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Distribution and habitat suitability maps of revised EUNIS Marine saltmarshes and Sparsely vegetated habitats

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1 Introduction

Under the Framework Contract EEA/NSS/17/002/Lot 1, Schaminée et al. (2020 in prep.) delivered expert rules to classify the EUNIS habitat types belonging to the group MA2, *Littoral biogenic habitat* and group U, *Inland habitats with no or little soil and mostly with sparse vegetation*. The work resulted in an improved classification that was used to assign a part of the European Vegetation Archive (EVA) to these EUNIS habitat types.

The work for the EEA was the starting point for the current study for ETC/BD, Task 1.7.5.1 to deliver distribution and suitability maps for the EUNIS habitat types belonging to the groups MA2 and U. In this report, habitat types belonging to group MA2 are further referred to as 'Marine saltmarshes and saline reed beds' and habitat types belong to group U as 'Sparsely vegetated habitats'.

2 Habitat suitability modelling

2.1 Introduction

For habitat suitability modelling, the latest version of the widely used software Maxent[1] for maximum entropy modelling of species geographic distributions was used. Maxent is a general-purpose machine-learning method with a simple and precise mathematical formulation, and has a number of aspects that make it well-suited for species distribution modelling when only presence (occurrence) data but not absence data are available (Philips et al. 2006). Because EUNIS habitats have a particular species composition, they are assumed to respond to specific ecological requirements, allowing us to generate correlative estimates of geographic distributions. Modelling habitats that have been floristically defined is a well-known procedure for ecological modelling at local scales, and a promising technique to be applied also at the continental level.

The Maxent modelling procedure considers both presence data (known observations of a given entity), and the so-called background data. Background data comprise a set of points used to describe the environmental variation of the study area according to the available environmental layers, as well as so-called RS-EBV's (Remote Sensed Essential Biodiversity Variables; predictors based on remote sensing data) such as Land Use Land Cover, Phenology or Inundation, that were already selected as predictors in 2018, 2019 and 2020 (Hennekens 2018, 2019, 2020). In addition, Vegetation height have now also been applied[2]. The environmental layers were selected from meaningful environmental predictors commonly used for modelling non-tropical plant and vegetation diversity, and are not mutually strongly correlated. It is assumed that these layers represent well the most important ecological gradients on a European scale. It is also assumed that by using additional meaningful predictors such as the RS-EBV's, the modelling will result in more realistic suitability maps, with less outliers (prediction in areas where the habitat is not expected to be present). In paragraph 2.2, the complete list of predictors and their sources is presented.

[1] Maxent version 3.4.1 was used. http://biodiversityinformatics.amnh.org/open_source/maxent/

[2] LAI (Leaf Area Index) predictor maps have been excluded as they have gaps due to presence of clouds in parts of Europe. Gaps will be ignored in the modelling process, which will eventually result in an incomplete suitability map.

A side effect of using the RS-EBV's is that the study area now excludes countries like Russia, Belarus and Ukraine, in the east part of Europe. This also has led to better predictions, because the very eastern part of Europe is not well represented in EVA which has an effect on the modelling.

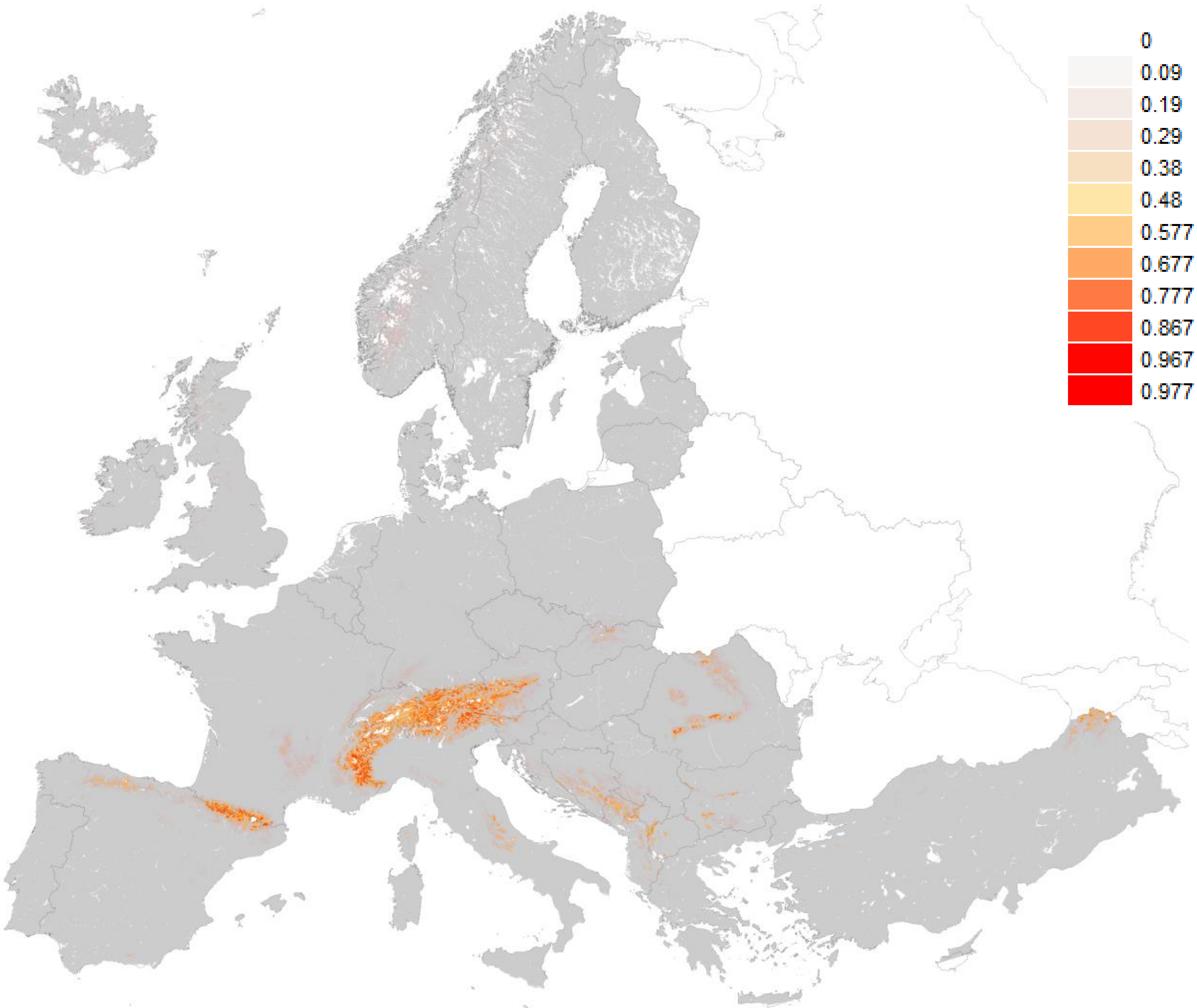


Figure 1 Example of a suitability map (U26; Temperate high-mountain base-rich scree and moraine) indicating with grey colour the geographic area that has been considered for this study.

2.2 Predictors

The following layers have been used as predictors (and their sources), with a resolution of 1x1 km:

Climate

- Temperature Seasonality (standard deviation *100)
  https://www.worldclim.org/bioclim
- Mean Temperature of Wettest Quarter
  https://www.worldclim.org/bioclim
- Annual Precipitation
  https://www.worldclim.org/bioclim
- Precipitation Seasonality (Coefficient of Variation)
  https://www.worldclim.org/bioclim
- Precipitation of Warmest Quarter
  https://www.worldclim.org/bioclim
- Solar radiation (× 365/8 kWh m-2)
  www.worldgrids.org
- Potential Evapotranspiration (mm yr-1)
  https://cgiarcsi.community/data/global-aridity-and-pet-database/

Topography

- Distance to water (rivers, lakes, sea)
  derived from the shapefile 'Inland_Waters.shp'
- Digital Elevation Map (DEM)
  Only applied for group U
- Distance to coast
  derived from shapefile 'Europe_coastline.shp'
  Only applied for group MA

Soil

- Bulk density of the soil (kg/m³)
  Hengl et al. 2014
  https://soilgrids.org/
- Cation Exchange Capacity of the soil
  Hengl et al. 2014
  https://soilgrids.org/
- Weight in % of clay particles (<0.0002 mm)
  Hengl et al. 2014
  https://soilgrids.org/
- Volume % of coarse fragments (> 2 mm)
  Hengl et al. 2014
  https://soilgrids.org/
- Soil organic carbon content (‰)
  Hengl et al. 2014
  https://soilgrids.org/

- Soil pH (water)
  Hengl et al. 2014
  https://soilgrids.org/
- Weight in % of silt particles (0.0002-0.05 mm)
  Hengl et al. 2014
  https://soilgrids.org/
- Weight in % of sand particles (0.05-2 mm)
  Hengl et al. 2014
  https://soilgrids.org/

RS-EBV's

- Land Use Land Cover (LULC)
  https://land.copernicus.eu/pan-european/corine-land-cover
- Inundation; occurrence
  Global Surface Water Explorer, 1984-2015, 30m, resampled to 1km (resampling methods: average resampling and mode resampling (selects the value which appears most often of all the sampled points))
- Phenology; End of Season (day number)
  End of Season, defined as the point in time where the NDVI drops below the NDVI at the start of the growing season
- Phenology; Length of season (days)
  Length of season, number of days between EoS and Sos [days]
- Phenology; Low of season (day number)
  Phenology; Low of season (day number with lowest NDVI)
- Phenology; NDVI mean
  Mean NDVI [0..10000]
- Phenology; NDVI seasonality
  Minimum NDVI [0..10000]
- Phenology; Peak of season (day number)
  Phenology; Peak of season (day number with highest NDVI)
- Phenology; Start of Season (day number)
  Start of Season, defined as the point in the year with the largest positive rate of change (maximum of 1st derivative) [day of year 1..365]
- Vegetation height (m)
  3D Global Vegetation Map, 2000, 1km

Anthropogenic

- Population density 2018
  https://landscan.ornl.gov/

More information on predictors and particularly on RS-EBV's can be found here: https://www.synbiosys.alterra.nl/nextgeoss/docs/Description_Abiotic_and_RSEBVs.pdf

2.3 Modelling

Maxent is expected to perform well for estimating the geographic distribution of EUNIS habitats in Europe. However, as with any other modelling techniques, this method is sensitive to sampling bias i.e. when the spatial distribution of presence data is reflecting an unequal sampling effort in different geographic regions. In Maxent, it has been proposed that the best way to account for sampling bias (when bias is known or expected to occur) is to generate background data reflecting the same bias of the presence data. When a complete set of presence data is available, a general recommendation is to generate background points from the occurrences of other species/communities that were sampled in a similar way (Elith et al. 2011).

Two different approaches have therefore been followed for the selection of a maximum of 5,000 locations for the background data. For the first approach, 5,000 locations were randomly selected by Maxent from the study area, whereas the second approach concerns a random stratified (one sample per 1x1 km grid) selection of 5,000 background locations of plots present in the EVA database. Concerning the observed occurrences of the EUNIS types also a random stratified selection has been applied with a maximum of 5000 observations. The two modelling approaches (background data selected from the EVA database or selected by Maxent) were evaluated for each of the EUNIS habitat types in order to estimate which assumption is more likely.

As it was the case with many other evaluated EUNIS habitats (Hennekens, 2018), the current study also showed that all maps using background data randomly selected by Maxent were far better (by visual inspection) than the maps produced using background randomly derived from the EVA database. Therefore, and in contrast with what is recommended by Elith et al. (2011), only suitability maps based on random selected background data by Maxent are considered in this report (Annex 2).

3 Results

For a number of habitat types, no maps have been provided because these types cannot be defined on a floristic basis and are therefore excluded from the modelling process (U11, U12, U31, U3E, U41, U42, U43, U51 and U53). Some of these types are completely without vegetation. For other habitat types, there is not sufficient plot data available within the study area to run a model (MA211, U2A, U35, U3C, U52 and U61).

Annex 1 presents the list of the habitat types included in the revised classification of the EUNIS groups MA2 and U, with indication if a distribution map and a suitability map are provided.

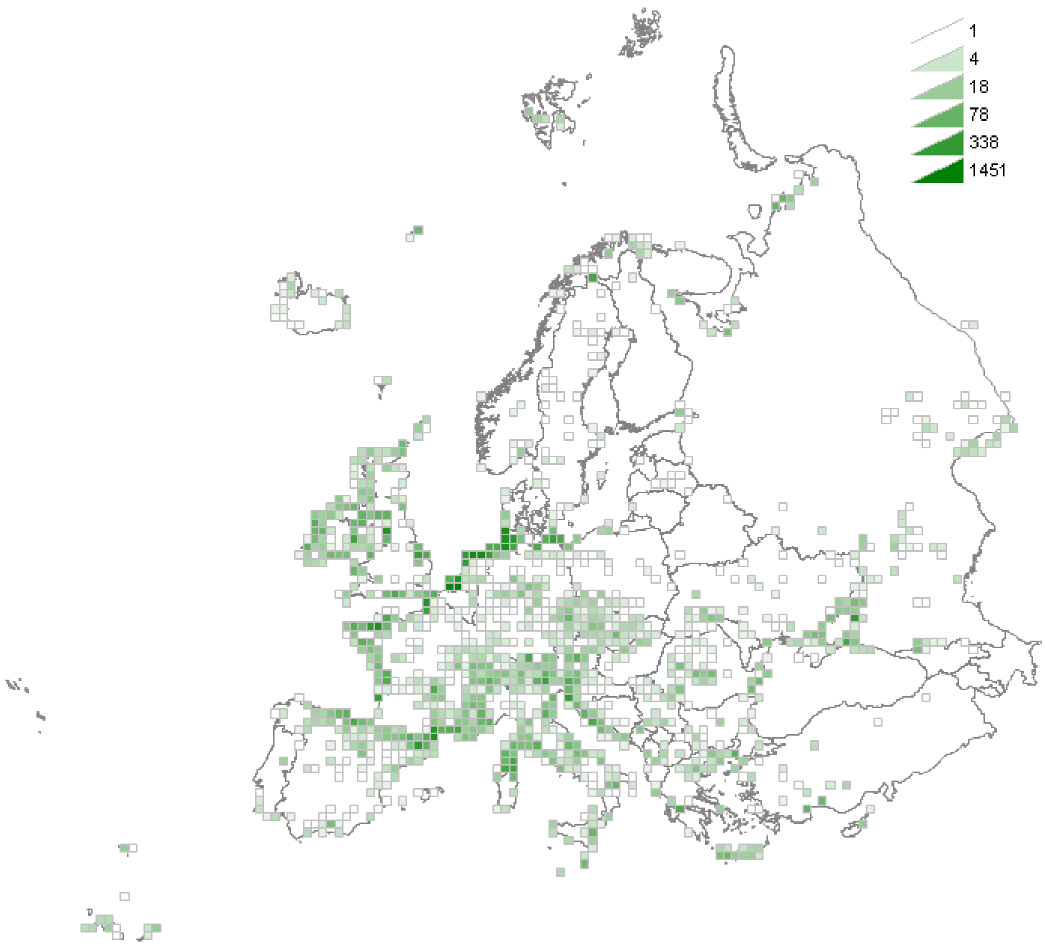
In Annex 2, the results of the analysis are presented. For each EUNIS habitat type, the following data are presented:

- A distribution map showing the location of the relevés that have been assigned to the EUNIS type concerned and therefore used as observation data. As background for the observations, the inventory effort regarding Marine saltmarshes for the MA2-habitat types and Sparsely vegetated habitat types for the U-habitat types is presented;
- A habitat suitability map with colours varying from grey, through orange to red, indicating increasingly favourable ecological conditions for the type (expressing the logistic output of the model between 0 and 1);
- A binary map based on the 10-percentile training presence. The 10-percentile training presence is a threshold which omits all regions with habitat suitability lower than the

representative of the species overall habitat, and thus should be omitted;

- Statistics from the Maxent modelling:
    - AUC, or the Area Under the Curve, as a general estimate of model performance. This is the likeliness that the classifier correctly orders two points (a random positive example and a random negative example). In general, AUC values in the range 0.5-0.7 were considered low, 0.7-0.9 were moderate and > 0.9 were high, suggesting poor, good and very good model performances, respectively. We provide two estimates of the AUC as calculated by Maxent. 'AUC training' reflects the internal fit between observed and predicted occurrences in the computed model. 'AUC test' provides the mean AUC obtained from a 10-fold cross-validation procedure in which ten different models were computed with a random selection of 90% of data (calibration data set) and 10% for testing the model (validation data set);
    - The 10-percentile training presence, as threshold for drawing the binary map;
    - Contribution in percentage of the predictors to the Maxent model. It indicates to what extent the environmental variables contribute to the model. A higher contribution value means a higher prediction value.

Figure 2 **Overall distribution of plot observations assigned to Marine saltmarshes and Sparsely vegetated habitats (27,662 plot observations)**



4 Discussion

Since 2018, remote sensed essential biodiversity variables (RS-EBV's), like phenology, have been introduced in the modelling process, resulting in the exclusion of the most eastern part of Europe, an area that is anyway already underrepresented in the EVA database. In general, it appears that the range of the **suitability** maps for Marine saltmarshes (MA2-habitat types) and Sparsely vegetated habitat types (U-habitat types) is much in line with the range of the **distribution** maps, which is contrasting with previous reports on the suitability maps of EUNIS habitats (Hennekens 2016, 2017).

Suitability maps are the result of a modelling process with all the potential shortcoming associated with it. On the basis of a limited set of predictors (climate, soil, and topography layers, as well as RS-EBV's), and a selection of in situ observations, the suitability for a certain habitat is calculated for each grid cell.

This process contains a number of uncertainties:

- The assignment of a plot observation to a EUNIS habitat type is based on expert rules. These rules may need further refinement, which could lead to different results;
- The number of plot observations may be too small to deliver an accountable model;
- The degree of detail in the predictor maps could be too limited, in other words the maps with a grid size of 1x1 km could be too coarse i.e. plants that form the basis of a habitat type operate on a much smaller scale then 1x1 km. In the field, micro climate and soil parameter may also differ significantly over short distances. Those two aspects are especially true for salt marches and sparsely vegetated habitats.

Saltmarshes and inland reed beds

At first, the 'Digital Elevation Map' (DEM) was included in the list of predictors. However, as Figure 4 clearly shows, saltmarshes were also predicted to occur inland, which is not realistic. This effect is caused by the DEM: saltmarshes are all located at sea level and that is why the contribution of the DEM to the saltmarsh models is very high (Figure 7), however sea level altitudes also occur inland.

To overcome this effect, the DEM was replaced with another predictor, 'Distance to coast'. The result of this swap is shown in Figure 5. With 'Distance to coast' as predictor, saltmarshes are no longer predicted inland. On the other hand, saltmarshes are now predicted almost everywhere along the coast, which is also not realistic. Still the map can be a good basis for a probability map, in case high resolution land cover data is brought into the modelling (see Mucher & Hennekens 2017). Like it is shown for the DEM, the overall contribution of 'Distance to coast' is also very high (Figure 8).

In Figure 6, the binary map of the model using both 'Distance to coast' and 'DEM' is shown. Compared with the model based on 'Distance to coast' (Figure 5), there is almost no difference. Moreover, the overall contribution of the predictors shows that 'Distance to coast' is predominant, followed by the DEM, and that all other predictors hardly contribute to the models (Figure 9). However, when modelling without DEM, the contribution of all other predictors is a bit higher.

It is therefore recommended to only include 'Distance to coast' and leave out DEM for modelling the coastal habitats, as it has no added value to the process and suppresses the contribution of other predictors.

Artefacts like predictions everywhere along the coast may be caused by:

- A too high contribution of a single predictor which will predominate the modelling;
- Too much location uncertainty for some of the observation data. Also, the location uncertainty is unknow for a large number of plots;
- A mismatch with the predictor Land Use Land Cover, showing that only 25% of all MA2-classified plots are linked to the class 'Saltmarshes' (Figure 9). Some of the plots are, although to a lesser extent, linked to the class 'pastures' and 'non-irrigated arable land' and these categories are occurring everywhere in Europe. A matching of 11% with intertidal flats makes sense as this land use type occurs in the vicinity of saltmarshes.

Figure 4 Part of binary map of habitat type MA224 modelled using 'Digital Elevation Map' (DEM)

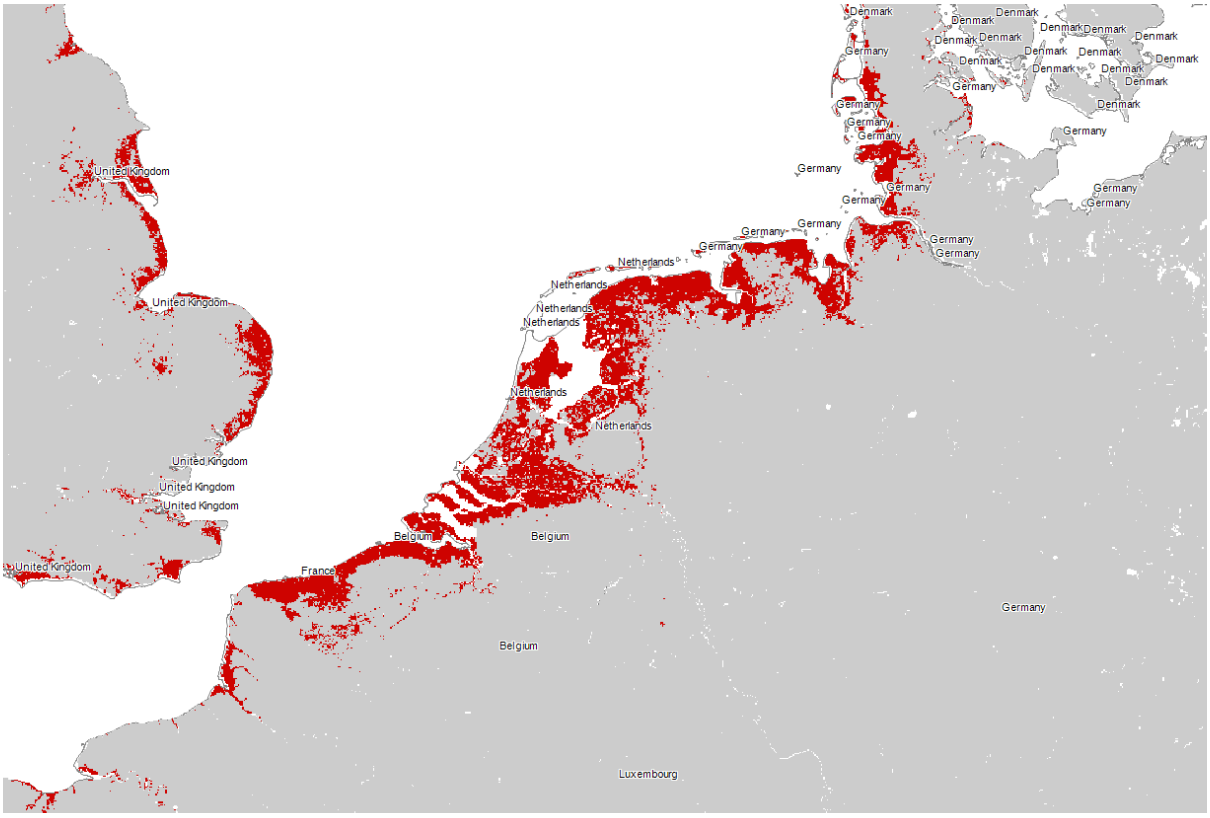


Figure 5 **Part of binary map of habitat type MA224 modelled using 'Distance to coast'**

Figure 6 **Part of binary map of habitat type MA224 modelled using both 'Distance to coast' and 'Digital Elevation Map' (DEM)**

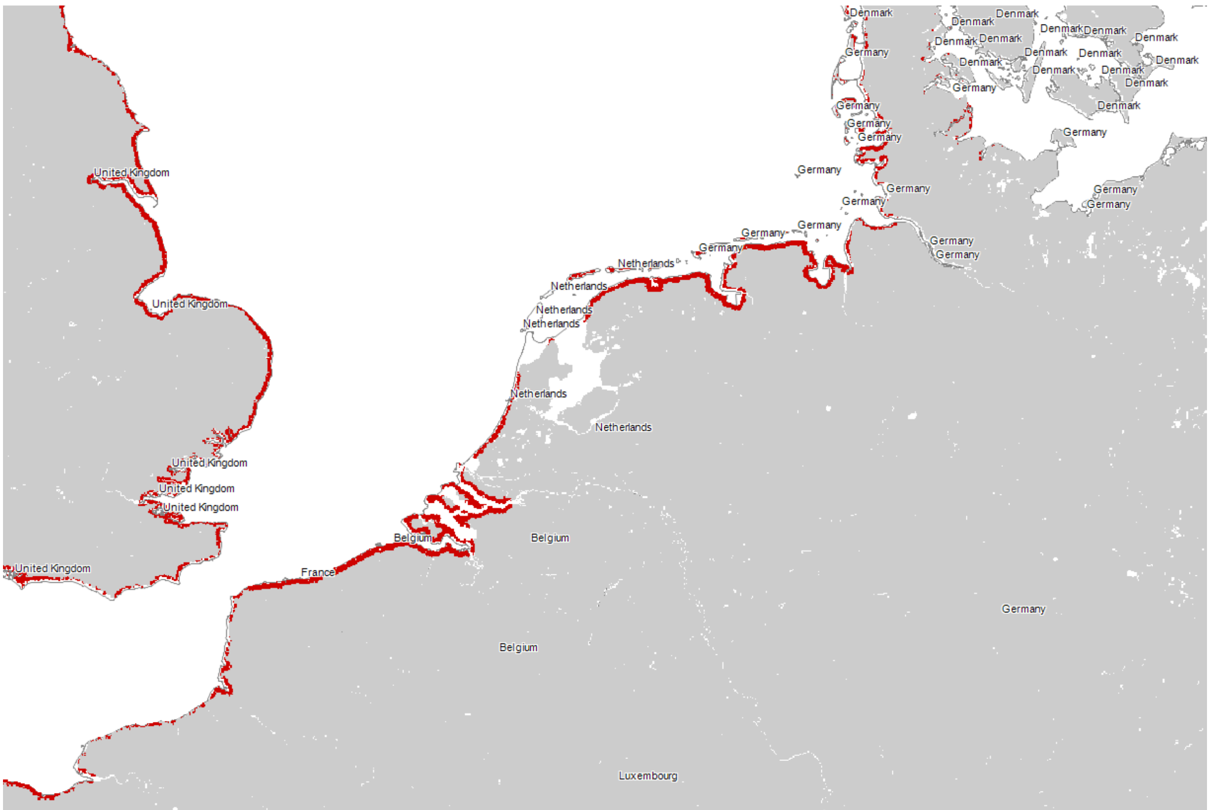


Figure 7 **Sum of contributions of all suitability models belonging to group MA, including 'Digital Elevation Map'**

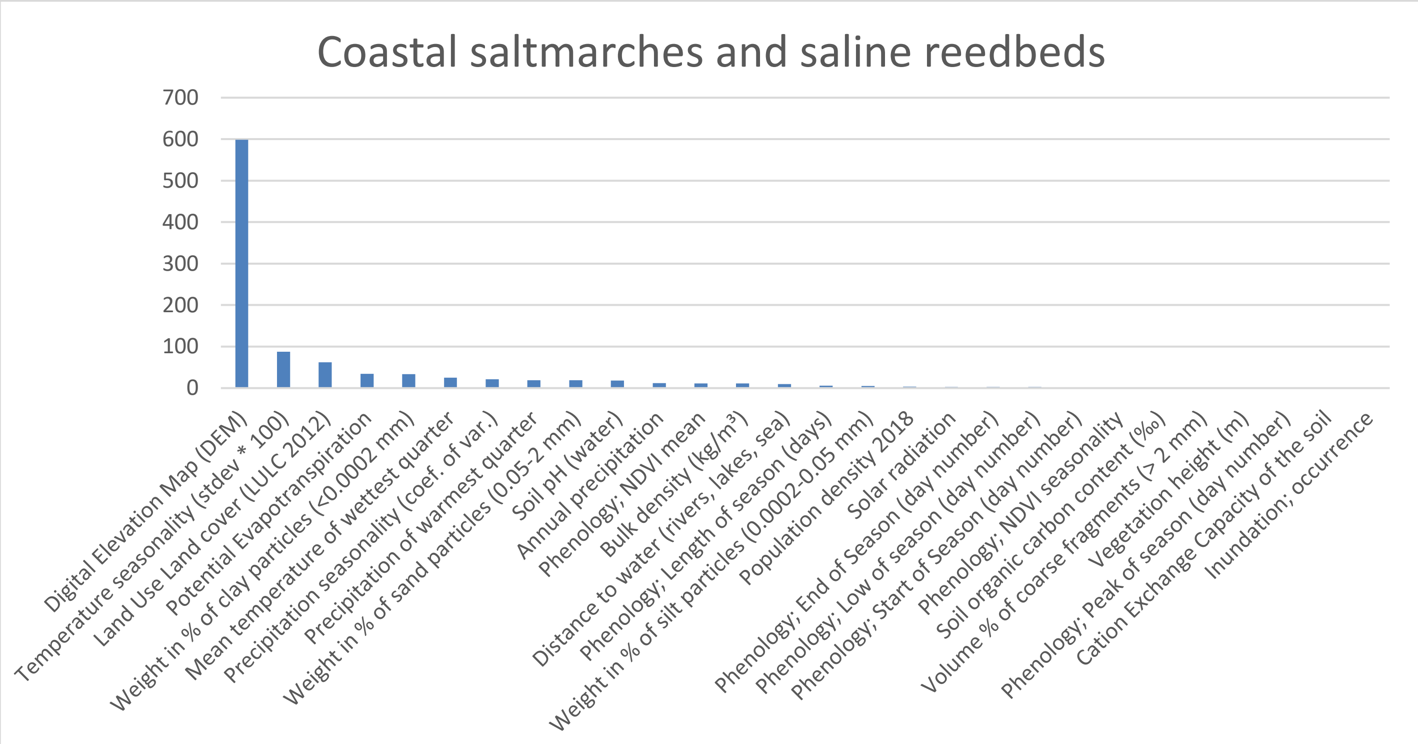


Figure 8 **Sum of contributions of all suitability models belonging to group MA, including 'Distance to coast'**

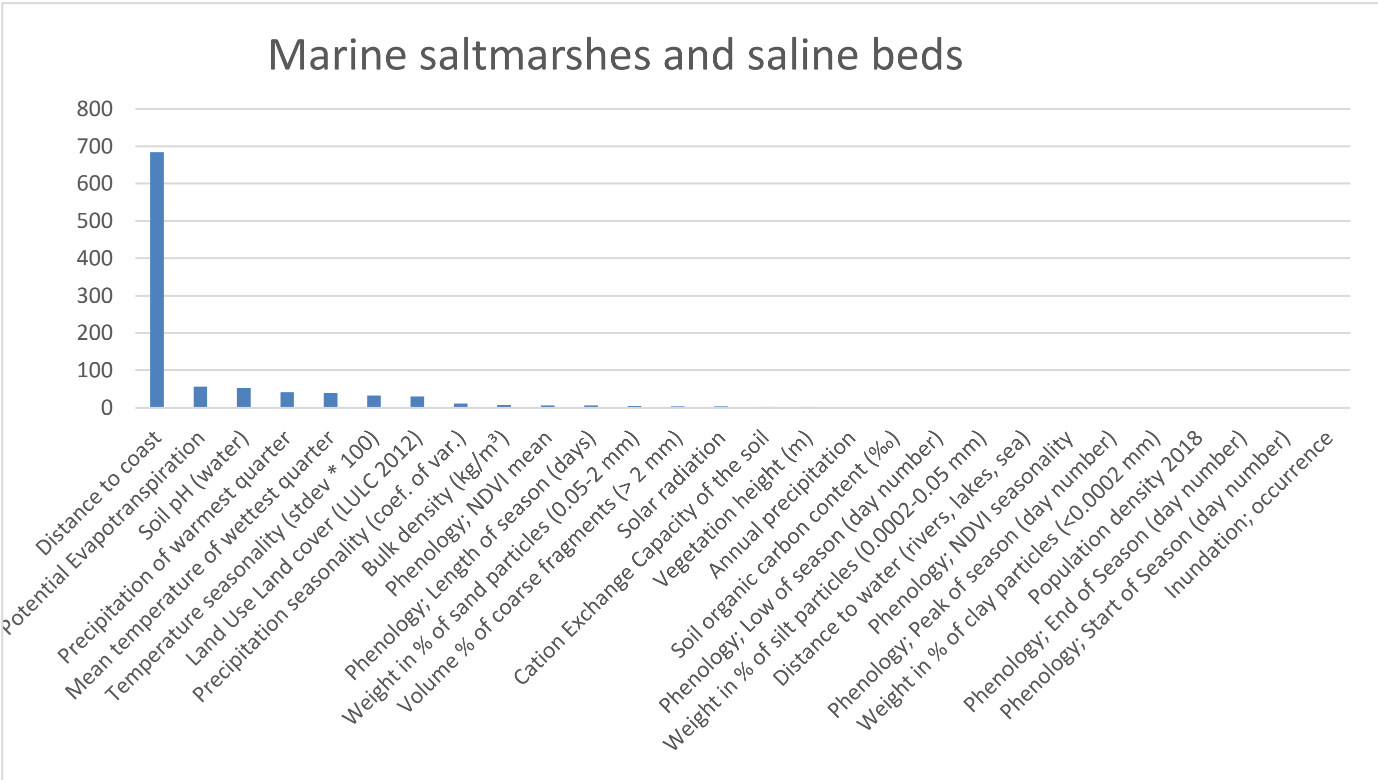


Figure 9 Sum of contributions of all suitability models belonging to group MA, including both 'Distance to coast' and 'Digital Elevation Map' (DEM).

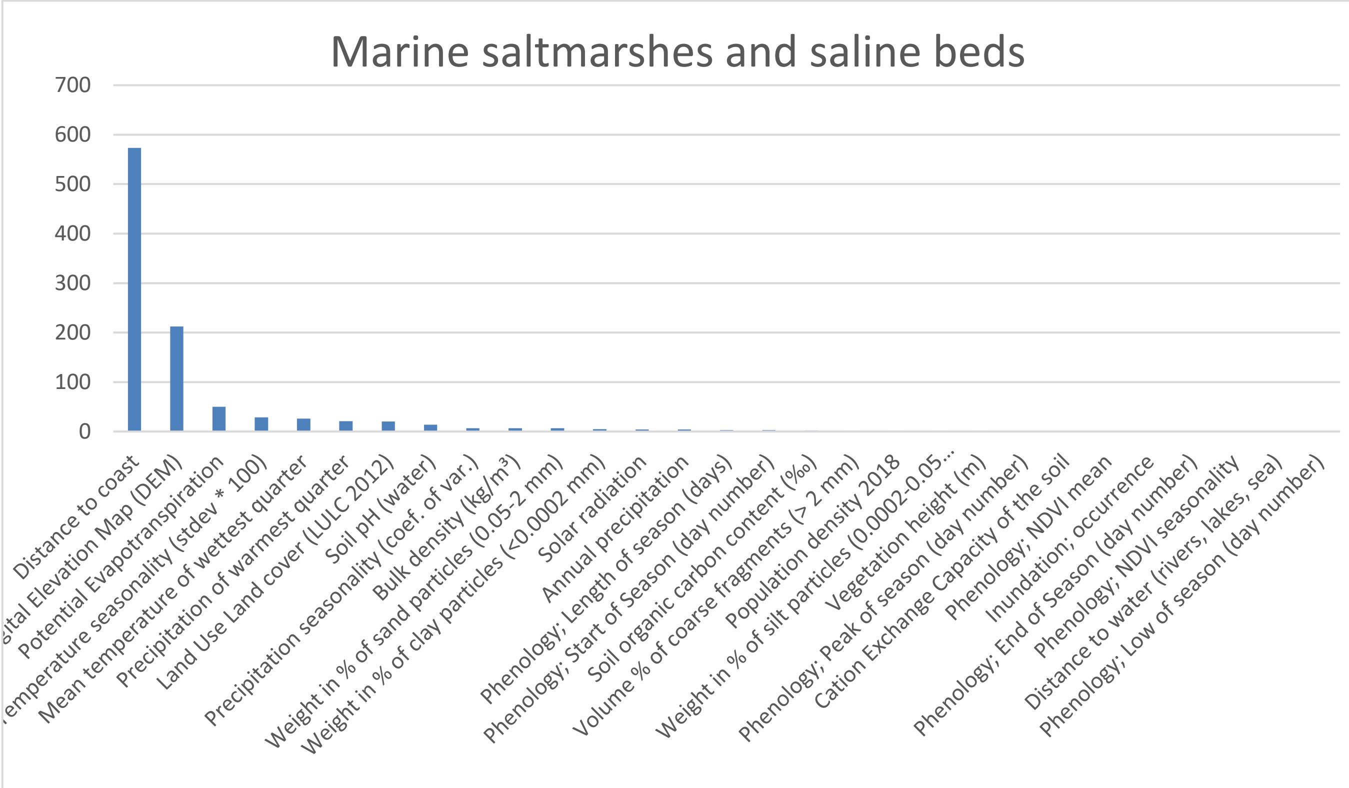
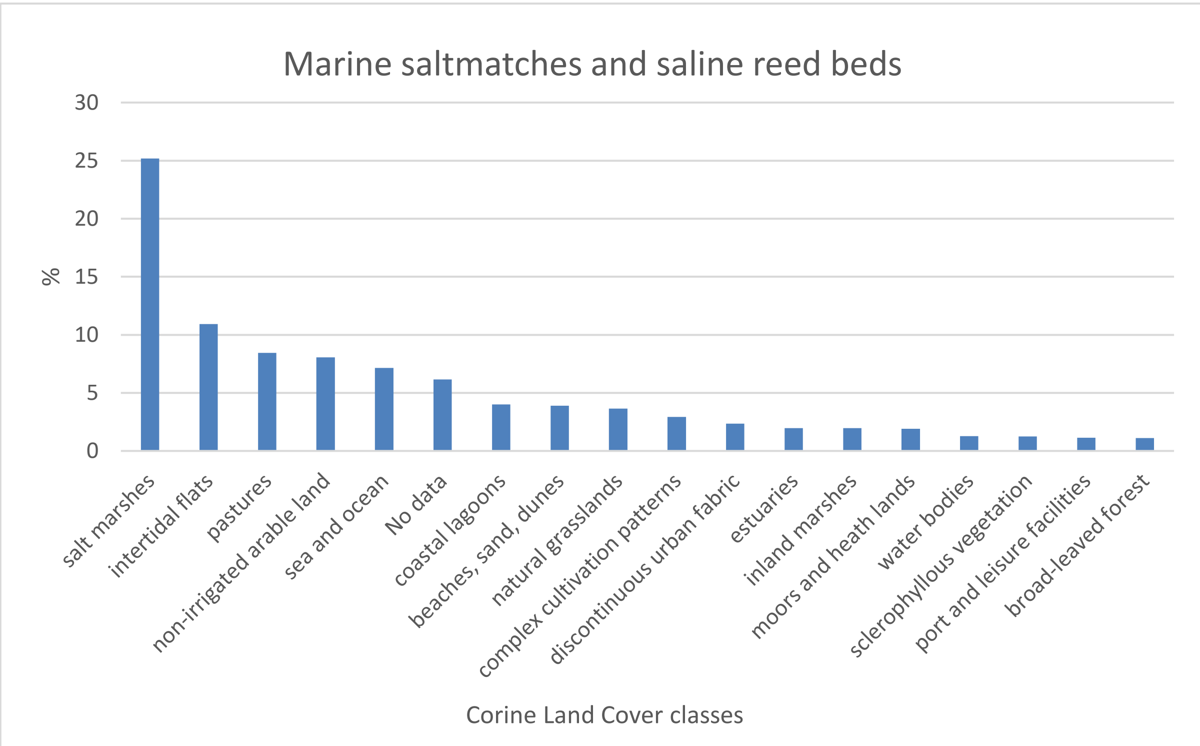


Figure 10 Percentage share of MA-related plots with Corine Land Cover classes



Sparsely vegetated habitats

Like with Marine saltmarshes, altitude by means of the ‘Digital Elevation Model’ (DEM) is the predominant predictor (Figure 11). This is what can be expected, as sparsely vegetated habitats often occur in remote mountainous areas, although some of the habitat types belonging to group U also occur on variable altitudes, from lowland to montane area (e.g. U27, U33, U37).

Matching the vegetation plots with Land Use Land Cover (Figure 12) shows that at least the first 4 categories make sense (Bare rocks, Broad-leaved forest, Natural grassland, Sparsely vegetated areas). Matching with Broad-leaved forest may seem strange, but it should be considered that the minimum mapping unit is 25 ha (https://land.copernicus.eu/pan-european/corine-land-cover). Sparsely vegetated patches are often smaller in size and are then included in adjacent land use types that occur over larger areas.

Figure 11 Sum of the contributions of all suitability models for group U

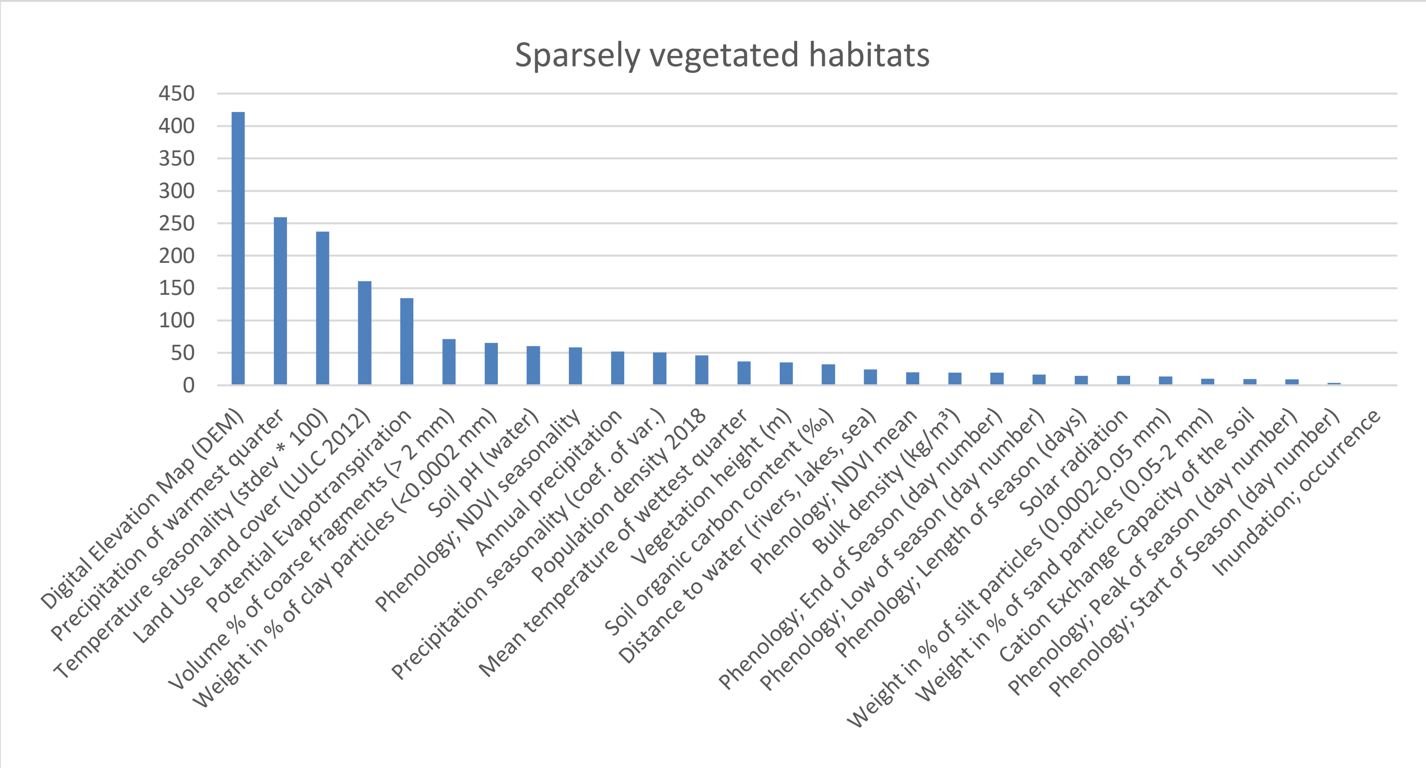
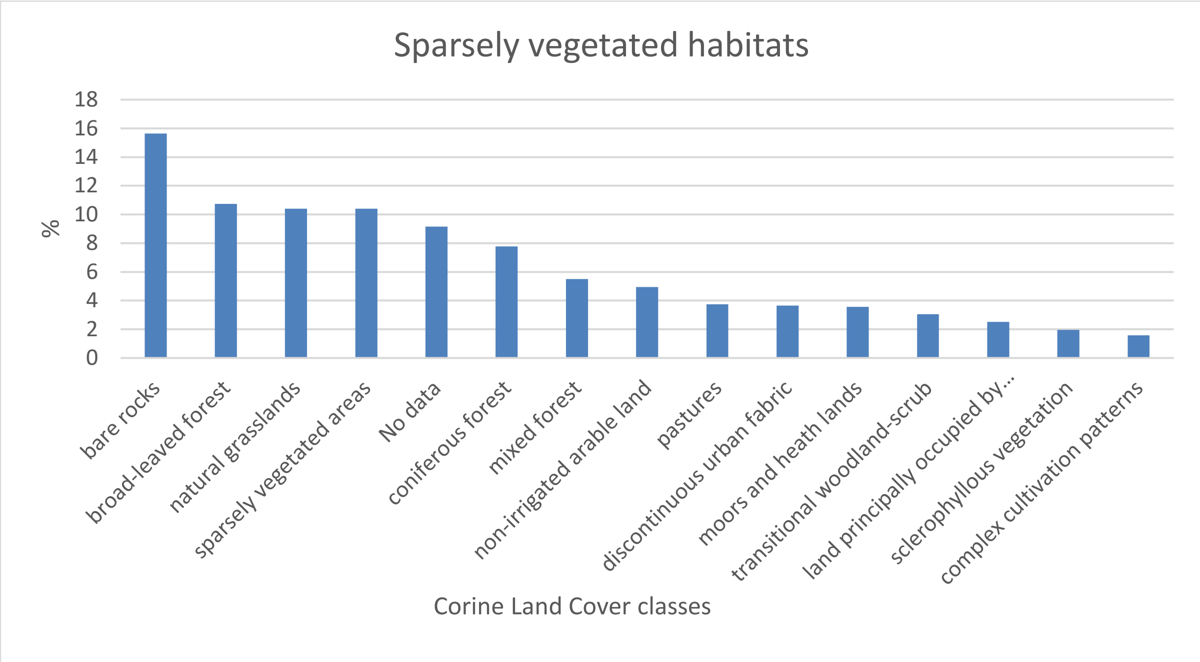


Figure 12 Percentage share of U-related plots with Corine Land Cover classes



References

Bogliani G & Della Rocca F. (Eds.) (2015). Biodiversity and rice production in rice agro-ecosystem. The Action Plan. Department of Earth and Environmental Sciences, University of Pavia (Italy).

Elith, J., J., Phillips, S. J., Hastie, T., Dudíte, M., Chee, Y. E. & Yates, C. J. (2011). A statistical explanation of MaxEnt for ecologists. Diversity and Distributions, 17: 43-57.

Hengl T, de Jesus J.M., MacMillan R.A., Batjes N.H., Heuvelink G.B.M., Ribeiro E., Alessandro Samuel-Rosa, Kempen, B., Leenaars, J.G.B., Walsh, M.G., Gonzalez. M.R. (2014) SoilGrids1km — Global Soil Information Based on Automated Mapping. PLoS ONE 9(8): e105992. doi:10.1371/journal.pone.0105992.

Hennekens S.M. & J.H.J. Schaminée (2016). Distribution and habitat suitability maps of revised EUNIS heath, scrub and tundra types' delivered within the 2015 EEA contract).

Hennekens, S.M. (2017). Distribution and habitat suitability maps of revised EUNIS grassland types. Task n°: 1.7.5.A. Report ETC/BD.

Hennekens, S.M. (2018). Distribution and habitat suitability maps of revised EUNIS grassland, heathland, scrub, tundra and forest types. Task n°: 1.7.5.1 Report ETC/BD.

Hennekens, S.M. (2019). Distribution and habitat suitability maps of revised EUNIS coastal and wetland habitats. Task n°: 1.7.5.1. Report ETC/BD.

Hennekens, S.M. (2020). Distribution and habitat suitability maps of revised EUNIS vegetated man-made habitats. Task n°: 1.7.5.1. Report ETC/BD.

Mücher, C.A. & S.M. Hennekens (2017). Modelling habitat probability maps for EUNIS habitat types heathland, scrub and tundra based on vegetation relevés, environmental data and Copernicus land cover data. Task n°: 1.7.5.C. Report ETC/BD.

Phillips, S.J., R.P. Anderson & R.E. Schapire (2006). Maximum entropy modelling of species geographic distributions. Ecological Modelling 190: 231–259.

Rega C., Short C., Marta Pérez-Soba M. & Maria Luisa Paracchini M.A. (2020). A classification of European agricultural land using an energy-based intensity indicator and detailed crop description. Landscape and urban planning 198.

Schaminée J.H.J., Chytrý M., Hennekens S.M., Janssen J.A.M., Knollová I., Marcenò C. &, Tichý L. (2020). Support to EUNIS habitat classification revision IV. Report for the European Environmental Agency (EEA/NSS/17/002/Lot 1), Copenhagen.

Annex 1 List of EUNIS habitat types (group MA2 & U) with indication of availability of distribution and suitability maps

New code	EUNIS 2012 code	Habitat name	Distribution map	Suitability map	No of plots
MA2	A2.5	Littoral biogenic habitat			
MA21	A2.5	Arctic Littoral biogenic habitat			
MA211	A2.5	Arctic coastal saltmarshes	x	-	344
MA22	A2.5	Atlantic littoral biogenic habitat			
MA221	A2.5	Atlantic saltmarsh driftline	x	x	78
MA222	A2.5	Atlantic upper saltmarshes	x	x	673
MA223	A2.5	Atlantic upper-mid saltmarshes and saline and brackish reed, rush and sedge beds	x	x	5625
MA224	A2.5	Atlantic mid-low saltmarshes	x	x	7609
MA225	A2.5	Atlantic pioneer saltmarshes	x	x	1253
MA23	A2.5	Baltic hydrolittoral biogenic habitat			
MA232	A2.5	Baltic coastal meadow	x	x	563
MA24	A2.5	lack sea littoral biogenic habitats			
MA241	A2.5	Black Sea littoral saltmarshes	x	x	1121
MA25	A2.5	Mediterranean littoral biogenic habitat			
MA251	A2.5	Mediterranean upper saltmarshes	x	x	297
MA252	A2.5	Mediterranean upper-mid saltmarshes and saline and brackish reed, rush and sedge beds	x	x	1176
MA253	A2.5	Mediterranean mid-low saltmarshes	x	x	2402
U	H	Inland habitats with no or little soil and mostly with sparse vegetation			
U1	H1	Terrestrial underground caves, cave systems, passages and waterbodies			
U11	H1.1; H1.2; H1.3; H1.4	Cave	-	-	-
U12	H1.7	Disused underground mines and tunnels	-	-	-
U2	H2	Screes			
U21	H2.1	Boreal and arctic siliceous scree and block field	x	x	24
U22	H2.3	Temperate high-mountain siliceous scree	x	x	626

U23	H2.5	Temperate, lowland to montane siliceous scree	x	x	114
U24	H2.5	Mediterranean siliceous scree	x	x	146
U25	H2.2	Boreal and arctic base-rich scree and block field	x	x	28
U26	H2.4	Temperate high-mountain base-rich scree and moraine	x	x	1081
U27	H2.6	Temperate, lowland to montane base-rich scree	x	x	999
U28	H2.6	Western Mediterranean base-rich scree	x	x	120
U29	H2.6	Eastern Mediterranean base-rich scree	x	x	105
U2A	H2.6	Crimean base-rich screes	x	-	1
U3	H3	Inland cliffs, rock pavements and outcrops			
U31	H3.1	Boreal and arctic siliceous inland cliff	-	-	0
U32	H3.1	Temperate high-mountain siliceous inland cliff	x	x	159
U33	H3.1	Temperate, lowland to montane siliceous inland cliff	x	x	277
U34	H3.1	Mediterranean siliceous inland cliff	x	x	142
U35	H3.2	Boreal and arctic base-rich inland cliff	x	-	11
U36	H3.2	Temperate high-mountain base-rich inland cliff	x	x	612
U37	H3.2	Temperate, lowland to montane base-rich inland cliff	x	x	1311
U38	H3.2	Mediterranean base-rich inland cliff	x	x	489
U39	H3.2	Boreal ultramafic inland cliff	-	x	0
U3A	H3.2	Temperate ultramafic inland cliff	x	x	47
U3B	H3.2	Mediterranean ultramafic inland cliff	x	x	21
U3C	H3.3	Macaronesian inland cliff	x	-	52
U3D	H3.4	Wet inland cliff	x	x	76
U3E	H3.5	Limestone pavement	-	-	-
U4	H4	Snow or ice-dominated habitats			
U41	H4.1	Snow pack	-	-	-
U42	H4.2	Ice cap and glacier	-	-	-
U43	H4.3	Rock glacier and unvegetated ice-dominated moraine	-	-	-
U5	H5	Miscellaneous inland habitats usually with very sparse or no vegetation			
U51	H5-1; H5.11	Fjell field	-	-	-
U52	H5.1	Polar desert	x	-	2
U53	H5.2	Glacial moraines with very sparse or no vegetation	-	-	-

U6	H6	Recent volcanic features			
U61	H6.1 H6.2	Subarctic volcanic field	x	-	20
U62	H6.1; H6.2	Mediterranean, Macaronesian and temperate volcanic field	x	x	58

Annex 2 Distribution and suitability maps of the revised EUNIS habitat types (group MA2 & U)

See PDF file: Annex 2, Distribution and suitability maps of the revised EUNIS habitat types (Group MA2 & U)