccation-prone overhang | GS∙1&KA∙3&UE∙2 |
| T6-1 | Sheltered lower supralittoral rock outcrop | TV∙1&KA∙1&VF∙1&HF∙1&IF∙A |
| T6-2 | Sheltered middle supralittoral rock outcrop | TV∙2&KA∙1&VF∙1&HF∙1&IF∙A |
| T6-3 | Sheltered upper supralittoral rock outcrop | TV∙3&KA∙1&VF∙1&HF∙1&IF∙A |
| T6-4 | Lime-rich sheltered upper supralittoral rock outcrop | TV∙3&KA∙2&VF∙1&HF∙1&IF∙A |
| T6-5 | Exposed lower supralittoral rock outcrop | TV∙1&KA∙1&VF∙2&HF∙1&IF∙A |
| T6-6 | Exposed middle supralittoral rock outcrop | TV∙2&KA∙1&VF∙1&HF∙2&IF∙A |
| T6-7 | Exposed upper supralittoral rock outcrop | TV∙3&KA∙1&VF∙1&HF∙1&IF∙B |
| T7-1 | Extremely lime-poor moderate snowbed | KA∙1&SV∙1 |
| T7-2 | Moderately lime-poor moderate snowbed | KA∙2&SV∙1 |
| T7-3 | Intermediately lime-rich moderate late snowbed | KA∙3&SV∙1 |
| T7-4 | Lime-poor to intermediately lime-rich late snowbed | KA∙2,3&SV∙2 |
| T7-5 | Lime-poor to intermediate lime-rich extremely late snowbed | KA∙2,3&SV∙3 |
| T7-6 | Moderately lime-rich moderate snowbed | KA∙4&SV∙1 |
| T7-7 | Moderately lime-rich late snowbed | KA∙4&SV∙2 |
| T7-8 | Strongly lime-rich moderate snowbed | KA∙5&SV∙1 |
| T7-9 | Strongly lime-rich late snowbed | KA∙5&SV∙2 |
| T7-10 | Lime-rich extreme snowbed | KA∙4,5&SV∙3 |
| T7-11 | Unvegetated extreme snowbed | KA∙2∙5&SV∙4 |
| T7-12 | Intermediately lime-rich moderate tall-herb snowbed | KA∙3&SV∙1&KI∙2 |
| T7-13 | Lime-rich moderate tall-herb snowbed | KA∙4&SV∙1&KI∙2 |
| T7-14 | Strongly lime-rich moderate tall-herb snowbed | KA∙5&SV∙1&KI∙2 |
| T8-1 | Mesotrophic bird-cliff meadow | UF∙A&NG∙1 |
| T8-2 | Moderately eutrophic bird-cliff meadow | UF∙A&NG∙2 |
| T8-3 | Strongly eutrophic bird-cliff meadow | UF∙A&NG∙3 |
| T8-4 | Mesotrophic tall-herb bird-cliff meadow | UF∙A&NG∙1&KI∙2 |
| T8-5 | Bird-perching mound | UF∙B&NG∙1 |
| T9-1 | Lime-poor to intermediately lime-rich moss tundra | KA∙1 (cde) |
| T9-2 | Lime-rich moss tundra | KA∙2 (fghi) |
| T10-1 | Arctic steppe heath | VI∙1 |
| T10-2 | Wind-exposed arctic steppe ridge | VI∙2 |
| T11-1 | Geolittoral hypersaline tidal gravel-dominated marsh | S1∙A&TV∙1 |
| T11-2 | Supralittoral hypersaline tidal gravel-dominated marsh | S1∙A&TV∙2 |
| T11-3 | Geolittoral hypersaline silt- and clay-dominated tidal marsh | S1∙B&TV∙1 |
| T12-1 | Lower geolittoral tidal meadow | TV∙1 |
| T12-2 | Middle geolittoral tidal meadow | TV∙2 |
| T12-3 | Upper geolittoral tidal meadow | TV∙3 |
| T12-4 | Supralittoral tidal meadow | TV∙4 |
| T13-1 | Lime-poor desiccation-prone boulder-dominated talus slope | UE∙2&KA∙1&S1∙A |
| T13-2 | Lime-poor desiccation-prone stone-dominated talus slope | UE∙2&KA∙1&S1∙B |
| T13-3 | Lime-poor desiccation-prone sand- and gravel-dominated talus slope | UE∙2&KA∙1&S1∙C |
| T13-4 | Intermediately to moderately lime-rich desiccation-prone boulder-dominated talus slope | UE∙2&KA∙2&S1∙A |
| T13-5 | Intermediately to moderately lime-rich desiccation-prone stone-dominated talus slope | UE∙2&KA∙2&S1∙B |
| T13-6 | Intermediately to moderately lime-rich desiccation-prone sand- and gravel-dominated talus slope | UE∙2&KA∙2&S1∙C |
| T13-7 | Strongly lime-rich desiccation-prone boulder-dominated talus slope | UE∙2&KA∙3&S1∙A |
| T13-8 | Strongly lime-rich desiccation-prone stone-dominated talus slope | UE∙2&KA∙3&S1∙B |
| T13-9 | Strongly lime-rich desiccation-prone sand- and gravel-dominated talus slope | UE∙2&KA∙3&S1∙C |
| T13-10 | Lime-poor hardly desiccation-prone boulder-dominated talus slope | UE∙1&KA∙1&S1∙A |
| T13-11 | Lime-poor hardly desiccation-prone stone-dominated talus slope | UE∙1&KA∙1&S1∙B |
| T13-12 | Intermediately to moderately lime-rich hardly desiccation-prone boulder-dominated talus slope | UE∙1&KA∙2&S1∙A |
| T13-13 | Intermediately to moderately lime-rich hardly desiccation-prone stone-dominated talus slope | UE∙1&KA∙2&S1∙B |
| T13-14 | Strongly lime-rich hardly desiccation-prone boulder-dominated talus slope | UE∙1&KA∙3&S1∙A |
| T13-15 | Strongly lime-rich hardly desiccation-prone stone-dominated talus slope | UE∙1&KA∙3&S1∙B |
| T13-16 | Unstabilised boulder-dominated talus slope | UE∙1&KA∙1,2,3&S1∙A&RU∙B |
| T13-17 | Unstabilised stone-dominated talus slope | UE∙1&KA∙1,2,3&S1∙B&RU∙B |
| T13-18 | Unstabilised sand- and gravel-dominated talus slope | UE∙1&KA∙1,2,3&S1∙C&RU∙B |
| T14-1 | Lime-poor to intermediately lime-rich alpine ridge | VI∙A&KA∙1 |
| T14-2 | Lime-rich alpine ridge | VI∙A&KA∙2 |
| T14-3 | Wind-deflated alpine ridge | VI∙B&KA∙1,2 |
| T15-1 | Lime-poor to intermediately lime-rich waterfall-sprayed meadow | KA∙1 |
| T15-2 | Lime-rich waterfall-sprayed meadow | KA∙2 |
| T16-1 | Lime-poor talus-slope heath | KA∙1&KI∙1&RU∙1 |
| T16-2 | Intermediately lime-rich talus-slope heath | KA∙2&KI∙1&RU∙1 |
| T16-3 | Moderately lime-rich talus-slope meadow | KA∙3&KI∙1&RU∙1 |
| T16-4 | Extremely lime-rich talus-slope meadow | KA∙4&KI∙1&RU∙1 |
| T16-5 | Intermediately lime-rich tall-herb talus-slope | KA∙2&KI∙2&RU∙1 |
| T16-6 | Lime-rich tall-herb talus slope | KA∙3,4&KI∙2&RU∙1 |
| T16-7 | Talus slope with high avalanche intensity | KA∙1,2,3,4&KI∙1&RU∙2 |
| T17-1 | Soil-dominated landslide | S1∙A |
| T17-2 | Gravel-dominated landslide | S1∙B |
| T17-3 | Sand-dominated landslide | S1∙C |
| T17-4 | Silt- and clay-dominted landslide | S1∙D |
| T18-1 | Moderately exposed open alluvial gravel- and stone-dominated sediment | S1∙A&VF∙1 |
| T18-2 | Moderately exposed open alluvial sand-dominated sediment | S1∙B&VF∙1 |
| T18-3 | Moderately exposed open alluvial silt- and clay-dominated sediment | S1∙C&VF∙1 |
| T18-4 | Strongly exposed open alluvial sediment | S1∙A,B,C&VF∙2 |
| T18-5 | Moderately exposed lime-rich open alluvial stone-dominated sediment | S1∙A&VF∙1&KA∙2 |
| T18-6 | Moderately exposed open alluvial sand-dominated erosion-prone sediment | S1∙B&VF∙1&ER∙2 |
| T19-1 | Lime-poor and intermediately lime-rich fine-textured soil patch in patterned ground | S1∙A&KA∙1,2 |
| T19-2 | Lime-rich fine-textured soil patch in patterned ground | S1∙B&KA∙1 |
| T19-3 | Stone border of patterned ground | S1∙B&KA∙2 |
| T20-1 | Lime-poor to intermediately lime-rich frost heath | KA∙1 |
| T20-2 | Lime-rich frost heath | KA∙2 |
| T21-1 | Tidal sand shore | SS∙1 |
| T21-2 | Primary dune | SS∙2 |
| T21-3 | White dune | SS∙3 |
| T21-4 | Grey dune | SS∙4 |
| T21-5 | Brown dune | SS∙5 |
| T21-6 | Dune heath | SS∙6 |
| T21-7 | Eroded dune | SS∙4,5&VI∙B |
| T21-8 | Dune slack | SS∙5,6&VM∙2 |
| T22-1 | Lime-poor and intermediately lime-rich alpine dry-grass heath | KA∙1&SV∙1 |
| T22-2 | Lime-poor and intermediately lime-rich alpine dry-grass snowbed | KA∙1&SV∙2 |
| T22-3 | Lime-rich alpine dry-grass heath | KA∙2&SV∙1 |
| T22-4 | Lime-rich alpine dry-grass snowbed | KA∙2&SV∙2 |
| T23-1 | Freshwater driftline |  |
| T24-1 | Sheltered tall-herb driftline | VF∙1 |
| T24-2 | Moderately exposed perennial driftline | VF∙2 |
| T24-3 | Exposed annual driftline | VF∙3 |
| T25-1 | Historical soil landslide | S1∙A |
| T25-2 | Historical gravel landslide | S1∙B |
| T25-3 | Historical sand landslide | S1∙C |
| T25-4 | Historical silt and clay landslide | S1∙D |
| T26-1 | Well-drained alpine heath initials of glacier foreland | SV∙1&VM∙1 |
| T26-2 | Paludified alpine heath initials of glacier foreland | SV∙1&VM∙2 |
| T26-3 | Well-drained snowbed initials of glacier foreland | SV∙2&VM∙1 |
| T26-4 | Paludified snowbed initials of glacier foreland | SV∙2&VM∙2 |
| T26-5 | Pioneer glacier foreland on gravel and stone | LA∙1&S1∙A |
| T26-6 | Pioneer glacier foreland on sand | LA∙1&S1∙B |
| T26-7 | Pioneer glacier foreland on silt and clay | LA∙1&S1∙C |
| T27-1 | Lime-poor to intermediately lime-rich boulder field | SV∙1&KA∙1 |
| T27-2 | Lime-poor to intermediately lime-rich boulder snowbed | SV∙2&KA∙1 |
| T27-3 | Lime-rich boulder field | SV∙1&KA∙2 |
| T27-4 | Lime-rich boulder snowbed | SV∙2&KA∙2 |
| T27-5 | Boulder field in unvegetated extreme snowbed | SV∙3&KA∙1,2 |
| T27-6 | Lime-poor to intermediately lime-rich wind-exposed boulder field | SV∙1&KA∙1&VI∙2 |
| T27-7 | Lime-rich wind-exposed boulder field | SV∙1&KA∙2&VI∙2 |
| T27-8 | Pioneer boulder field | LA∙1 |
| T28-1 | Lime-poor polar desert | KA∙1 |
| T28-2 | Intermediately lime-rich to moderately lime-rich polar desert | KA∙2 |
| T28-3 | Strongly lime-rich polar desert | KA∙3 |
| T29-1 | Epilittoral pioneer stone beach | TV∙2&S1∙A&LA∙1 |
| T29-2 | Epilittoral consolidated stone beach | TV∙2&S1∙A&LA∙2 |
| T29-3 | Epilittoral pioneer gravel beach | TV∙2&S1∙B&LA∙1 |
| T29-4 | Epilittoral consolidated gravel beach | TV∙2&S1∙B&LA∙2 |
| T29-5 | Epilittoral pioneer shell-bed beach | TV∙2&S1∙C&LA∙1 |
| T29-6 | Epilittoral consolidated shell-bed beach | TV∙2&S1∙C&LA∙2 |
| T29-7 | Supralittoral pioneer stone beach | TV∙1&S1∙A&LA∙1 |
| T29-8 | Supralittoral pioneer gravel beach | TV∙1&S1∙B&LA∙1 |
| T29-9 | Supralittoral pioneer shell-bed beach | TV∙1&S1∙C&LA∙1 |
| T29-10 | Wind-deflated supralittoral consolidated gravel beach | TV∙2&S1∙B&LA∙2&VI∙2 |
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| T30-2 | Strongly exposed alluvial forest on gravel- and stone-dominated sediment | S1∙A&VF∙2 |
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| T30-5 | Moderately exposed alluvial tall-herb forest | S1∙B&VF∙1&KI∙2 |
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| T31-2 | Lime-poor subxeric boreal heath | KA∙1&UF∙2 |
| T31-3 | Lime-poor xeric boreal heath | KA∙1&UF∙3 |
| T31-4 | Intermediately lime-rich submesic boreal heath | KA∙2&UF∙1 |
| T31-5 | Intermediately lime-rich subxeric boreal heath | KA∙2&UF∙2 |
| T31-6 | Intermediately lime-rich xeric boreal heath | KA∙2&UF∙3 |
| T31-7 | Moderately lime-rich submesic boreal heath | KA∙3&UF∙1 |
| T31-8 | Moderately lime-rich subxeric boreal heath | KA∙3&UF∙2 |
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| T31-10 | Strongly lime-rich submesic boreal heath | KA∙4&UF∙1 |
| T31-11 | Strongly lime-rich subxeric boreal heath | KA∙4&UF∙2 |
| T31-12 | Strongly lime-rich xeric boreal heath | KA∙4&UF∙3 |
| T31-13 | Intermediately lime-rich boreal tall-herb heath | KA∙2&UF∙1&KI∙2 |
| T31-14 | Lime-rich boreal tall-herb meadow | KA∙3,4&UF∙1&KI∙2 |
| T32-1 | Lime-poor low-intensity managed semi-natural grassland | KA∙1&HI∙1 |
| T32-2 | Lime-poor semi-natural grassland | KA∙1&HI∙2 |
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| T32-4 | Intermediately lime-rich semi-natural grassland | KA∙2&HI∙2 |
| T32-5 | Intermediately lime-rich high-intensity managed semi-natural grassland | KA∙2&HI∙3 |
| T32-6 | Moderately lime-rich low-intensity managed semi-natural grassland | KA∙3&HI∙1 |
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| T32-9 | Strongly lime-rich low-intensity managed semi-natural grassland | KA∙4&HI∙1 |
| T32-10 | Strongly lime-rich semi-natural grassland | KA∙4&HI∙2 |
| T32-11 | Lime-rich low-intensity managed semi-natural tall-herb grassland | KA∙3,4&HI∙1&KI∙2 |
| T32-12 | Lime-rich semi-natural tall-herb grassland | KA∙3,4&HI∙2,3&KI∙2 |
| T32-13 | Lime-poor low-intensity managed semi-natural dry grassland | KA∙1&HI∙1&UF∙2 |
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| T33-1 | Upper geolittoral semi-natural tidal meadow | TV∙1 |
| T33-2 | Supralittoral semi-natural tidal meadow | TV∙2 |
| T34-1 | Lime-poor submesic coastal heath | KA∙1&UF∙1 |
| T34-2 | Lime-poor subxeric coastal heath | KA∙1&UF∙2 |
| T34-3 | Lime-poor xeric coastal heath | KA∙1&UF∙3 |
| T34-4 | Intermediately lime-rich submesic coastal heath | KA∙2&UF∙1 |
| T34-5 | Intermediately lime-rich subxeric coastal heath | KA∙2&UF∙2 |
| T34-6 | Intermediately lime-rich xeric coastal heath | KA∙2&UF∙3 |
| T34-7 | Moderately lime-rich subxeric coastal heath | KA∙3&UF∙2 |
| T34-8 | Moderately lime-rich xeric coastal heath | KA∙3&UF∙3 |
| T34-9 | Strongly lime-rich subxeric coastal heath | KA∙4&UF∙2 |
| T34-10 | Strongly lime-rich xeric coastal heath | KA∙4&UF∙3 |
| T34-11 | Lime-poor wet coastal heath | KA∙1&UF∙2&VM∙2 |
| T34-12 | Intermediately lime-rich wet coastal heath | KA∙2&UF∙2&VM∙2 |
| T35-1 | Wasteland and artificial soil deposit | S1∙A |
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| T35-3 | Sand pit and artificial sand deposit | S1∙C |
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| T36-1 | Terrestrialised former wetland | HS∙A |
| T36-2 | Terrestrialised former river-bed sediment | HS∙B |
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| T37-1 | Strongly modified, contaminated surficial deposit | HS∙A |
| T37-2 | Inorganic strongly modified or synthetic, new soft artificial substrate | HS∙B |
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| T38-1 | Tree plantation |  |
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| T39-3 | Quarry, road cut and other artificial hard substrate in pioneer phase | HS∙B&LA∙1 |
| T39-4 | Quarry, road cut and other artificial hard substrate in consolidation phase | HS∙B&LA∙2 |
| T39-5 | Terrestrialised former freshwater rock in pioneer phase | HS∙C&LA∙1 |
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| T44-1 | Arable field |  |
| T45-1 | Agriculturally improved pasture | HI∙1&SP∙A |
| T45-2 | Low-intensity managed agriculturally improved grassland | HI∙1&SP∙B |
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| V1-1 | Strongly lime-poor fen expanse carpet | KA∙1&TV∙1 |
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| V1-4 | Strongly lime-poor fen expanse lower hummock | KA∙1&TV∙4 |
| V1-5 | Strongly lime-poor fen expanse upper hummock | KA∙1&TV∙5 |
| V1-6 | Moderately lime-poor fen expanse carpet | KA∙2&TV∙1 |
| V1-7 | Moderately lime-poor fen expanse lower lawn | KA∙2&TV∙2 |
| V1-8 | Moderately lime-poor fen expanse upper lawn | KA∙2&TV∙3 |
| V1-9 | Moderately lime-poor fen expanse lower hummock | KA∙2&TV∙4 |
| V1-10 | Intermediately lime-rich fen expanse carpet | KA∙3&TV∙1 |
| V1-11 | Intermediately lime-rich fen expanse lower lawn | KA∙3&TV∙2 |
| V1-12 | Intermediately lime-rich fen expanse upper lawn | KA∙3&TV∙3 |
| V1-13 | Intermediately lime-rich fen expanse lower hummock | KA∙3&TV∙4 |
| V1-14 | Moderately lime-rich fen expanse carpet | KA∙4&TV∙1 |
| V1-15 | Moderately lime-rich fen expanse lower lawn | KA∙4&TV∙2 |
| V1-16 | Moderately lime-rich fen expanse upper lawn | KA∙4&TV∙3 |
| V1-17 | Extremely lime-rich fen expanse carpet | KA∙5&TV∙1 |
| V1-18 | Extremely lime-rich fen expanse lower lawn | KA∙5&TV∙2 |
| V1-19 | Extremely lime-rich fen expanse upper lawn | KA∙5&TV∙3 |
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| V1-21 | Strongly lime-poor fen margin carpet and lower lawn | KA∙1&TV∙1,2&MF∙1 |
| V1-22 | Strongly lime-poor fen margin upper lawn and hummock | KA∙1&TV∙3∙5&MF∙1 |
| V1-23 | Moderately lime-poor fen margin carpet and lower lawn | KA∙2&TV∙1,2&MF∙1 |
| V1-24 | Moderately lime-poor fen margin upper lawn and lower hummock | KA∙2&TV∙3,4&MF∙1 |
| V1-25 | Intermediately lime-rich fen margin carpet and lower lawn | KA∙3&TV∙1,2&MF∙1 |
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| V1-27 | Moderatly lime-rich fen margin carpet and lower lawn | KA∙4&TV∙1,2&MF∙1 |
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| V1-29 | Lime-rich fen margin upper lawn and lower hummock | KA∙4,5&TV∙3,4&MF∙1 |
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| V1-31 | Lime-rich spring fen carpet and lower lawn | KA∙4&TV∙1,2&MF∙1&KI∙2 |
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| V2-6 | Lime-rich swamp forest hummock | KA∙3&TV∙2 |
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| V3-5 | Bog expanse upper hummock | TV∙5 |
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| V4-2 | Intermediately lime-rich astatic spring | KA∙2&KI∙1 |
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| V4-6 | Intermediately lime-rich peaty astatic spring | KA∙2&KI∙1&KT∙2 |
| V4-7 | Intermediately lime-rich peaty eustatic spring | KA∙2&KI∙2&KT∙2 |
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| V5-2 | Thermal spring | JV∙2 |
| V6-1 | Lime-poor to intermediately lime-rich moderate wet snowbed | SV∙1&KA∙1&KI∙1 |
| V6-2 | Lime-rich moderate wet snowbed | SV∙1&KA∙2&KI∙1 |
| V6-3 | Lime-poor to intermediately lime-rich late wet snowbed | SV∙2&KA∙1&KI∙1 |
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| V6-5 | Lime-poor to intermediately lime-rich extremely late wet snowbed | SV∙3&KA∙1&KI∙1 |
| V6-6 | Lime-rich extremely late wet snowbed | SV∙3&KA∙2&KI∙1 |
| V6-7 | Lime-poor to intermediately lime-rich late spring snowbed | SV∙2&KA∙1&KI∙2 |
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| V7-1 | Lime-poor to intermediately lime-rich Arctic permafrost wetland | KA∙1 |
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| V10-1 | Lime-poor to intermediately lime-rich semi-natural wet grassland | KA∙1&KI∙1 |
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| V10-3 | Semi-natural spring wet grassland | KA∙1,2&KI∙2 |
| V11-1 | Lime-poor peat quarry | KA∙1 |
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| V12-2 | Intermediately lime-rich to lime-rich drained fen | VT∙A&KA∙2 |
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| V13-2 | New peat-forming wetland originating by paludification of strongly modified terrestrial land | HS∙A&IO∙2 |
| V13-3 | New wetland originating by paludification of strongly modified agricultural land | HS∙B&IO∙1 |
| V13-4 | New peat-forming wetland originating by paludification of strongly modified agricultural land | HS∙B&IO∙2 |
| V13-5 | New wetland originating by damming of forest | HS∙C&IO∙1 |
| V13-6 | New peat-forming wetland originating by damming of forest | HS∙C&IO∙2 |
| V13-7 | New wetland originating from terrestrialised freshwater bottom | HS∙D&IO∙1 |
| V13-8 | New peat-forming wetland originating from terrestrialised freshwater bottom | HS∙D&IO∙2 |
| I1-1 | Snow and ice-covered ground |  |
| I2-1 | Polar sea-ice |  |

**References**

Halvorsen, R., et al., [2016] (2019). NiN – typeinndeling og beskrivelsessystem for natursystemnivået. *Natur i Norge (NiN) Systemdokumentasjon*, **3** (Version 2.1.0), 1–525. (<https://www.artsdatabanken.no/Files/14539/Artikkel_3___Natursystemniv_et___typeinndeling_og_beskrivelsessystem_(versjon_2.1.0).pdf)>

Towards a systematics of ecodiversity: the EcoSyst framework

**APPENDIX S6 | ADAPTATION OF NiN ECOSYSTEM TYPES AND ATTRIBUTES TO PRACTICAL LAND-COVER MAPPING**

**S6.0 |** **Contents**

S6.1 | Background

S6.2 | NiN mapping guidelines

S6.3 | Documentation and tools

In this appendix, we explain how the NiN implementation of EcoSyst principles is adapted to practical land-cover mapping.

**S6.1 | Background**

The pressure from conflicting land-use interests is high and acts in concert with ongoing climate changes that are amplified at northern latitudes (Pithan & Mauritsen, 2014). The need for detailed and up-to-date land-cover information is therefore increasing (Fuchs, Herold, Verburg, Clevers, & Eberle, 2015). High-quality land-cover maps are pivotal in the planning and implementation of policy related to nature and resource management, e.g. to reach biodiversity conservation goals (Cherrill, 2016). To meet these demands, the ‘Nature in Norway’ (NiN) implementation (version 2.2.0) of the EcoSyst framework has been operationalized for detailed land-cover mapping at the ecosystem level.

Land-cover mapping, in the broadest sense, is a process in many phases. The end product of the mapping process is a map of the spatial distribution of land-cover units; i.e. a map that describes the physical cover of a part the Earth’s surface by providing spatially explicit information of the whereabouts of all type units defined by the implemented mapping system (Zonneveld, 1989). Widely different approaches to land-cover mapping are in use, including field-based surveys (Ullerud, Bryn, Halvorsen, & Hemsing, 2018), aerial photo interpretation (Ihse, 2007; Ullerud, Bryn, & Skånes, *in press*), analysis of remote sensing data such as satellite images (Xie, Sha, & Yu, 2008) or airborne laser scanning data (ALS, or LiDAR; Halvorsen et al., 2016), distribution modelling (Ullerud, Bryn, & Klanderud, 2016; Horvath, Halvorsen, et al., 2019), and combinations of these methods.

Depending on the mapping method chosen, the planned use of the map and other issues, land-cover maps are stored in geodatabases in vector or raster format. The choice among available methods and formats typically entail trade-offs. One important trade-off is between the needs for progress and observer independence on one hand and detail and direct relevance for biodiversity conservation and management on the other. High demands on progress favour automated classification of remote sensing data while relevance for biodiversity favours labour-intensive field surveys and fine-resolution mapping of types defined by species composition and environmental characteristics (which, so far, cannot be identified by use of other methods). The different methods for land-cover mapping can be used as stand-alone methods, or, preferably, in combination. Remote sensing of satellite images through supervised or object-oriented classification may, for instance, be used as the first step in a two-step procedure, providing an infrastructure that facilitates targeted field survey mapping. Another important trade-off is between purposes, either to account for all information of potential interest for any user, which calls for a fine division into many types, or to fulfil the needs of (a) specific user group(s) for information arranged for (a) specific purpose(s), typically at a pre-determined map scale (Küchler & Zonneveld, 1988).

In order to avoid inflation of types and to make the system of mapping units more flexible, most systems have two components: a hierarchical type system with several levels of generalization and a system of attribute variables that open for describing variation that is not captured by the type system, to the level of detail required by the users (Rodwell, 2006; Bryn, Strand, Angeloff, & Rekdal, 2018). For many purposes, interest is centered on attributes rather than the types.

**S6.2 | NiN mapping guidelines**

The two different strategies for NiN-based land-cover mapping outlined in the mapping guidelines of Bryn, Halvorsen, & Ullerud (2018) are: (i) mapping of ecosystem types, which can be performed either as selective mapping (mapping of a pre-selected list of types) or wall-to-wall mapping (mapping of all types); and (ii) mapping of attributes, i.e. mapping units defined by variables of an attribute system (the attribute system of NiN is described in Appendix S3). Ecosystem-type mapping is described in detail below. Attribute mapping is selective mapping by which mapping units are defined by a specific condition, either a specific value of an attribute variable (e.g. presence of the landform kettle-hole) or a minimum value for the attribute variable (e.g. more than 4 downed logs per decare over an area larger than 2 decares).

The type hierarchy at the ecosystem level of ecodiversity in the Nature in Norway implementation of EcoSyst (version 2.2.0) primarily addresses variation in species composition at or in the ground and bottom main ecosystem components, first of all the species composition of plants, and its variation along local environmental complex-gradients (LECs). The species composition of herbs, graminoids, bryophytes and lichens is not easily detected by remote sensing techniques; this is particularly true when the ground is covered by a dense shrub or tree layer. Accordingly, the focus of the standardised mapping guidelines for NiN version 2.2.0 is on field survey methods for mapping of terrestrial and wetland land-cover units at the ecosystem level (Bryn, Halvorsen, et al., 2018b; Bryn & Ullerud, 2018).

The ecosystem, the lowest ecodiversity level in the NiN implementation of EcoSyst, contains a type hierarchy of land-cover units with full spatial coverage (Table 2; principle #2). Ecosystem type units at the lowermost hierarchical level, the minor types, define the finest spatial scale to which land-cover mapping by NiN can be performed and, hence, the highest possible resolution of derived map products.

All maps are prepared for a specific spatial scale, which determines the level of detail shown on the map. Adaptation of a nature-type system to mapping at a specific spatial scale implies setting a minimum polygon size. In addition to the inherent generalisation provided by the aggregation of patterns of natural variation into land-cover types, the scale adaptation determines the overall degree of generalisation of the real patterns of natural variation enforced during the mapping process (e.g. Brocklehurst, Lewis, Napier, & Lynch, 2007). Land-cover maps are therefore generalised spatial representations of pre-defined phenomena, in this case ecosystem types. The minor ecosystem types in NiN version 2.2.0 are not *a priori* adapted to mapping to a specific scale, but the limit for fine-grained patterns of variation along local environmental complex-gradients (LECs) adopted in this version of NiN results in minor types that serve as mapping units at the 1:500 scale. An example of fine-scaled patterns that are reflected in a series of minor types along an LEC, is the five minor types along the hummock-lawn-carpet gradient of bogs (‘duration of period without inundation’; TV), which may replace each other over distances of less than 1 m (Økland, 1989).

In order to provide flexibility and adaptability to different user groups, different demands on progress and mapping costs, differences in competence among field mappers, and other issues relating to mapping purpose, the NiN system has been adapted to mapping at five different scales: 1:500, 1:2500, 1:5000, 1:10 000 and 1:20 000 (Table S6.23). Scale adaptation is accomplished by a procedure by which minor ecosystem types are merged, in a step-wise manner, into land-cover mapping units appropriate for the scale in question (Table S6.23). This procedure is based upon six general and nine specific principles described in Bryn, Halvorsen, et al., (2018). The most important principles are: (i) The process starts with all minor types within a major type, successively merging

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scale 1:500, 1:2500 and 1:5000 | SV | 2 (ab) | 2: Lime-poor and intermediately lime-rich alpine dry-grass snowbed | 4: Lime-rich alpine dry-grass snow-bed |
| 1 (0) | 1: Lime-poor and intermediately lime-rich alpine dry-grass heath | 3: Lime-rich alpine dry-grass heath |
| (a) | | 1 (bcde) | 2 (fgh) |
| KA | |
|  |  | |  | |
| Scale: 1:10000 and 1:20000 | SV | 2 (ab) | 1: Lime-poor alpine dry-grass heath and snow-beds | 2: Lime-rich alpine dry-grass heaths and snow-beds |
| 1 (0) |
| (b) | | 1 (bcde) | 2 (fgh) |
| KA | |
| **FIGURE S6.9** The process by which minor ecosystem types are merged into mapping units adapted to specific mapping scales, illustrated by the major type T22, ‘Arctic-alpine dry-grass heath’. (a) T22 ecological subspace with four minor types, defined by division of two local environmental complex-gradients (LECs) into 2 major-type specific standard segments each: ‘lime richness’ (KA), with seven elementary segments (b–h), along the horizontal axis; and ‘growing-season reduction due to prolonged snow cover’ (SV), with three elementary segments (0–b), on the vertical axis. The standard segments, denoted by numbers 1 and 2, are obtained by amalgamation of elementary segments. The four minor types are mapping units adapted to scale 1:500, 1:2500 and 1:5000. (B) Merging of the four minor types to two mapping units adapted to scales 1:10000 and 1:20000 by amalgamation of types along LEC SV, which displays variation at a relatively fine scale. | | | | |

minor types according to the spatial scale at which variation along each type-defining LEC typically occurs. (ii) Minor types defined by fine-scale LECs are merged first. The scale at which each LEC is subjected to merging of minor types is guided by the scale-specific minimum polygon size indicated in Table S6.23. (iii) Minor ecosystem types are merged with ecologically very closely related types, i.e. neighboring types along the defining LECs. (iv) Major types and, accordingly, minor types that belong to different major types, are never merged. The resulting scale-adapted mapping units thus comprise ecologically and spatially closely related minor types (Figure S6.9).

A set of general and special rules that make up the mapping guidelines for NiN (Bryn, Halvorsen, et al., 2018) regulate important quality parameters such as minimum polygon size, when to delineate mosaics and composite spatial units, etc., and provide recommendations about which materials (aerial photos, etc.) and methods (field PCs, etc.) to use. Choices in these respects strongly influence progress during field-work (Bryn, Halvorsen, et al., 2018; Bryn & Ullerud, 2018; see Table S6.23).

Merging of minor ecosystem types into scale-adapted mapping units reduces observer dependence and increases map consistency (Eriksen et al., 2018; Ullerud, Bryn, Halvorsen, & Hemsing, 2018). Research on sources of error in land-cover mapping by NiN is in an early phase, but preliminary results indicate that delineation errors contribute more strongly to the total error in land-cover maps than incorrect assignment to mapping unit (Haga, Bryn, Nilsen, & Ullerud, 2018).

**S6.3 | Documentation and tools**

Two handbooks, i.e. guidelines for terrestrial NiN-based mapping, have been published: a complete textbook for mappers, students and users of NiN-based maps (Bryn, Halvorsen, et al., 2018), and a short guide, optimized for use in the field (Bryn & Ullerud, 2018). Mapping guidelines for marine

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **TABLE S6.23** Characteristics of adaptations of Nature in Norway (NiN) version 2.2.0 to terrestrial land-cover mapping to five pre-defined scales. | | | | | | |
| Scale | Mapping purpose | Relative amount of information | Relative mapping progress | Relative cost of mapping | # of mapping units | Minimum polygon size  (m2) |
| 1:20 000 | Wall-to-wall mapping of large areas | Low | Fast | Low | 141 | 2500 |
| 1:10 000 | Wall-to-wall mapping of small areas | Relatively low | Relatively fast | Relatively low | 175 | 1000 |
| 1:5000 | Selective mapping, area- representative surveys | Inter-mediate | Inter-mediate | Inter-mediate | 281 | 250 |
| 1:2500 | Monitoring, ground truths for modelling, point mapping | High | Slow | High | 352 | 100 |
| 1:500 | Detailed description of field experimental or intensive monitoring sites | Very high | Very slow | Very high | 448 | 1 |

ecosystems have recently been published (Andersen et al., 2019), whereas elaboration of guidelines for freshwater ecosystems is in progress. Halvorsen et al. (2019) give an overview of methods for quality control of NiN-based land-cover maps. A QGIS set-up (template) for NiN-based mapping has been developed for training of students and field workers. This is available for free download at GitHub (Horvath, Nilsen, & Bryn, 2019).

**References**

Andersen, G. S., Bekkby, T., Dolan, M., Bøe, R., Thormar, J., Buhl-Mortensen, P., ... Bryn, A. (2019). Feltveileder for kartlegging av marin naturvariasjon etter NiN (2.2) – Utgave 1. *Natur i Norge Kartleggingsveileder*, **3**, 1–65. (<https://www.artsdatabanken.no/Files/29649/Feltveileder_for_kartlegging_av_marin_naturvariasjon_etter_NiN.pdf>)

Brocklehurst, P., Lewis, D. B., Napier, D., & Lynch, D. (2007). Northern territory guidelines and field methodology for vegetation survey and mapping. *Northern Territory Government Department of natural Resources, Environment and the Arts Technical Report*, **2007: 2**, 1-92.

Bryn, A., Strand, G.-H., Angeloff, M., & Rekdal, Y. (2018). Land cover in Norway based on an area frame survey of vegetation types. *Norwegian Journal of Geography*, **72**, 131–145.

Bryn, A., Halvorsen, R., & Ullerud, H.A. (2018). Hovedveileder for kartlegging av terrestrisk naturvariasjon etter NiN (2.2.0), utgave 1. *Natur i Norge Kartleggingsveileder*, **1**, 1–217. (<https://www.artsdatabanken.no/Files/22388/Hovedveileder_for_kartlegging_av_terrestrisk_naturvariasjon_etter_NiN_(2.2.0)_-_utgave_1.pdf>)

Bryn, A., & Ullerud, H. A. (2018). Feltveileder for kartlegging av terrestrisk naturvariasjon etter NiN (2.2.0) – tilpasset målestokk 1:5000 og 1:20 000, utgave 1. *Natur i Norge Kartleggingsveileder*, **2**, 1–44. (<https://www.artsdatabanken.no/Files/29648/Feltveileder_for_kartlegging_av_terrestrisk_naturvariasjon_etter_NiN_2.2.pdf>)

Cherrill, A. (2016). Inter-observer variation in habitat survey data: investigating the consequences for professional practice. *Journal of Environmental Planning and Management*, **59**, 1813–1832.

Eriksen, E. L., Ullerud, H. A., Halvorsen, R., Aune, S., Bratli, H., Horvath, P., ... Bryn, A. (2018). Point of view: error estimation in field assignment of land cover types. *Phytocoenologia*, **49**, 135–148.

Fuchs, R., Herold, M., Verburg, P. H., Clevers, J., & Eberle, J. (2015). Gross changes in reconstructions of historic land cover/use for Europe between 1900 and 2010. *Global change Biology*, **21**, 299–313.

Haga, H. E. E. S., Bryn, A., Nilsen, A. B., & Ullerud, H. A. (2018). Opplæring av nye feltkartleggere: ABC-metoden. *Kart og Plan*, **78**, 377–382.

Halvorsen, R., Mazzoni, S., Dirksen, J. W., Næsset, E., Gobakken, T., & Ohlson, M. (2016). How important are choice of model selection method and spatial autocorrelation of presence data for distribution modelling by MaxEnt? *Ecological Modelling*, **328**, 108–118.

Halvorsen, R., Eriksen, E. L., Wollan, A. K., Ullerud, H. A., Bryn, A., Nilsen, A. B.. & Bratli, H. [2018] (2019). Forarbeid til standard for kontroll av kvalitet i naturtypekart etter NiN. *Natur i Norge FoU-Rapport*, **1**, 1–138. (<https://www.artsdatabanken.no/Files/29714/Forarbeid_til_standard_for_kontroll_av_kvalitet_i_naturtypekart_etter_NiN.pdf>)

Horvath, P., Nilsen, A. B., & Bryn, A. (2019). Oppsett og tilrettelegging av QGIS for NiN naturtypekartlegging. *Universitetet i Oslo Naturhistorisk Museum Rapport*, **83**, 1–20.

Horvath, P., Halvorsen, R., Stordal, F., Tallaksen, L. M., Tang, H., & Bryn, A. (2019) Distribution modelling of vegetation types based on area-frame survey data. *Applied Vegetation Science*, **22**, 547–560.

Ihse, M. (2007). Colour infrared aerial photography as a tool for vegetation mapping and change detection in environmental studies of Nordic ecosystems: a review. *Norwegian Journal of Geography*, **61**, 170–191.

Küchler, A. W., & Zonneveld, I. S. (1988). *Vegetation mapping*. Dordrecht: Kluwer.

Økland, R. H. (1989) A phytoecological study of the mire Northern Kisselbergmosen, SE Norway. I. Introduction, flora, vegetation and ecological conditions. *Sommerfeltia*, **8**, 1–172.

Pithan, F., & Mauritsen, T. (2014). Arctic amplification dominated by temperature feedbacks in contemporary climate models. *Nature Geoscience*, **7**, 181–184.

Rodwell, J. S. (2006). *National vegetation classification: users’ handbook*. – Peterborough: Joint Nature Conservation Committee.

Ullerud, H. A., Bryn, A., Halvorsen, R., & Hemsing, L. Ø. (2018). Consistency of land cover mapping; influence of fieldworkers, spatial scale and classification system. *Applied Vegetation Science,* **21**, 278–288.

Ullerud, H. A., Bryn, A., & Klanderud, K. (2016). Distribution modelling of vegetation types in the boreal-alpine ecotone. *Applied Vegetation Science*, **19**, 528–540.

Ullerud, H. A., Bryn, A., & Skånes, H. (*In press*). Bridging theory and implementation – testing an abstract classification system for practical mapping by field survey and 3D aerial photographic interpretation. *Norwegian Journal of Geography*, *in press*.

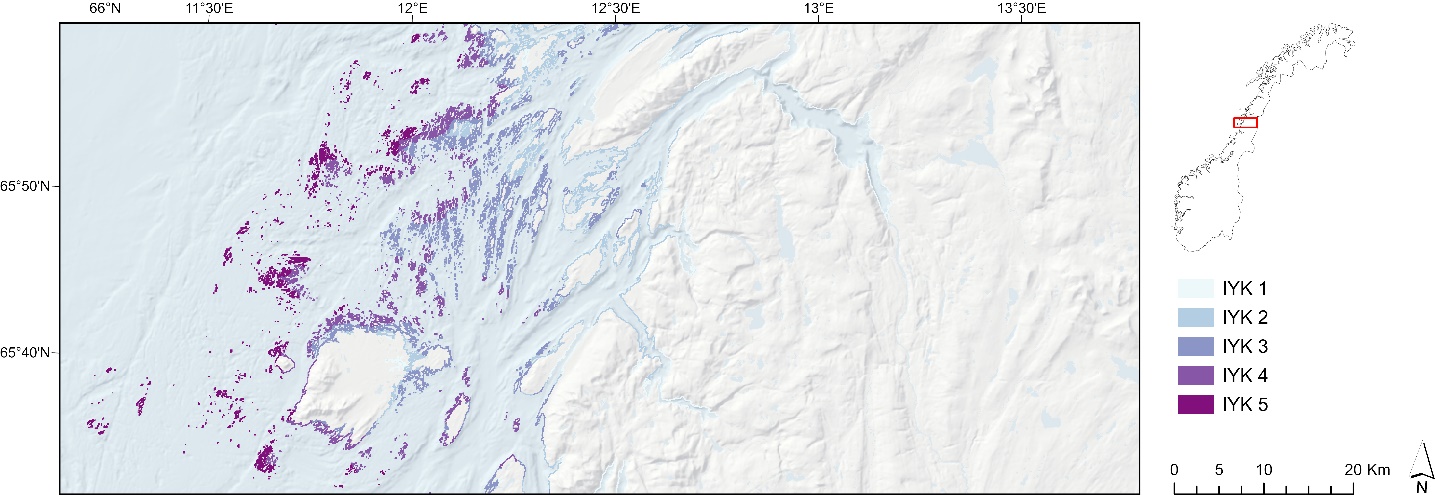
Xie, Y. C., Sha, Z. Y., & Yu, M. (2008). Remote sensing imagery in vegetation mapping: a review. *Journal of Plant Ecology*, **1**, 9–23.

Zonneveld, I. S. (1989) The land unit – a fundamental concept in landscape ecology, and its applications. *Landscape Ecology*, **3**, 67–86.

Towards a systematics of ecodiversity: the EcoSyst framework

**APPENDIX S7 | NiN IMPLEMENTATION: COMPLEX LANDSCAPE GRADIENTS (CLGs)**

This appendix gives an overview of the complex landscape gradients (CLGs) that serve as descriptors of the characterising source of variation at the landscape level in the NiN implementation of EcoSyst (version 2.2.0) for Norway. CLGs are defined as abstract continuous variables that express more or less gradual, co-ordinated change in sets of more or less strongly correlated landscape variables. CLGs include continuous as well as more stepwise variation in landscape element composition. Figures S7.10 to S7.14 exemplify the distribution of variation along five CLGs in Nordland county, Norway; Table S7.24 provides a systematic overview of all CLGs in NiN version 2.2.0.

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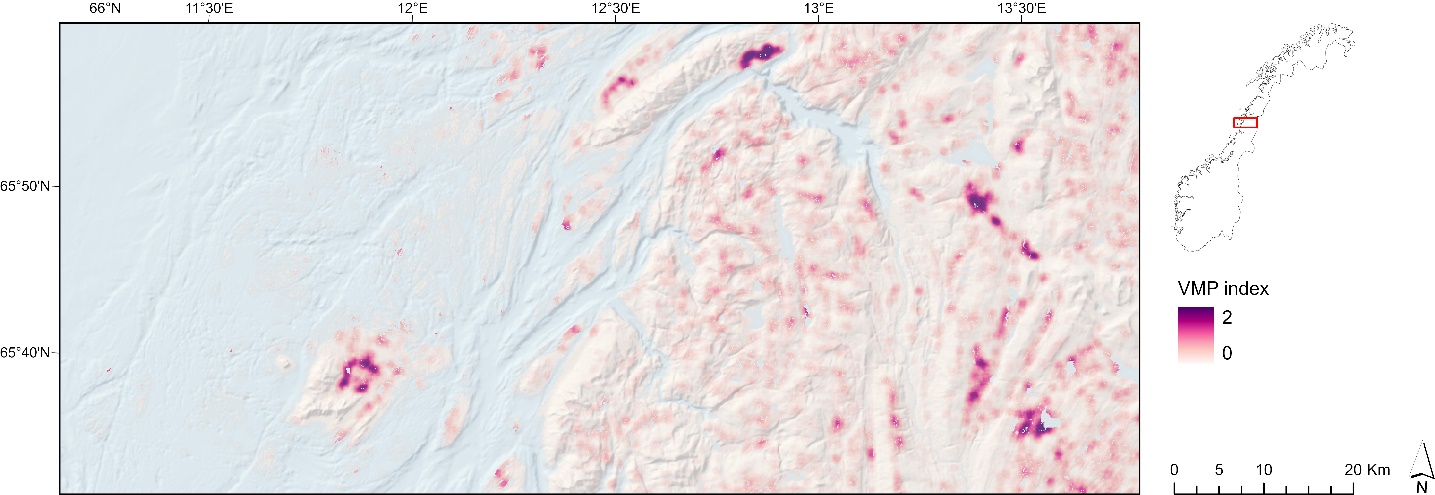
**FIGURE S7.10** The complex landscape gradient ‘Inner-outer coast’ (IYK), which expresses variation in coastal landscapes from areas with ‘inland properties’ on the inner side of larger islands, hardly exposed to the harsh conditions of the open sea (sheltered inner coast; IYK∙1), to the outer coast, directly exposed to the actions of wind, waves and ocean currents (strongly wave-exposed outer coast; IYK∙5). The intermediate segments are moderately protected coast (IYK∙2), moderately wave-exposed coast (IYK∙3) and wave-exposed outer coast (IYK∙4).

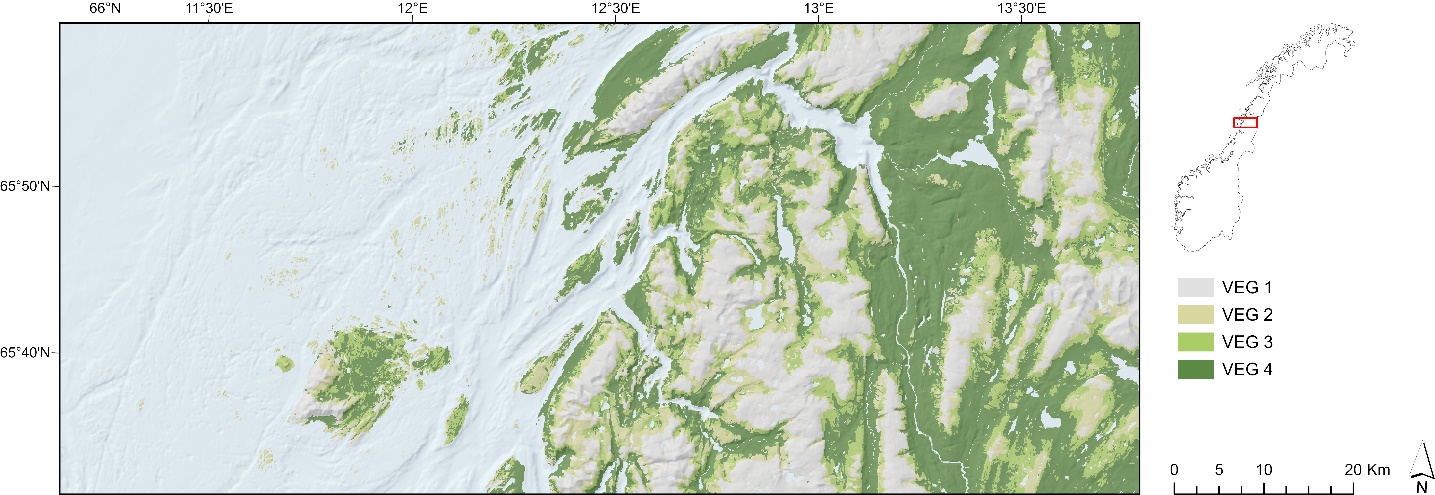


**FIGURE S7.11** The complex landscape gradient ‘relief in coastal plains’ (REK), which expresses terrain-form variation within the coastal plains major landscape type from flat terrain to steep and rugged terrain: flat coastal plains (REK∙1); undulating coastal plains (REK∙2); rugged coastal plains (REK∙3).

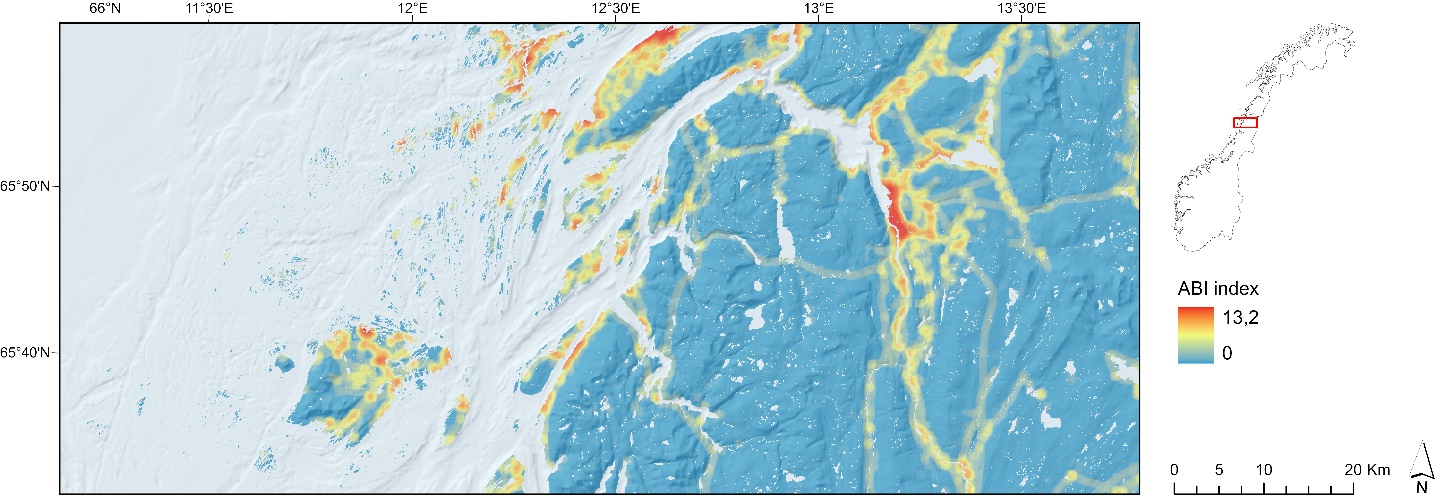
**TABLE S7.24** Complex landscape gradients (CLGs) used in the NiN implementation of EcoSyst (version 2.2.0) for Norway, with short descriptions. Code = three-letter code formed by abbreviation of the corresponding term in Norwegian (Erikstad, Halvorsen, & Simensen, 2019). If Erikstad, & al. (2019) use a different code, that is given in brackets. Ty = CLG category [GE – geo-ecological gradient; BE – bio-ecological gradient; LU – land-use-related (anthropogenous) gradient]. Se = number of segments into which the CLG is divided. MG = major-type group (I – inland; K – coastal). MT = major-type(s) [KA – coastal hills and mountains; KF – (coastal) fjords, KS – coastal plains; IA – (inland) hills and mountains; ID – (inland) valleys; IS – inland plains] in which the LEC is used for division into minor types.

| **Code** | **CLG** | **Description** | **Ty** | **Se** | **MG** | **MT** |
| --- | --- | --- | --- | --- | --- | --- |
| REF  [REIA] | Relief in hills and mountains | Terrain-form variation within (inland) hill and mountain landscapes; from depressions in hills and mountains (REF∙1), via undulating inland hills and mountains (REF∙2), moderately rugged hills and mountains (REF∙3) and rugged hills and mountains (REF∙4) to steep and rugged hills and mountains (REF∙5) | GE | 5 | I | IA |
| RED  [REIDKF] | Relief in valleys and fjords | Terrain-form variation within (inland) valley and (coastal) fjord landscapes; as expressed by the depth/width ratio of the valley/fjord relative to its surroundings; from wide fjord/valley (RED∙1) via open fjord/valley (RED∙2) and narrow fjord/valley (RED∙3) to deeply cut fjord/valley (RED∙4) | GE | 4 | IK | ID  KF |
| REK  [REKS] | Relief in coastal plains [REKS] | Terrain-form variation within coastal plains from flat (REK∙1) and relatively flat (REK∙2) coastal plains to rugged coastal plains, often with remnant peaks (REK∙3) | GE | 3 | K | KS |
| DIK  [KA] | Distance to coast | Variation in inland landscape properties from near-coastal inland plains (situated < 5 km from the coastline) to inland plains in the interior of the land mass | GE | 2 | I | IS |
| IYK | Inner-outer coast | Variation in coastal landscapes from areas with ‘inland properties’ on the inner side of larger islands, hardly exposed to the harsh conditions of the open sea (protected inner coast; IYK∙1), to the outer coast, directly exposed to the actions of wind, waves and ocean currents (strongly wave-exposed outer coast; IYK∙5); the intermediate segments are moderately protected coast (IYK∙2), moderately wave-exposed coast (IYK∙3) and wave-exposed outer coast (IYK∙4) | GE | 4 | K | KS |
| INP  [IP] | Abundance of lakes | Variation within valleys from landscapes without lakes or with small lakes only (INP∙1; all lakes < 2 km2), via valleys with medium-sized lakes (INP∙1; lakes 2–8 km2), to valleys with large lakes, typically ‘inland fjords’ > 8 km² | GE | 3 | I | ID |
| VMP  [VP] | Abundance of wetlands | Variation within inland landscapes in the areal cover of wetland (including mires) and the abundance of small lakes and tarns (which are often associated with wetlands); from low or medium abundance (VMK∙1) to high abundance (VMK∙2) | GE | 2 | IK | IS  KF,KS |
| BRP  [BP] | Glacier presence | Variation in the presence of glacier(s); glacier absent (BRP∙1) and glacier present (BRP∙2) | GE | 2 | I | IA,IS, ID |
| VEG  [VE] | Vegetation cover | Variation in vegetation cover from barren mountains, without or with sparse vegetation cover (VEG∙1) to forested or potentially forested areas below the climatic forest line (VEG∙4); the intermediate segments are: open mountain heaths (VEG∙2) and boreal heath-dominated areas below the climatic forest line, kept open due to historical land-use by logging and grazing (VEG∙3) | BE | 4 | I,K | IA,IS,ID  KF |
| ABI  [AI] | Land-use intensity | Variation in impact by human infrastructure (agricultural land-use excepted) from low (ABI∙1) and intermediate (ABI∙2) to settlement (village or small town; ABI∙3) and city (ABI∙4), expressed by an index (range: 0–13.2) that integrates the abundances of buildings, roads and other visible signs of human infrastructure | LU | 4 | I,K | IA,IS,ID  KF,KS |
| JBI  [JP] | Agricultural land-use intensity | Variation in expressed agricultural land-use intensity, from low (JP∙1) to high (JP∙2) | LU | 2 | IK | IA,IS,ID  KF,KS |

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**FIGURE S7.12** The complex landscape gradient ‘abundance of wetlands’ (VMP), which expresses the areal coverof wetland (including mires) and the abundance of small lakes and tarns. Increasing colour intensity illustrates the stepless variation from low-medium abundance (VMP∙1) to high abundance (VMP∙2).

**FIGURE S7.13** The complex landscape gradient ‘vegetation cover’ (VEG), which expresses variation from barren mountains, without or with sparse vegetation cover (VEG∙1) to forested or potentially forested areas below the climatic timberline (VEG∙4). The intermediate segments are: open mountain heaths (VEG∙2) and boreal heath-dominated areas below the climatic timberline, kept open after logging (VEG∙3).

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**FIGURE S7.14** The complex landscape gradient ‘land-use intensity’ (ABI) from low (ABI∙1) and intermediate land-use intensity (ABI∙2) to settlement (ABI∙3) and city (ABI∙4), expressed by a continuous index (range: 0–13.2) that integrates the abundances of buildings, roads and other visible signs of human infrastructure (agricultural land-use excepted).

**References**

Erikstad, L., Halvorsen, R., & Simensen, T. (2019), *Natur i Norge (NiN) versjon 2.2. Inndelingen i landskapstyper*. – Trondheim: Norwegian Biodiversity Information Centre. (<https://www.artsdatabanken.no/nin/landskap>, accessed 19 July 2019)

Towards a systematics of ecodiversity: the EcoSyst framework

**APPENDIX S8 | NiN IMPLEMENTATION: LANDSCAPE TYPES**

This appendix gives an overview of the type hierarchy at the landscape level, in the NiN implementation of EcoSyst (version 2.2.0) for Norway. The type hierarchy (Figure S8.15), which contains three major-type groups with nine major types (Table S8.25), is constructed in accordance with the principles and methods explained in section S2.2 by use of the complex landscape gradients (CLGs) described in Table S7.24 as key source of variation. Table S8.26 provides a full list of the 284 minor types, with definitions in terms of CLG segment combinations, into which coastal and inland major types are divided. Major types of marine landscapes have not yet been further divided.



**FIGURE S8.15** The type hierarchy of the NiN implementation of EcoSyst for the landscape level, with three hierarchical levels: major-type groups, major types and minor types. The minor-type level is not yet developed for marine landscapes. The lowermost level in the figure (boxes with stippled edges) shows the number of unique spatial landscape units belonging to each minor type, accotrding to the first version of the area-covering Norwegian landscape type map (Figure 5a).

**TABLE S8.25** Major landscape types in the NiN implementation of EcoSyst (version 2.2.0) for Norway, with major-type group codes, major-type codes and the number of minor types in each major type. Note that major types of marine landscapes have not yet been divided into minor types.

|  |  |  |  |
| --- | --- | --- | --- |
| **Major-type group code** | **Major-type code** | **Major type** | **Number of minor types** |
| I | IA | Inland hills and mountains | 54 |
| I | ID | Inland valleys | 104 |
| I | IS | Inland plains | 36 |
| K | KA | Coastal hills and mountains | 26 |
| K | KF | Coastal fjords | 63 |
| K | KS | Coastal plains | 1 |
| M | MA | Marine hills and mountains | – |
| M | MV | Marine valleys | – |
| M | MS | Marine plains | – |

**TABLE S8.26** List of minor landscape types (codes and names) in the NiN implementation of EcoSyst for Norway, version 2.2.0. Definition = definition of each minor type as a combination of segments along relevant CLGs (see Table S7.24 for description of CLGs). Codes for major-type groups and major types are explained in Table 8.25.

| **Major-type group code** | **Major-type code** | **Minor-type code** | **Minor type** | **Definition** |
| --- | --- | --- | --- | --- |
| I | IA | IA-1 | Depressions in hilly landscapes below the forest line | REF∙1&BRP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | IA | IA-2 | Depressions in hilly landscapes below the forest line with agriculture | REF∙1&BRP∙1&VEG∙1&ABI∙1&JBI∙2 |
| I | IA | IA-3 | Depressions in hilly landscapes below the forest line with settlements/infrastructure | REF∙1&BRP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | IA | IA-4 | Depressions in hilly landscapes below the forest line with settlements/infrastructure and agriculture | REF∙1&BRP∙1&VEG∙1&ABI∙2&JBI∙2 |
| I | IA | IA-5 | Depressions in hilly landscapes below the forest line with village/small town | REF∙1&BRP∙1&VEG∙1&ABI∙3&JBI∙1 |
| I | IA | IA-6 | Depressions in hilly landscapes below the forest line with village/small town and agriculture | REF∙1&BRP∙1&VEG∙1&ABI∙3&JBI∙2 |
| I | IA | IA-7 | Depressions in hilly landscapes below the forest line with city | REF∙1&BRP∙1&VEG∙1&ABI∙4&JBI∙1 |
| I | IA | IA-8 | Depressions in hills and mountain landscapes with boreal heath | REF∙1&BRP∙1&VEG∙2&ABI∙1&JBI∙1 |
| I | IA | IA-9 | Depressions in hills and mountain landscapes with boreal heath and agriculture | REF∙1&BRP∙1&VEG∙2&ABI∙1&JBI∙2 |
| I | IA | IA-10 | Depressions in hills and mountain landscapes with boreal heath and settlements/infrastructure | REF∙1&BRP∙1&VEG∙2&ABI∙2&JBI∙1 |
| I | IA | IA-11 | Depressions in open heath mountain landscapes | REF∙1&BRP∙1&VEG∙3&ABI∙1&JBI∙1 |
| I | IA | IA-12 | Depressions in barren mountain landscapes | REF∙1&BRP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | IA | IA-13 | Depressions in barren mountain landscapes with glacier | REF∙1&BRP∙2&VEG∙4&ABI∙1&JBI∙1 |
| I | IA | IA-14 | Undulating hills below the forest line | REF∙2&BRP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | IA | IA-15 | Undulating hills below the forest line with agriculture | REF∙2&BRP∙1&VEG∙1&ABI∙1&JBI∙2 |
| I | IA | IA-16 | Undulating hills below the forest line with settlements/infrastructure | REF∙2&BRP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | IA | IA-17 | Undulating hills below the forest line with settlements/infrastructure and agriculture | REF∙2&BRP∙1&VEG∙1&ABI∙2&JBI∙2 |
| I | IA | IA-18 | Undulating hills below the forest line with village/small town | REF∙2&BRP∙1&VEG∙1&ABI∙3&JBI∙1 |
| I | IA | IA-19 | Undulating hills below the forest line with village/small town and agriculture | REF∙2&BRP∙1&VEG∙1&ABI∙3&JBI∙2 |
| I | IA | IA-20 | Undulating hills below the forest line with city | REF∙2&BRP∙1&VEG∙1&ABI∙4&JBI∙1 |
| I | IA | IA-21 | Undulating hills and mountains with boreal heath | REF∙2&BRP∙1&VEG∙2&ABI∙1&JBI∙1 |
| I | IA | IA-22 | Undulating hills and mountains with boreal heath and settlements/infrastructure | REF∙2&BRP∙1&VEG∙2&ABI∙2&JBI∙1 |
| I | IA | IA-23 | Undulating open heath mountains | REF∙2&BRP∙1&VEG∙3&ABI∙1&JBI∙1 |
| I | IA | IA-24 | Undulating open heath mountains with settlements/infrastructure | REF∙2&BRP∙1&VEG∙3&ABI∙2&JBI∙1 |
| I | IA | IA-25 | Undulating barren mountains | REF∙2&BRP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | IA | IA-26 | Undulating barren mountains with glacier | REF∙2&BRP∙2&VEG∙4&ABI∙1&JBI∙1 |
| I | IA | IA-27 | Moderately rugged hills below the forest line | REF∙3&BRP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | IA | IA-28 | Moderately rugged hills below the forest line with agriculture | REF∙3&BRP∙1&VEG∙1&ABI∙1&JBI∙2 |
| I | IA | IA-29 | Moderately rugged hills below the forest line with settlements/infrastructure | REF∙3&BRP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | IA | IA-30 | Moderately rugged hills below the forest line with settlements/infrastructure and agriculture | REF∙3&BRP∙1&VEG∙1&ABI∙2&JBI∙2 |
| I | IA | IA-31 | Moderately rugged hills below the forest line with village/small town | REF∙3&BRP∙1&VEG∙1&ABI∙3&JBI∙1 |
| I | IA | IA-32 | Moderately rugged hills below the forest line with village/small town and agriculture | REF∙3&BRP∙1&VEG∙1&ABI∙3&JBI∙2 |
| I | IA | IA-33 | Moderately rugged hills and mountains with boreal heath | REF∙3&BRP∙1&VEG∙2&ABI∙1&JBI∙1 |
| I | IA | IA-34 | Moderately rugged hills and mountains with boreal heath and agriculture | REF∙3&BRP∙1&VEG∙2&ABI∙1&JBI∙2 |
| I | IA | IA-35 | Moderately rugged hills and mountains with boreal heath and settlements/infrastructure | REF∙3&BRP∙1&VEG∙2&ABI∙2&JBI∙1 |
| I | IA | IA-36 | Moderately rugged open heath mountains | REF∙3&BRP∙1&VEG∙3&ABI∙1&JBI∙1 |
| I | IA | IA-37 | Moderately rugged open heath mountains with settlements/infrastructure | REF∙3&BRP∙1&VEG∙3&ABI∙2&JBI∙1 |
| I | IA | IA-38 | Moderately rugged barren mountains | REF∙3&BRP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | IA | IA-39 | Moderately rugged barren mountains with glacier | REF∙3&BRP∙2&VEG∙4&ABI∙1&JBI∙1 |
| I | IA | IA-40 | Rugged hills with forests | REF∙4&BRP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | IA | IA-41 | Rugged hills below the forest line with settlements/infrastructure | REF∙4&BRP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | IA | IA-42 | Rugged hills below the forest line with settlements/infrastructure and agriculture | REF∙4&BRP∙1&VEG∙1&ABI∙2&JBI∙2 |
| I | IA | IA-43 | Rugged hills below the forest line with village/small town | REF∙4&BRP∙1&VEG∙1&ABI∙3&JBI∙1 |
| I | IA | IA-44 | Rugged hills and mountains with boreal heath | REF∙4&BRP∙1&VEG∙2&ABI∙1&JBI∙1 |
| I | IA | IA-45 | Rugged open heath mountains | REF∙4&BRP∙1&VEG∙3&ABI∙1&JBI∙1 |
| I | IA | IA-46 | Rugged barren mountains | REF∙4&BRP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | IA | IA-47 | Rugged barren mountains with glacier | REF∙4&BRP∙2&VEG∙4&ABI∙1&JBI∙1 |
| I | IA | IA-48 | Steep and rugged hills with forests | REF∙5&BRP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | IA | IA-49 | Steep and rugged hills below the forest line with settlements/infrastructure | REF∙5&BRP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | IA | IA-50 | Steep and rugged hills below the forest line with village/small town | REF∙5&BRP∙1&VEG∙1&ABI∙3&JBI∙1 |
| I | IA | IA-51 | Steep and rugged hills and mountains with boreal heath | REF∙5&BRP∙1&VEG∙2&ABI∙1&JBI∙1 |
| I | IA | IA-52 | Steep and rugged open heath mountains | REF∙5&BRP∙1&VEG∙3&ABI∙1&JBI∙1 |
| I | IA | IA-53 | Steep and rugged barren mountains | REF∙5&BRP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | IA | IA-54 | Steep and rugged barren mountains with glacier | REF∙5&BRP∙2&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-1 | Wide valley below the forest line | RED∙1&INP∙1&BRP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | ID | ID-2 | Wide valley below the forest line with agriculture | RED∙1&INP∙1&BRP∙1&VEG∙1&ABI∙1&JBI∙2 |
| I | ID | ID-3 | Wide valley below the forest line with settlements/infrastructure | RED∙1&INP∙1&BRP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | ID | ID-4 | Wide valley below the forest line with settlements/infrastructure and agriculture | RED∙1&INP∙1&BRP∙1&VEG∙1&ABI∙2&JBI∙2 |
| I | ID | ID-5 | Wide valley below the forest line with village/small town | RED∙1&INP∙1&BRP∙1&VEG∙1&ABI∙3&JBI∙1 |
| I | ID | ID-6 | Wide valley below the forest line with village/small town and agriculture | RED∙1&INP∙1&BRP∙1&VEG∙1&ABI∙3&JBI∙2 |
| I | ID | ID-7 | Wide valley with boreal heath below the forest line | RED∙1&INP∙1&BRP∙1&VEG∙2&ABI∙1&JBI∙1 |
| I | ID | ID-8 | Wide valley with boreal heath below the forest line with settlements/infrastructure | RED∙1&INP∙1&BRP∙1&VEG∙2&ABI∙2&JBI∙1 |
| I | ID | ID-9 | Wide valley with heath above the forest line | RED∙1&INP∙1&BRP∙1&VEG∙3&ABI∙1&JBI∙1 |
| I | ID | ID-10 | Wide barren mountain valley | RED∙1&INP∙1&BRP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-11 | Wide barren mountain valley with glacier | RED∙1&INP∙1&BRP∙2&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-12 | Wide valley below the forest line with medium sized lakes | RED∙1&INP∙2&BRP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | ID | ID-13 | Wide valley below the forest line with medium sized lakes and agriculture | RED∙1&INP∙2&BRP∙1&VEG∙1&ABI∙1&JBI∙2 |
| I | ID | ID-14 | Wide valley below the forest line with medium sized lakes and settlements/infrastructure | RED∙1&INP∙2&BRP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | ID | ID-15 | Wide valley below the forest line with medium sized lakes and settlements/infrastructure and agriculture | RED∙1&INP∙2&BRP∙1&VEG∙1&ABI∙2&JBI∙2 |
| I | ID | ID-16 | Wide valley below the forest line with medium sized lakes and village/small town | RED∙1&INP∙2&BRP∙1&VEG∙1&ABI∙3&JBI∙1 |
| I | ID | ID-17 | Wide valley with boreal heath below the forest line with medium sized lakes | RED∙1&INP∙2&BRP∙1&VEG∙2&ABI∙1&JBI∙1 |
| I | ID | ID-18 | Wide valley with boreal heath below the forest line, medium sized lakes and settlements/infrastructure | RED∙1&INP∙2&BRP∙1&VEG∙2&ABI∙2&JBI∙1 |
| I | ID | ID-19 | Wide valley with heath above the forest line with medium sized lakes | RED∙1&INP∙2&BRP∙1&VEG∙3&ABI∙1&JBI∙1 |
| I | ID | ID-20 | Wide barren mountain valley with medium sized lakes | RED∙1&INP∙2&BRP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-21 | Wide valley below the forest line with inland fjord | RED∙1&INP∙3&BRP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | ID | ID-22 | Wide valley below the forest line with inland fjord and settlements/infrastructure | RED∙1&INP∙3&BRP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | ID | ID-23 | Wide valley below the forest line with inland fjord with settlements/infrastructure and agriculture | RED∙1&INP∙3&BRP∙1&VEG∙1&ABI∙2&JBI∙2 |
| I | ID | ID-24 | Wide valley below the forest line with inland fjord and village/small town | RED∙1&INP∙3&BRP∙1&VEG∙1&ABI∙3&JBI∙1 |
| I | ID | ID-25 | Wide valley below the forest line with inland fjord and village/small town and agriculture | RED∙1&INP∙3&BRP∙1&VEG∙1&ABI∙3&JBI∙2 |
| I | ID | ID-26 | Wide valley below the forest line with inland fjord and city | RED∙1&INP∙3&BRP∙1&VEG∙1&ABI∙4&JBI∙1 |
| I | ID | ID-27 | Wide valley with boreal heath below the forest line with inland fjord | RED∙1&INP∙3&BRP∙1&VEG∙2&ABI∙1&JBI∙1 |
| I | ID | ID-28 | Wide valley with boreal heath below the forest line with inland fjord and settlements/infrastructure | RED∙1&INP∙3&BRP∙1&VEG∙2&ABI∙2&JBI∙1 |
| I | ID | ID-29 | Wide valley with boreal heath below the forest line with inland fjord and village/small town | RED∙1&INP∙3&BRP∙1&VEG∙2&ABI∙3&JBI∙1 |
| I | ID | ID-30 | Wide valley with heath above the forest line with inland fjord | RED∙1&INP∙3&BRP∙1&VEG∙3&ABI∙1&JBI∙1 |
| I | ID | ID-31 | Wide barren mountain valley with inland fjord | RED∙1&INP∙3&BRP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-32 | Open valley below the forest line | RED∙2&INP∙1&BRP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | ID | ID-33 | Open valley below the forest line with agriculture | RED∙2&INP∙1&BRP∙1&VEG∙1&ABI∙1&JBI∙2 |
| I | ID | ID-34 | Open valley below the forest line with settlements/infrastructure | RED∙2&INP∙1&BRP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | ID | ID-35 | Open valley below the forest line with settlements/infrastructure and agriculture | RED∙2&INP∙1&BRP∙1&VEG∙1&ABI∙2&JBI∙2 |
| I | ID | ID-36 | Open valley below the forest line with village/small town | RED∙2&INP∙1&BRP∙1&VEG∙1&ABI∙3&JBI∙1 |
| I | ID | ID-37 | Open valley below the forest line with village/small town and agriculture | RED∙2&INP∙1&BRP∙1&VEG∙1&ABI∙3&JBI∙2 |
| I | ID | ID-38 | Open valley with boreal heath below the forest line | RED∙2&INP∙1&BRP∙1&VEG∙2&ABI∙1&JBI∙1 |
| I | ID | ID-39 | Open valley with boreal heath below the forest line with settlements/infrastructure | RED∙2&INP∙1&BRP∙1&VEG∙2&ABI∙2&JBI∙1 |
| I | ID | ID-40 | Open valley with boreal heath below the forest line with village/small town | RED∙2&INP∙1&BRP∙1&VEG∙2&ABI∙3&JBI∙1 |
| I | ID | ID-41 | Open valley with heath above the forest line | RED∙2&INP∙1&BRP∙1&VEG∙3&ABI∙1&JBI∙1 |
| I | ID | ID-42 | Open valley with heath above the forest line with settlements/infrastructure | RED∙2&INP∙1&BRP∙1&VEG∙3&ABI∙2&JBI∙1 |
| I | ID | ID-43 | Open barren mountain valley | RED∙2&INP∙1&BRP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-44 | Open barren mountain valley with glacier | RED∙2&INP∙1&BRP∙2&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-45 | Open valley below the forest line with medium sized lakes | RED∙2&INP∙2&BRP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | ID | ID-46 | Open valley below the forest line with medium sized lakes and settlements/infrastructure | RED∙2&INP∙2&BRP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | ID | ID-47 | Open valley below the forest line with medium sized lakes, settlements/infrastructure and agriculture | RED∙2&INP∙2&BRP∙1&VEG∙1&ABI∙2&JBI∙2 |
| I | ID | ID-48 | Open valley below the forest line with medium sized lakes and village/small town | RED∙2&INP∙2&BRP∙1&VEG∙1&ABI∙3&JBI∙1 |
| I | ID | ID-49 | Open valley with boreal heath below the forest line with medium sized lakes | RED∙2&INP∙2&BRP∙1&VEG∙2&ABI∙1&JBI∙1 |
| I | ID | ID-50 | Open valley with boreal heath below the forest line with medium sized lakes and settlements/infrastructure | RED∙2&INP∙2&BRP∙1&VEG∙2&ABI∙2&JBI∙1 |
| I | ID | ID-51 | Open valley with heath above the forest line with medium sized lakes | RED∙2&INP∙2&BRP∙1&VEG∙3&ABI∙1&JBI∙1 |
| I | ID | ID-52 | Open barren mountain valley with medium sized lakes | RED∙2&INP∙2&BRP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-53 | Open barren mountain valley with medium sized lakes and settlements/infrastructure | RED∙2&INP∙2&BRP∙1&VEG∙4&ABI∙2&JBI∙1 |
| I | ID | ID-54 | Open barren mountain valley with medium sized lakes and glacier | RED∙2&INP∙2&BRP∙2&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-55 | Open valley below the forest line with inland fjord | RED∙2&INP∙3&BRP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | ID | ID-56 | Open valley below the forest line with inland fjord and settlements/infrastructure | RED∙2&INP∙3&BRP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | ID | ID-57 | Open valley below the forest line with inland fjord and settlements/infrastructure and agriculture | RED∙2&INP∙3&BRP∙1&VEG∙1&ABI∙2&JBI∙2 |
| I | ID | ID-58 | Open valley below the forest line with inland fjord and village/small town | RED∙2&INP∙3&BRP∙1&VEG∙1&ABI∙3&JBI∙1 |
| I | ID | ID-59 | Open valley with boreal heath below the forest line with inland fjord | RED∙2&INP∙3&BRP∙1&VEG∙2&ABI∙1&JBI∙1 |
| I | ID | ID-60 | Open valley with boreal heath below the forest line with inland fjord and settlements/infrastructure | RED∙2&INP∙3&BRP∙1&VEG∙2&ABI∙2&JBI∙1 |
| I | ID | ID-61 | Open valley with heath above the forest line with inland fjord | RED∙2&INP∙3&BRP∙1&VEG∙3&ABI∙1&JBI∙1 |
| I | ID | ID-62 | Open valley with heath above the forest line with inland fjord and settlements/infrastructure | RED∙2&INP∙3&BRP∙1&VEG∙3&ABI∙2&JBI∙1 |
| I | ID | ID-63 | Open barren mountain valley with inland fjord | RED∙2&INP∙3&BRP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-64 | Open barren mountain valley with inland fjord and glacier | RED∙2&INP∙3&BRP∙2&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-65 | Narrow valley below the forest line | RED∙3&INP∙1&BRP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | ID | ID-66 | Narrow valley below the forest line with agriculture | RED∙3&INP∙1&BRP∙1&VEG∙1&ABI∙1&JBI∙2 |
| I | ID | ID-67 | Narrow valley below the forest line with settlements/infrastructure | RED∙3&INP∙1&BRP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | ID | ID-68 | Narrow valley below the forest line with settlements/infrastructure and agriculture | RED∙3&INP∙1&BRP∙1&VEG∙1&ABI∙2&JBI∙2 |
| I | ID | ID-69 | Narrow valley below the forest line with village/small town | RED∙3&INP∙1&BRP∙1&VEG∙1&ABI∙3&JBI∙1 |
| I | ID | ID-70 | Narrow valley with boreal heath below the forest line | RED∙3&INP∙1&BRP∙1&VEG∙2&ABI∙1&JBI∙1 |
| I | ID | ID-71 | Narrow valley with boreal heath below the forest line with settlements/infrastructure | RED∙3&INP∙1&BRP∙1&VEG∙2&ABI∙2&JBI∙1 |
| I | ID | ID-72 | Narrow valley with heath above the forest line | RED∙3&INP∙1&BRP∙1&VEG∙3&ABI∙1&JBI∙1 |
| I | ID | ID-73 | Narrow barren mountain valley | RED∙3&INP∙1&BRP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-74 | Narrow barren mountain valley with settlements/infrastructure | RED∙3&INP∙1&BRP∙1&VEG∙4&ABI∙2&JBI∙1 |
| I | ID | ID-75 | Narrow barren mountain valley with glacier | RED∙3&INP∙1&BRP∙2&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-76 | Narrow valley below the forest line with medium sized lakes | RED∙3&INP∙2&BRP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | ID | ID-77 | Narrow valley below the forest line with medium sized lakes and settlements/infrastructure | RED∙3&INP∙2&BRP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | ID | ID-78 | Narrow valley below the forest line with medium sized lakes and village/small town | RED∙3&INP∙2&BRP∙1&VEG∙1&ABI∙3&JBI∙1 |
| I | ID | ID-79 | Narrow valley with boreal heath below the forest line with medium sized lakes | RED∙3&INP∙2&BRP∙1&VEG∙2&ABI∙1&JBI∙1 |
| I | ID | ID-80 | Narrow valley with boreal heath below the forest line with medium sized lakes and settlements/infrastructure | RED∙3&INP∙2&BRP∙1&VEG∙2&ABI∙2&JBI∙1 |
| I | ID | ID-81 | Narrow valley with heath above the forest line with medium sized lakes | RED∙3&INP∙2&BRP∙1&VEG∙3&ABI∙1&JBI∙1 |
| I | ID | ID-82 | Narrow barren mountain valley with medium sized lakes | RED∙3&INP∙2&BRP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-83 | Narrow barren mountain valley with medium sized lakes and glacier | RED∙3&INP∙2&BRP∙2&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-84 | Narrow valley below the forest line with inland fjord | RED∙3&INP∙3&BRP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | ID | ID-85 | Narrow valley below the forest line with inland fjord and settlements/infrastructure | RED∙3&INP∙3&BRP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | ID | ID-86 | Narrow valley with inland fjord and settlements/infrastructure and agriculture | RED∙3&INP∙3&BRP∙1&VEG∙1&ABI∙2&JBI∙2 |
| I | ID | ID-87 | Narrow valley with boreal heath below the forest line with inland fjord | RED∙3&INP∙3&BRP∙1&VEG∙2&ABI∙1&JBI∙1 |
| I | ID | ID-88 | Narrow valley with heath above the forest line with inland fjord | RED∙3&INP∙3&BRP∙1&VEG∙3&ABI∙1&JBI∙1 |
| I | ID | ID-89 | Narrow barren mountain valley with inland fjord | RED∙3&INP∙3&BRP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-90 | Deeply cut valley below the forest line | RED∙4&INP∙1&BRP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | ID | ID-91 | Deeply cut valley below the forest line with settlements/infrastructure | RED∙4&INP∙1&BRP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | ID | ID-92 | Deeply cut valley below the forest line with village/small town | RED∙4&INP∙1&BRP∙1&VEG∙1&ABI∙3&JBI∙1 |
| I | ID | ID-93 | Deeply cut valley with boreal heath below the forest line | RED∙4&INP∙1&BRP∙1&VEG∙2&ABI∙1&JBI∙1 |
| I | ID | ID-94 | Deeply cut valley with boreal heath below the forest line with settlements/infrastructure | RED∙4&INP∙1&BRP∙1&VEG∙2&ABI∙2&JBI∙1 |
| I | ID | ID-95 | Deeply cut valley with heath above the forest line | RED∙4&INP∙1&BRP∙1&VEG∙3&ABI∙1&JBI∙1 |
| I | ID | ID-96 | Deeply cut barren mountain valley | RED∙4&INP∙1&BRP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-97 | Deeply cut barren mountain valley with glacier | RED∙4&INP∙1&BRP∙2&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-98 | Deeply cut valley below the forest line with medium sized lakes | RED∙4&INP∙2&BRP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | ID | ID-99 | Deeply cut valley below the forest line with medium sized lakes and settlements/infrastructure | RED∙4&INP∙2&BRP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | ID | ID-100 | Deeply cut barren mountain valley with medium sized lakes | RED∙4&INP∙2&BRP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | ID | ID-101 | Deeply cut valley below the forest line with inland fjord | RED∙4&INP∙3&BRP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | ID | ID-102 | Deeply cut valley below the forest line with inland fjord and settlements/infrastructure | RED∙4&INP∙3&BRP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | ID | ID-103 | Deeply cut valley with boreal heath below the forest line with inland fjord | RED∙4&INP∙3&BRP∙1&VEG∙2&ABI∙1&JBI∙1 |
| I | ID | ID-104 | Deeply cut barren mountain valley with inland fjord | RED∙4&INP∙3&BRP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | IS | IS-1 | Inland undulating plain below the forest line | DIK∙1&BRP∙1&VMP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | IS | IS-2 | Inland undulating plain below the forest line agriculture | DIK∙1&BRP∙1&VMP∙1&VEG∙1&ABI∙1&JBI∙2 |
| I | IS | IS-3 | Inland undulating plain below the forest line with settlements/infrastructure | DIK∙1&BRP∙1&VMP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | IS | IS-4 | Inland undulating plain below the forest line with settlements/infrastructure and agriculture | DIK∙1&BRP∙1&VMP∙1&VEG∙1&ABI∙2&JBI∙2 |
| I | IS | IS-5 | Inland undulating plain below the forest line with village/small town | DIK∙1&BRP∙1&VMP∙1&VEG∙1&ABI∙3&JBI∙1 |
| I | IS | IS-6 | Inland undulating plain below the forest line with village/small town and agriculture | DIK∙1&BRP∙1&VMP∙1&VEG∙1&ABI∙3&JBI∙2 |
| I | IS | IS-7 | Inland undulating plain below the forest line with city | DIK∙1&BRP∙1&VMP∙1&VEG∙1&ABI∙4&JBI∙1 |
| I | IS | IS-8 | Inland undulating plain with boreal heath below the forest line | DIK∙1&BRP∙1&VMP∙1&VEG∙2&ABI∙1&JBI∙1 |
| I | IS | IS-9 | Inland undulating plain with boreal heath below the forest line with settlements/infrastructure | DIK∙1&BRP∙1&VMP∙1&VEG∙2&ABI∙2&JBI∙1 |
| I | IS | IS-10 | Inland undulating heath mountain plain | DIK∙1&BRP∙1&VMP∙1&VEG∙3&ABI∙1&JBI∙1 |
| I | IS | IS-11 | Inland undulating barren heath mountain plain | DIK∙1&BRP∙1&VMP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | IS | IS-12 | Inland undulating barren mountain plain with glacier | DIK∙1&BRP∙2&VMP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | IS | IS-13 | Inland undulating plain below the forest line with wetlands | DIK∙1&BRP∙1&VMP∙2&VEG∙1&ABI∙1&JBI∙1 |
| I | IS | IS-14 | Inland undulating plain below the forest line with wetlands and settlements/infrastructure | DIK∙1&BRP∙1&VMP∙2&VEG∙1&ABI∙2&JBI∙1 |
| I | IS | IS-15 | Inland undulating plain below the forest line with wetlands and settlements/infrastructure and agriculture | DIK∙1&BRP∙1&VMP∙2&VEG∙1&ABI∙2&JBI∙2 |
| I | IS | IS-16 | Inland undulating plain below the forest line with wetlands and village/small town | DIK∙1&BRP∙1&VMP∙2&VEG∙1&ABI∙3&JBI∙1 |
| I | IS | IS-17 | Inland undulating plain with boreal heath below the forest line with wetlands | DIK∙1&BRP∙1&VMP∙2&VEG∙2&ABI∙1&JBI∙1 |
| I | IS | IS-18 | Inland undulating heath mountain plain with wetlands | DIK∙1&BRP∙1&VMP∙2&VEG∙3&ABI∙1&JBI∙1 |
| I | IS | IS-19 | Inland undulating barren mountain plain with wetlands | DIK∙1&BRP∙1&VMP∙2&VEG∙4&ABI∙1&JBI∙1 |
| I | IS | IS-20 | Coast-near undulating plain below the forest line | DIK∙2&BRP∙1&VMP∙1&VEG∙1&ABI∙1&JBI∙1 |
| I | IS | IS-21 | Coast-near undulating plain below the forest line with settlements/infrastructure | DIK∙2&BRP∙1&VMP∙1&VEG∙1&ABI∙2&JBI∙1 |
| I | IS | IS-22 | Coast-near undulating plain below the forest line with settlements/infrastructure and agriculture | DIK∙2&BRP∙1&VMP∙1&VEG∙1&ABI∙2&JBI∙2 |
| I | IS | IS-23 | Coast-near undulating plain below the forest line with village/small town | DIK∙2&BRP∙1&VMP∙1&VEG∙1&ABI∙3&JBI∙1 |
| I | IS | IS-24 | Coast-near undulating plain below the forest line with village/small town and agriculture | DIK∙2&BRP∙1&VMP∙1&VEG∙1&ABI∙3&JBI∙2 |
| I | IS | IS-25 | Coast-near undulating plain below the forest line with city | DIK∙2&BRP∙1&VMP∙1&VEG∙1&ABI∙4&JBI∙1 |
| I | IS | IS-26 | Coast-near undulating plain with boreal heath below the forest line | DIK∙2&BRP∙1&VMP∙1&VEG∙2&ABI∙1&JBI∙1 |
| I | IS | IS-27 | Coast-near undulating heath mountain plain | DIK∙2&BRP∙1&VMP∙1&VEG∙3&ABI∙1&JBI∙1 |
| I | IS | IS-28 | Coast-near undulating barren mountain plain | DIK∙2&BRP∙1&VMP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | IS | IS-29 | Coast-near undulating barren mountain plain with glacier | DIK∙2&BRP∙2&VMP∙1&VEG∙4&ABI∙1&JBI∙1 |
| I | IS | IS-30 | Coast-near undulating plain below the forest line with wetlands | DIK∙2&BRP∙1&VMP∙2&VEG∙1&ABI∙1&JBI∙1 |
| I | IS | IS-31 | Coast-near undulating plain below the forest line with wetlands and agriculture | DIK∙2&BRP∙1&VMP∙2&VEG∙1&ABI∙1&JBI∙2 |
| I | IS | IS-32 | Coast-near undulating plain below the forest line with wetlands and settlements/infrastructure | DIK∙2&BRP∙1&VMP∙2&VEG∙1&ABI∙2&JBI∙1 |
| I | IS | IS-33 | Coast-near undulating plain below the forest line with wetlands and settlements/infrastructure and agriculture | DIK∙2&BRP∙1&VMP∙2&VEG∙1&ABI∙2&JBI∙2 |
| I | IS | IS-34 | Coast-near undulating plain with boreal heath below the forest line with wetlands | DIK∙2&BRP∙1&VMP∙2&VEG∙2&ABI∙1&JBI∙1 |
| I | IS | IS-35 | Coast-near undulating heath mountain plain with wetlands | DIK∙2&BRP∙1&VMP∙2&VEG∙3&ABI∙1&JBI∙1 |
| I | IS | IS-36 | Coast-near undulating barren mountain plain with wetlands | DIK∙2&BRP∙1&VMP∙2&VEG∙4&ABI∙1&JBI∙1 |
| K | KF | KF-1 | Wide fjord | RED∙1&VMP∙1&ABI∙1&JBI∙1 |
| K | KF | KF-2 | Wide fjord with settlements/infrastructure | RED∙1&VMP∙1&ABI∙2&JBI∙1 |
| K | KF | KF-3 | Wide fjord with settlements/infrastructure and high agricultural land-use intensity | RED∙1&VMP∙1&ABI∙2&JBI∙2 |
| K | KF | KF-4 | Wide fjord with village/small town | RED∙1&VMP∙1&ABI∙3&JBI∙1 |
| K | KF | KF-5 | Wide fjord with city | RED∙1&VMP∙1&ABI∙4&JBI∙1 |
| K | KF | KF-6 | Wide fjord with wetlands | RED∙1&VMP∙2&ABI∙1&JBI∙1 |
| K | KF | KF-7 | Wide fjord with wetlands and settlements/infrastructure | RED∙1&VMP∙2&ABI∙2&JBI∙1 |
| K | KF | KF-8 | Open fjord | RED∙2&VMP∙1&ABI∙1&JBI∙1 |
| K | KF | KF-9 | Open fjord with settlements/infrastructure | RED∙2&VMP∙1&ABI∙2&JBI∙1 |
| K | KF | KF-10 | Open fjord with settlements/infrastructure and high agricultural land-use intensity | RED∙2&VMP∙1&ABI∙2&JBI∙2 |
| K | KF | KF-11 | Open fjord with village/small town | RED∙2&VMP∙1&ABI∙3&JBI∙1 |
| K | KF | KF-12 | Open fjord with village/small town and high agricultural land-use intensity | RED∙2&VMP∙1&ABI∙3&JBI∙2 |
| K | KF | KF-13 | Open fjord with city | RED∙2&VMP∙1&ABI∙4&JBI∙1 |
| K | KF | KF-14 | Open fjord with wetlands | RED∙2&VMP∙2&ABI∙1&JBI∙1 |
| K | KF | KF-15 | Open fjord with wetlands and settlements/infrastructure | RED∙2&VMP∙2&ABI∙2&JBI∙1 |
| K | KF | KF-16 | Open fjord with wetlands and village/small town | RED∙2&VMP∙2&ABI∙3&JBI∙1 |
| K | KF | KF-17 | Narrow fjord | RED∙3&VMP∙1&ABI∙1&JBI∙1 |
| K | KF | KF-18 | Narrow fjord with settlements/infrastructure | RED∙3&VMP∙1&ABI∙2&JBI∙1 |
| K | KF | KF-19 | Narrow fjord with settlements/infrastructure and high agricultural land-use intensity | RED∙3&VMP∙1&ABI∙2&JBI∙2 |
| K | KF | KF-20 | Narrow fjord with village/small town | RED∙3&VMP∙1&ABI∙3&JBI∙1 |
| K | KF | KF-21 | Narrow fjord with village/small town and high agricultural land-use intensity | RED∙3&VMP∙1&ABI∙3&JBI∙2 |
| K | KF | KF-22 | Narrow fjord with wetlands | RED∙3&VMP∙2&ABI∙1&JBI∙1 |
| K | KF | KF-23 | Narrow fjord with wetlands and settlements/infrastructure | RED∙3&VMP∙2&ABI∙2&JBI∙1 |
| K | KF | KF-24 | Deeply cut fjord | RED∙4&VMP∙1&ABI∙1&JBI∙1 |
| K | KF | KF-25 | Deeply cut fjord with settlements/infrastructure | RED∙4&VMP∙1&ABI∙2&JBI∙1 |
| K | KF | KF-26 | Deeply cut fjord with village/small town | RED∙4&VMP∙1&ABI∙3&JBI∙1 |
| K | KS | KS-1 | Sheltered inner coastal plain | IYK∙1,2&REK∙1&VMP∙1&ABI∙1,2&JBI∙1 |
| K | KS | KS-2 | Sheltered inner coastal plain with high agricultural land-use intensity | IYK∙1,2&REK∙1&VMP∙1&ABI∙1,2&JBI∙2 |
| K | KS | KS-3 | Sheltered inner coastal plain with village/small town | IYK∙1,2&REK∙1&VMP∙1&ABI∙3&JBI∙1 |
| K | KS | KS-4 | Sheltered inner coastal plain with village/small town and high agricultural land-use intensity | IYK∙1,2&REK∙1&VMP∙1&ABI∙3&JBI∙2 |
| K | KS | KS-5 | Sheltered inner coastal plain with city | IYK∙1,2&REK∙1&VMP∙1&ABI∙4&JBI∙1 |
| K | KS | KS-6 | Sheltered inner coastal plain with wetlands | IYK∙1,2&REK∙1&VMP∙2&ABI∙1,2&JBI∙1 |
| K | KS | KS-7 | Sheltered inner coastal plain with wetlands and high agricultural land-use intensity | IYK∙1,2&REK∙1&VMP∙2&ABI∙1,2&JBI∙2 |
| K | KS | KS-8 | Sheltered inner coastal plain with wetlands with village/small town | IYK∙1,2&REK∙1&VMP∙2&ABI∙3&JBI∙1 |
| K | KS | KS-9 | Sheltered inner flat coastal plain | IYK∙1,2&REK∙2&VMP∙1&ABI∙1,2&JBI∙1 |
| K | KS | KS-10 | Sheltered inner undulating coastal plain with high agricultural land-use intensity | IYK∙1,2&REK∙2&VMP∙1&ABI∙1,2&JBI∙2 |
| K | KS | KS-11 | Sheltered inner undulating coastal plain with village/small town | IYK∙1,2&REK∙2&VMP∙1&ABI∙3&JBI∙1 |
| K | KS | KS-12 | Sheltered inner undulating coastal plain with village/small town and high agricultural land-use intensity | IYK∙1,2&REK∙2&VMP∙1&ABI∙3&JBI∙2 |
| K | KS | KS-13 | Sheltered inner undulating coastal plain with city | IYK∙1,2&REK∙2&VMP∙1&ABI∙4&JBI∙1 |
| K | KS | KS-14 | Sheltered inner undulating coastal plain with city and high agricultural land-use intensity | IYK∙1,2&REK∙2&VMP∙1&ABI∙4&JBI∙2 |
| K | KS | KS-15 | Sheltered inner undulating coastal plain with wetlands | IYK∙1,2&REK∙2&VMP∙2&ABI∙1,2&JBI∙1 |
| K | KS | KS-16 | Sheltered inner undulating coastal plain with wetlands and high agricultural land-use intensity | IYK∙1,2&REK∙2&VMP∙2&ABI∙1,2&JBI∙2 |
| K | KS | KS-17 | Sheltered inner rugged coastal plain | IYK∙1,2&REK∙3&VMP∙1&ABI∙1,2&JBI∙1 |
| K | KS | KS-18 | Sheltered inner rugged coastal plain with high agricultural land-use intensity | IYK∙1,2&REK∙3&VMP∙1&ABI∙1,2&JBI∙2 |
| K | KS | KS-19 | Sheltered inner rugged coastal plain with village/small town | IYK∙1,2&REK∙3&VMP∙1&ABI∙3&JBI∙1 |
| K | KS | KS-20 | Sheltered inner rugged coastal plain with wetlands | IYK∙1,2&REK∙3&VMP∙2&ABI∙1,2&JBI∙1 |
| K | KS | KS-21 | Moderately wave-exposed flat coastal plain | IYK∙3&REK∙1&VMP∙1&ABI∙1,2&JBI∙1 |
| K | KS | KS-22 | Moderately wave-exposed flat coastal plain with high agricultural land-use intensity | IYK∙3&REK∙1&VMP∙1&ABI∙1,2&JBI∙2 |
| K | KS | KS-23 | Moderately wave-exposed flat coastal plain with village/small town | IYK∙3&REK∙1&VMP∙1&ABI∙3&JBI∙1 |
| K | KS | KS-24 | Moderately wave-exposed flat coastal plain with village/small town and high agricultural land-use intensity | IYK∙3&REK∙1&VMP∙1&ABI∙3&JBI∙2 |
| K | KS | KS-25 | Moderately wave-exposed flat coastal plain with city | IYK∙3&REK∙1&VMP∙1&ABI∙4&JBI∙1 |
| K | KS | KS-26 | Moderately wave-exposed flat coastal plain with wetlands | IYK∙3&REK∙1&VMP∙2&ABI∙1,2&JBI∙1 |
| K | KS | KS-27 | Moderately wave-exposed undulating coastal plain | IYK∙3&REK∙2&VMP∙1&ABI∙1,2&JBI∙1 |
| K | KS | KS-28 | Moderately wave-exposed undulating coastal plain with high agricultural land-use intensity | IYK∙3&REK∙2&VMP∙1&ABI∙1,2&JBI∙2 |
| K | KS | KS-29 | Moderately wave-exposed undulating coastal plain with village/small town | IYK∙3&REK∙2&VMP∙1&ABI∙3&JBI∙1 |
| K | KS | KS-30 | Moderately wave-exposed undulating coastal plain with village/small town and high agricultural land-use intensity | IYK∙3&REK∙2&VMP∙1&ABI∙3&JBI∙2 |
| K | KS | KS-31 | Moderately wave-exposed undulating coastal plain with city | IYK∙3&REK∙2&VMP∙1&ABI∙4&JBI∙1 |
| K | KS | KS-32 | Moderately wave-exposed undulating coastal plain with wetlands | IYK∙3&REK∙2&VMP∙2&ABI∙1,2&JBI∙1 |
| K | KS | KS-33 | Moderately wave-exposed undulating coastal plain with wetlands and village/small town | IYK∙3&REK∙2&VMP∙2&ABI∙3&JBI∙1 |
| K | KS | KS-34 | Moderately wave-exposed rugged coastal plain | IYK∙3&REK∙3&VMP∙1&ABI∙1,2&JBI∙1 |
| K | KS | KS-35 | Moderately wave-exposed rugged coastal plain with high agricultural land-use intensity | IYK∙3&REK∙3&VMP∙1&ABI∙1,2&JBI∙2 |
| K | KS | KS-36 | Moderately wave-exposed rugged coastal plain with village/small town | IYK∙3&REK∙3&VMP∙1&ABI∙3&JBI∙1 |
| K | KS | KS-37 | Moderately wave-exposed rugged coastal plain with wetlands and high agricultural land-use intensity | IYK∙3&REK∙3&VMP∙2&ABI∙1,2&JBI∙2 |
| K | KS | KS-38 | Very wave-exposed outer flat coastal plain | IYK∙4&REK∙1&VMP∙1&ABI∙1,2&JBI∙1 |
| K | KS | KS-39 | Very wave-exposed outer flat coastal plain with high agricultural land-use intensity | IYK∙4&REK∙1&VMP∙1&ABI∙1,2&JBI∙2 |
| K | KS | KS-40 | Very wave-exposed outer flat coastal plain with village/small town | IYK∙4&REK∙1&VMP∙1&ABI∙3&JBI∙1 |
| K | KS | KS-41 | Very wave-exposed outer flat coastal plain with village/small town and high agricultural land-use intensity | IYK∙4&REK∙1&VMP∙1&ABI∙3&JBI∙2 |
| K | KS | KS-42 | Very wave-exposed outer flat coastal plain with wetlands | IYK∙4&REK∙1&VMP∙2&ABI∙1,2&JBI∙1 |
| K | KS | KS-43 | Very wave-exposed outer flat coastal plain with wetlands with village/small town | IYK∙4&REK∙1&VMP∙2&ABI∙3&JBI∙1 |
| K | KS | KS-44 | Very wave-exposed outer undulating coastal plain | IYK∙4&REK∙2&VMP∙1&ABI∙1,2&JBI∙1 |
| K | KS | KS-45 | Very wave-exposed outer undulating coastal plain with high agricultural land-use intensity | IYK∙4&REK∙2&VMP∙1&ABI∙1,2&JBI∙2 |
| K | KS | KS-46 | Very wave-exposed outer undulating coastal plain with village/small town | IYK∙4&REK∙2&VMP∙1&ABI∙3&JBI∙1 |
| K | KS | KS-47 | Very wave-exposed outer undulating coastal plain with village/small town and high agricultural land-use intensity | IYK∙4&REK∙2&VMP∙1&ABI∙3&JBI∙2 |
| K | KS | KS-48 | Very wave-exposed outer undulating coastal plain with city | IYK∙4&REK∙2&VMP∙1&ABI∙4&JBI∙1 |
| K | KS | KS-49 | Very wave-exposed outer undulating coastal plain with wetlands | IYK∙4&REK∙2&VMP∙2&ABI∙1,2&JBI∙1 |
| K | KS | KS-50 | Very wave-exposed outer rugged coastal plain | IYK∙4&REK∙3&VMP∙1&ABI∙1,2&JBI∙1 |
| K | KS | KS-51 | Very wave-exposed outer rugged coastal plain with village/small town | IYK∙4&REK∙3&VMP∙1&ABI∙3&JBI∙1 |
| K | KS | KS-52 | Extremely wave-exposed outer flat coastal plain | IYK∙5&REK∙1&VMP∙1&ABI∙1,2&JBI∙1 |
| K | KS | KS-53 | Extremely wave-exposed outer flat coastal plain with high agricultural land-use intensity | IYK∙5&REK∙1&VMP∙1&ABI∙1,2&JBI∙2 |
| K | KS | KS-54 | Extremely wave-exposed outer flat coastal plain with village/small town | IYK∙5&REK∙1&VMP∙1&ABI∙3&JBI∙1 |
| K | KS | KS-55 | Extremely wave-exposed outer flat coastal plain with wetlands | IYK∙5&REK∙1&VMP∙2&ABI∙1,2&JBI∙1 |
| K | KS | KS-56 | Extremely wave-exposed outer flat coastal plain with wetlands and village/small town | IYK∙5&REK∙1&VMP∙2&ABI∙3&JBI∙1 |
| K | KS | KS-57 | Extremely wave-exposed outer flat undulating coastal plain | IYK∙5&REK∙2&VMP∙1&ABI∙1,2&JBI∙1 |
| K | KS | KS-58 | Extremely wave-exposed outer undulating coastal plain with village/small town | IYK∙5&REK∙2&VMP∙1&ABI∙3&JBI∙1 |
| K | KS | KS-59 | Extremely wave-exposed outer undulating coastal plain with village/small town and high agricultural land-use intensity | IYK∙5&REK∙2&VMP∙1&ABI∙3&JBI∙2 |
| K | KS | KS-60 | Extremely wave-exposed outer undulating coastal plain with city | IYK∙5&REK∙2&VMP∙1&ABI∙4&JBI∙1 |
| K | KS | KS-61 | Extremely wave-exposed outer undulating coastal plain with wetlands | IYK∙5&REK∙2&VMP∙2&ABI∙1,2&JBI∙1 |
| K | KS | KS-62 | Extremely wave-exposed outer rugged coastal plain | IYK∙5&REK∙3&VMP∙1&ABI∙1,2&JBI∙1 |
| K | KS | KS-63 | Extremely wave-exposed outer rugged coastal plain with wetlands | IYK∙5&REK∙3&VMP∙2&ABI∙1,2&JBI∙1 |
| K | KA | KA-1 | Coastal hills- and mountains | - |