Processing European habitats probability maps for EUNIS Forest (T), Heathland, scrub and tundra (S) and Grassland (R) habitat types based on vegetation relevés, environmental data and Copernicus land cover

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December 2019
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Context:
The Topic Centre has prepared this Technical paper in collaboration with the European Environment Agency (EEA) under its 2019 work programmes as a contribution to the EEA’s work on biodiversity assessments.

Citation:
Please cite this report as
Mücher, S. and Hennekens, S., 2019. Processing European habitat probability maps for EUNIS Forest (T), Heathland, scrub and tundra (S) and Grassland (R) habitat types based on vegetation relevés, environmental data and Copernicus land cover. ETC/BD report to the EEA.

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Processing European habitat probability maps for EUNIS Forest (T), Heathland, scrub and tundra (S) and Grassland (R) habitat types based on vegetation relevés, environmental data and Copernicus land cover
1 Background and objectives

1.1 Background

This report is part of the assignment of Wageningen Environmental Research (Alterra) for the European Topic Centre Biological Diversity (ETC/BD). The European Topic Centres (ETCs) are European consortia brought together to support the European Environment Agency (EEA) in its mandate on environmental information. ETCs are according to the EEA regulation and in practice, an important instrument in supporting the EEA through the execution of sizeable, continuous, well-defined tasks with the involvement of member countries. In particular ETCs support EEA data centres for the issues related to air, climate change, water, biodiversity and land use and may provide help to EEA in supporting other data centres coordinated by Eurostat and JRC. The ETC/BD is an European consortium working with the European Environment Agency under a framework partnership agreement. The main tasks of ETC/BD are to:

1. Assist the EEA in its task of reporting on Europe’s environment by addressing state and trends of biodiversity in Europe.
2. Provide the relevant information to support the implementation of environmental and sustainable development policies in Europe in particular for EU nature and biodiversity policies (DG Environment: Nature and Biodiversity).
3. Build capacity for reporting on biodiversity in Europe, mainly through the European Information and Observation Network (Eionet).

More information about ETC/BD can be found at: https://www.eionet.europa.eu/etcs/etc-bd

1.2 Objectives

This report is affiliated with task 1.7.5.A from the ETC/BD Action Plan 2018. The general objectives of this task are:

- To support the development of the EEA assessment framework up to 2020 by contributing to assessments of ecosystems and their conditions based on existing information and data to support the EU Biodiversity Strategy to 2020 (and its targets), in particular relevant data gathered from the Nature Directives, in close dialogue with the MAES process.
- To contribute to the biodiversity knowledge base by gathering evidence on the main drivers of biodiversity loss and biological characterisation of ecosystems, helping a better understanding of the links between pressures, conditions and services.
- To explore the contribution of Copernicus to biodiversity and ecosystem assessments.
- To explore the results of Art. 12 (Birds Directive) and Art. 17 (Habitats Directive) for various ecosystem assessment purposes.

More specifically, the objective in relation to this report is: to enhance the spatial delineation of ecosystems with remote sensing data, environmental data and in-situ vegetation relevés to produce actual high-resolution habitat probability maps for EUNIS habitat types at level 3 for the formations Forest, Heathland scrub and tundra, and Grassland.

In 2018 all EUNIS habitat types belonging to the groups E (grassland), F (heathland, scrub and tundra) and G (forest) have been revised under the Framework Contract EEA/NSS/17/002/Lot 1 (Schaminée et al. 2018). The revision resulted in an improved classification that was used to assign a large part of the European Vegetation Archive (EVA) to EUNIS habitat types. This work was the starting point for the current study for
ETC/BD, Task 1.7.5.1 to deliver distribution, suitability and probability maps for the EUNIS habitat types belonging to group E, F and G.

This resulted in newly defined EUNIS habitat suitability maps which were also based on much more in-situ vegetation plot data.

### Table 1.1 Targeted EUNIS formations, their old and new codes and their number

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<thead>
<tr>
<th>EUNIS Formation</th>
<th>Old Code</th>
<th>New Code</th>
<th>Number of habitats processed</th>
</tr>
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<tbody>
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<td>Forests</td>
<td>G T</td>
<td></td>
<td># 38</td>
</tr>
<tr>
<td>Heathland, scrub and Tundra</td>
<td>F S</td>
<td></td>
<td># 34</td>
</tr>
<tr>
<td>Grasslands</td>
<td>E R</td>
<td></td>
<td># 48</td>
</tr>
<tr>
<td>Total</td>
<td></td>
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</tbody>
</table>

On basis of this in newly defined EUNIS habitat suitability maps, 120 new habitat probability maps have been processed by exploiting Copernicus land cover data.

Table 1.2 shows the 120 habitat types for which habitat probability maps have been produced by combining the EUNIS habitat suitability maps with a 10-percentile threshold with Copernicus land cover information. For forests and grasslands habitats the Copernicus high resolution layers (HRLs) forest and grasslands could be used with a 20 meter spatial resolution across Europe, while for the formation Heath, scrub and tundra, we had to use the CORINE land cover information at a 100 meter resolution. For all habitat types we used the most actual Copernicus land cover information (Chapter 4).

### Table 1.2 List of 120 EUNIS habitat suitability types at level 3 that has been used as an input for the processing of the habitat probability maps based on actual land cover information.

<table>
<thead>
<tr>
<th>#</th>
<th>New Code</th>
<th>New code</th>
<th>Old code</th>
<th>10-per threshold</th>
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<td>R11</td>
<td>E11a</td>
<td>0.2075</td>
<td>Pannonian and Pontic sandy steppe</td>
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<td>2</td>
<td>R12</td>
<td>R12</td>
<td>E11b</td>
<td>0.3212</td>
<td>Cryptogam- and annual-dominated vegetation on siliceous rock outcrops</td>
</tr>
<tr>
<td>3</td>
<td>R13</td>
<td>R13</td>
<td>E11d</td>
<td>0.3279</td>
<td>Cryptogam- and annual-dominated vegetation on calcareous and ultramafic rock outcrops</td>
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<tr>
<td>4</td>
<td>R14</td>
<td>R14</td>
<td>E11e</td>
<td>0.4348</td>
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<tr>
<td>5</td>
<td>R16</td>
<td>R16</td>
<td>E11g</td>
<td>0.4221</td>
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<tr>
<td>6</td>
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<td>R17</td>
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<td>7</td>
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<td>R18</td>
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<td>8</td>
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<td>R35</td>
<td>E34a</td>
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</table>

Continental dry grassland (true steppe)

Mediterranean closely grazed dry grassland

Mediterranean tall perennial dry grassland

Mediterranean annual-rich dry grassland

Iberian oromediterranean siliceous dry grassland

Iberian oromediterranean basiphilous dry grassland

Mediterranean tall perennial dry grassland

Mediterranean annual-rich dry grassland

Mediterranean to Atlantic open, dry, acid and neutral grassland

Heavy-metal grassland in Western and Central Europe

Mesic permanent pasture of lowlands and mountains

Low and medium altitude hay meadow

Mountain hay meadow

Iberian summer pasture (vallicar)

Mediterranean tall humid inland grassland

Mediterranean short moist grassland of lowlands

Mediterranean short moist grassland of mountains

Submediterranean moist meadow

Moist or wet mesotrophic to eutrophic hay meadow
<table>
<thead>
<tr>
<th></th>
<th>R36</th>
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<th>E34b</th>
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<th>Moist or wet mesotrophic to eutrophic pasture</th>
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<td>Temperate and boreal moist or wet oligotrophic grassland</td>
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<td>R41</td>
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<td>R42</td>
<td>E43a</td>
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<td>Boreal and arctic acidophilous alpine grassland</td>
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<td>R43</td>
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<tr>
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<td>R45</td>
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<td>R51</td>
<td>R51</td>
<td>E52a</td>
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<td>Thermophilous forest fringe of base-rich soils</td>
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<tr>
<td>41</td>
<td>R52</td>
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<td>0.2576</td>
<td>Forest fringe of acidic nutrient-poor soils</td>
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<td>E54</td>
<td>0.4702</td>
<td>Lowland moist or wet tall-herb and fern fringe</td>
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<td>44</td>
<td>R56</td>
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<td>E55</td>
<td>0.4299</td>
<td>Montane to subalpine moist or wet tall-herb and fern fringe</td>
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<td>47</td>
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<td>E63</td>
<td>0.2774</td>
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**FORESTS (#38)**

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<td>G28</td>
<td>0.2897</td>
<td>Broadleaved evergreen plantation of non site-native trees</td>
</tr>
<tr>
<td>T31</td>
<td>T31</td>
<td>G31a</td>
<td>0.5703</td>
<td>Temperate mountain Picea forest</td>
</tr>
<tr>
<td>T32</td>
<td>T32</td>
<td>G31b</td>
<td>0.5128</td>
<td>Temperate mountain Abies forest</td>
</tr>
<tr>
<td>T33</td>
<td>T33</td>
<td>G31c</td>
<td>0.4368</td>
<td>Mediterranean mountain Abies forest</td>
</tr>
<tr>
<td>T34</td>
<td>T34</td>
<td>G32</td>
<td>0.5222</td>
<td>Temperate subalpine Larix, Pinus cembra and Pinus uncinata forest</td>
</tr>
<tr>
<td>T35</td>
<td>T35</td>
<td>G34a</td>
<td>0.4268</td>
<td>Temperate continental Pinus sylvestris forest</td>
</tr>
<tr>
<td>T36</td>
<td>T36</td>
<td>G34b</td>
<td>0.4283</td>
<td>Temperate and submediterranean montane Pinus sylvestris-Pinus nigra forest</td>
</tr>
<tr>
<td>T37</td>
<td>T37</td>
<td>G34c</td>
<td>0.4211</td>
<td>Mediterranean montane Pinus sylvestris-Pinus nigra forest</td>
</tr>
<tr>
<td>T39</td>
<td>T39</td>
<td>G36</td>
<td>0.3135</td>
<td>Mediterranean and Balkan subalpine Pinus heldreichii-Pinus peuce forest</td>
</tr>
<tr>
<td>T3A</td>
<td>T3A</td>
<td>G37</td>
<td>0.4017</td>
<td>Mediterranean lowland to submontane Pinus forest</td>
</tr>
<tr>
<td>T3C</td>
<td>T3C</td>
<td>G39a</td>
<td>0.2991</td>
<td>Taxus baccata forest</td>
</tr>
<tr>
<td>T3D</td>
<td>T3D</td>
<td>G39b</td>
<td>0.2777</td>
<td>Mediterranean Cupressaceae forest</td>
</tr>
<tr>
<td>T3F</td>
<td>T3F</td>
<td>G3A</td>
<td>0.5426</td>
<td>Dark taiga</td>
</tr>
<tr>
<td>T3G</td>
<td>T3G</td>
<td>G3B</td>
<td>0.5686</td>
<td>Pinus sylvestris light taiga</td>
</tr>
<tr>
<td>T3J</td>
<td>T3J</td>
<td>G3Da</td>
<td>0.4502</td>
<td>Pinus and Larix mire forest</td>
</tr>
<tr>
<td>T3K</td>
<td>T3K</td>
<td>G3Db</td>
<td>0.4123</td>
<td>Picea mire forest</td>
</tr>
<tr>
<td>T3M</td>
<td>T3M</td>
<td>G3F1</td>
<td>0.4456</td>
<td>Coniferous plantation of non site-native trees</td>
</tr>
</tbody>
</table>

Notice that the value of all habitat suitability maps below the 10 percentile threshold has been set to zero as an input for the calculation of the habitat probability maps.
1.3 Content of the report

This report on the production of the EUNIS forest, heathland, scrub & tundra and grassland habitat probability maps at level 3 has 4 chapters. Chapter 1 describes the background and the objectives of the project. Chapter 2 is an introduction on the habitat modelling, starting with the distribution, followed by habitat suitability and finally the habitat probability maps. The integration of in-situ vegetation relevés, environmental data layers and Remote Sensing enabled Essential Biodiversity Variables (RS-EBVs), including Copernicus high resolution land cover information, plays an important role in the overall methodology. Chapter 3 explains how the EUNIS habitat suitability maps have been produced. Chapter 4 describes the Copernicus land cover data sources. Chapter 5 describes how the habitat probability maps have been processed based on the integration of the low resolution habitat suitability maps with the high resolution Copernicus land cover data.

Appendix 1 shows the #38 Forests (T formation) probability maps, including the distribution map (original in-situ vegetation plots) and a detail of the probability maps that shows the real detail of the maps. So in total Appendix 1 has 114 figures.

Appendix 2 shows the #34 Heathland, scrub and Tundra (S formation) probability maps, including the distribution map (original in-situ vegetation plots) and a detail of the probability maps that shows the real detail of the maps. So in total Appendix 2 has 102 figures.

Appendix 3 shows the #48 Grassland (R formation) probability maps, including the distribution map (original in-situ vegetation plots) and a detail of the probability maps that shows the real detail of the maps. So in total Appendix 3 has 144 figures.
2 Habitat modelling

2.1 Introduction

Although it is rare to record or map EUNIS habitat types in the field, there are many data sources which allow mapping of their distribution. The most important single source of information are vegetation plots (also known as relevés), given areas in which all plant species occurring are recorded. In the past few years a large number of national and regional databases with such data have been brought together within the European Vegetation Archive project (http://euroveg.org/eva-database). Together with other sources of data, they allow the production of several types of distribution map as explained below.

Distribution – maps of known occurrences based on the locality of vegetation plots which can be assigned to a EUNIS habitat class. They show localities where the habitat is known to occur (at least at the time of survey), but give an incomplete record of the actual distribution.

Suitability – modelling of areas where the environment is suitable for the habitat.

Probability – the modelled suitability map is refined by using actual land cover information.

2.2 Methodology

![Distribution → Suitability → Probability](image)

Figure 2.1 G1.6a: Fagus woodland on non-acid soils

The road from individual vegetation relevés to finally a probability map of a EUNIS class, roughly comprises three steps (see also figure 2.1).

1. Relevés stored in the European Vegetation Database (EVA) are assigned to EUNIS classes using expert rules. An expert rule defines the floristic composition (which species should be present and which species should be absent) of a class and is used to select those relevés that meet the imposed condition. The selection is used to create a distribution map, as far as the geographic location is tied to the relevés.

2. The distribution, by means of geographic locations of the relevés, see Figure 1, is used in the second step, the distribution model. For the modelling the distribution data are related to climate and soil data, environmental data that is stored in grid maps at a European scale. The modelling software Maxent (Phillips et al., 2006) calculates which environmental layers have the largest contribution to the model, in other words explains the distribution of the vegetation relevés (thus the EUNIS class)
the best. One of the outcomes of the model is a **suitability map**, see Figure 1. This map indicates how suitable, in terms of climate and soil conditions an area is for the EUNIS class concerned. This on a scale of 0 to 1, in the map in Appendix B with colours running from white, via green to red.

3. Where step 1 and 2 are bottom-up approaches, the third step is a top-down approach, where all kind of land cover data (earth observation data like high resolution satellite data, is used to filter the suitability map to eventually get to a refined **probability map**, see Figure 1. As such the probability map is a refinement of the suitability map.

While the suitability map can be considered as a potential distribution map, the probability map presents more the actual distribution of the habitat type. Although the probably map still represents a modelled distribution and overestimates the actual distribution.

All three steps are explained more in detail in the unpublished report ‘Modelling the spatial distribution of EUNIS forest habitat types’ by Mücher, et al. (2015).

![Figure 2.2](image)

**Figure 2.2** Newly adjusted general workflow for the processing of refined EUNIS forest habitat probability maps (adjusted from Mücher et al., 2015).
3 Habitat suitability maps

For habitat suitability modelling, the widely used software Maxent 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 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. It is assumed that these layers represent well the most important ecological gradients on a European scale. The layers were selected from meaningful environmental predictors commonly used for modelling non-tropical plant and vegetation diversity, and are not mutually strongly correlated. In addition to what was selected as predictors in previous years (Hennekens 2016, 2017), also so-called RS-enabled EBV’s (Remote Sensed Essential Biodiversity Variables; predictors based on remote sensing data), such as LAI, phenology, land cover, chlorophyll content, inundation, vegetation height have now been applied (Skidmore et al, 2015, Pettorelli et al., 2016).

It is assumed that by using additional meaningful predictors such as the RS-enabled 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).

As a side effect of using the RS-EBS’s 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 currently not well represented in EVA.

As environmental predictors (and their sources) the following climate and soil layers have been used:

**Climate**

- Potential Evapotranspiration
- Solar radiation
- Temperature Seasonality (standard deviation *100)
  http://www.worldclim.org/bioclim
- Mean Temperature of Wettest Quarter
  http://www.worldclim.org/bioclim
- Annual Precipitation
  http://www.worldclim.org/bioclim
- Precipitation Seasonality (Coefficient of Variation)
  http://www.worldclim.org/bioclim
- Precipitation of Warmest Quarter
  http://www.worldclim.org/bioclim
Topography

- Distance to water (rivers, lakes, sea)
  derived from the shapefile ‘Inland_Waters.shp’
- Digital Elevation Map (DEM)

Soil

- Bulk density of the soil (kg/m³)
  Hengl et al. 2014
- Cation Exchange Capacity of the soil
  Hengl et al. 2014
- Weight in % of clay particles (<0.0002 mm)
  Hengl et al. 2014
- Volume % of coarse fragments (> 2 mm)
  Hengl et al. 2014
- Soil organic carbon content (‰)
  Hengl et al. 2014
- Soil pH (water)
  Hengl et al. 2014
- Weight in % of silt particles (0.0002-0.05 mm)
  Hengl et al. 2014
- Weight in % of sand particles (0.05-2 mm)
  Hengl et al. 2014

RS-EBV’s

- 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
Processing European habitat probability maps for EUNIS Forest (T), Heathland, scrub and tundra (S) and Grassland (R) habitat types based on vegetation relevés, environmental data and Copernicus land cover.

More information on predictors and particularly on RS-EBS’s can be found here: [https://www.synbiosys.alterra.nl/nextgeoss/docs/Description_Abiotic_and_RSEBV.pdf](https://www.synbiosys.alterra.nl/nextgeoss/docs/Description_Abiotic_and_RSEBV.pdf)

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, assuming biased and non-biased presence 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 (assuming biased and non-biased data) were evaluated for each of the EUNIS habitat types in order to estimate which assumption is more likely. Surprisingly the current study showed that all maps using background data that was randomly selected by Maxent were far more better (by visual inspection) than the maps produced using background randomly derived from the EVA database. Figure 3.1 clearly shows an overestimation of habitat type F1.6a (Fagus forest on non-acid soils) in a large part of Europe, whereas figure 3.2 presents a more realistic picture.

**Figure 3.1** EUNIS type F1.6a; background data based on locations from randomly selected plots in the EVA database.

**Figure 3.2** EUNIS type F1.6a; background data randomly selected from the study area by Maxent.
Another test that was performed was running all models with and without the RS-EBV’s predictors. In figure 3.3 and 3.4 it is shown that leaving out RS-EBV’s does not affect the distribution range. However it also shown that including RS-EBV’s the suitability is more differentiated, compare figure 3.5 and 3.6.

In a next step, actual land cover information plays a key role to fine-tune the habitat suitability maps into habitat probability maps, and the land cover sources and processing are discussed in Chapter 4, while the methodology for the habitat probability maps is discussed in Chapter 5.
4 Copernicus Land Cover

The European land cover databases with the highest spatial resolution are the Copernicus HRLs (High Resolution Layers with a 20 meter spatial resolution and exist for specific themes: 1) imperviousness 2) forests; 3) permanent waterbodies; 4: grasslands and 5) wetlands (see also https://land.copernicus.eu/).

So for the Forest habitat probability maps we incorporated the Copernicus Forest HRL with a spatial resolution of 20 meter. For the Grassland habitat probability maps we incorporated the Copernicus Grassland HRL with a spatial resolution of 20 meter. And only for the formation Heathland, scrub and tundra no Copernicus HRL was available, and therefore we used the most recent CORINE land cover information at a 100 meter spatial resolution.

For forest we used the Copernicus HRL Forest for 2015 with the forest types: broadleaved forest (1) and coniferous forest (2) (source: FTY_2015_020m_eu_03035_d04_full.tif from EEA).

For each EUNIS forest habitat type at level 3 we had to determine if the habitat was related to 1) broadleaved forest or 2) coniferous forest.
<table>
<thead>
<tr>
<th>#</th>
<th>New Code</th>
<th>Old code</th>
<th>New name</th>
<th>Forest type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>T11</td>
<td>G11</td>
<td>Temperate Salix and Populus riparian forest</td>
<td>1-Broadleaved</td>
</tr>
<tr>
<td>2</td>
<td>T12</td>
<td>G12a</td>
<td>Alnus glutinosa-Alnus incana forest on riparian and mineral soils</td>
<td>1-Broadleaved</td>
</tr>
<tr>
<td>3</td>
<td>T13</td>
<td>G12b</td>
<td>Temperate hardwood riparian forest</td>
<td>1-Broadleaved</td>
</tr>
<tr>
<td>4</td>
<td>T14</td>
<td>G13</td>
<td>Mediterranean and Macaronesian riparian forest</td>
<td>1-Broadleaved</td>
</tr>
<tr>
<td>5</td>
<td>T15</td>
<td>G14</td>
<td>Broadleaved swamp forest on non-acid peat</td>
<td>1-Broadleaved</td>
</tr>
<tr>
<td>6</td>
<td>T16</td>
<td>G15</td>
<td>Broadleaved mire forest on acid peat</td>
<td>1-broadleaved</td>
</tr>
<tr>
<td>7</td>
<td>T17</td>
<td>G16a</td>
<td>Fagus forest on non-acid soils</td>
<td>1-broadleaved</td>
</tr>
<tr>
<td>8</td>
<td>T18</td>
<td>G16b</td>
<td>Fagus forest on acid soils</td>
<td>1-broadleaved</td>
</tr>
<tr>
<td>9</td>
<td>T19</td>
<td>G17a</td>
<td>Temperate and submediterranean thermophilous deciduous forest</td>
<td>1-Broadleaved</td>
</tr>
<tr>
<td>10</td>
<td>T1A</td>
<td>G17b</td>
<td>Mediterranean thermophilous deciduous forest</td>
<td>1-broadleaved</td>
</tr>
<tr>
<td>11</td>
<td>T1B</td>
<td>G18</td>
<td>Acidophilous Quercus forest</td>
<td>1-broadleaved</td>
</tr>
<tr>
<td>12</td>
<td>T1C</td>
<td>G19a</td>
<td>Temperate and boreal mountain Betula and Populus tremula forest on mineral soils</td>
<td>1-broadleaved</td>
</tr>
<tr>
<td>13</td>
<td>T1D</td>
<td>G19b</td>
<td>Southern European mountain Betula and Populus tremula forest on mineral soils</td>
<td>1-Broadleaved</td>
</tr>
<tr>
<td>14</td>
<td>T1E</td>
<td>G1Aa</td>
<td>Carpinus and Quercus mesic deciduous forest</td>
<td>1-Broadleaved</td>
</tr>
<tr>
<td>15</td>
<td>T1F</td>
<td>G1Ab</td>
<td>Ravine forest</td>
<td>1-Broadleaved</td>
</tr>
<tr>
<td>16</td>
<td>T1G</td>
<td>G1Aa</td>
<td>Alnus cordata forest</td>
<td>1-Broadleaved</td>
</tr>
<tr>
<td>17</td>
<td>T1H</td>
<td>G1C</td>
<td>Broadleaved deciduous plantation of non site-native trees</td>
<td>1-Broadleaved</td>
</tr>
<tr>
<td>18</td>
<td>T21</td>
<td>G21</td>
<td>Mediterranean evergreen Quercus forest</td>
<td>1-Broadleaved</td>
</tr>
<tr>
<td>19</td>
<td>T22</td>
<td>G22</td>
<td>Mainland laurophyllous forest</td>
<td>1-Broadleaved</td>
</tr>
<tr>
<td>20</td>
<td>T24</td>
<td>G24</td>
<td>Olea europaea-Ceratonia silquua forest</td>
<td>1-Broadleaved</td>
</tr>
<tr>
<td>21</td>
<td>T27</td>
<td>G26</td>
<td>Ilex aquifolium forest</td>
<td>1-Broadleaved</td>
</tr>
<tr>
<td>22</td>
<td>T29</td>
<td>G28</td>
<td>Broadleaved evergreen plantation of non site-native trees</td>
<td>1-Broadleaved</td>
</tr>
<tr>
<td>23</td>
<td>T31</td>
<td>G31a</td>
<td>Temperate mountain Picea forest</td>
<td>2-Coniferous</td>
</tr>
<tr>
<td>24</td>
<td>T32</td>
<td>G31b</td>
<td>Temperate mountain Abies forest</td>
<td>2-Coniferous</td>
</tr>
<tr>
<td>25</td>
<td>T33</td>
<td>G31c</td>
<td>Mediterranean mountain Abies forest</td>
<td>2-Coniferous</td>
</tr>
<tr>
<td>26</td>
<td>T34</td>
<td>G32</td>
<td>Temperate subalpine Larix, Pinus cembra and Pinus uncinata forest</td>
<td>2-Coniferous</td>
</tr>
<tr>
<td>27</td>
<td>T35</td>
<td>G34a</td>
<td>Temperate continental Pinus sylvestris forest</td>
<td>2-Coniferous</td>
</tr>
<tr>
<td>28</td>
<td>T36</td>
<td>G34b</td>
<td>Temperate and submediterranean montane Pinus sylvestris-Pinus nigra forest</td>
<td>2-Coniferous</td>
</tr>
<tr>
<td>29</td>
<td>T37</td>
<td>G34c</td>
<td>Mediterranean montane Pinus sylvestris-Pinus nigra forest</td>
<td>2-Coniferous</td>
</tr>
<tr>
<td>30</td>
<td>T39</td>
<td>G36</td>
<td>Mediterranean and Balkan subalpine Pinus heldreichii-Pinus peuce forest</td>
<td>2-Coniferous</td>
</tr>
<tr>
<td>31</td>
<td>T3A</td>
<td>G37</td>
<td>Mediterranean lowland to submontane Pinus forest</td>
<td>2-Coniferous</td>
</tr>
<tr>
<td>32</td>
<td>T3C</td>
<td>G39a</td>
<td>Taxus baccata forest</td>
<td>2-Coniferous</td>
</tr>
<tr>
<td>33</td>
<td>T3D</td>
<td>G39b</td>
<td>Mediterranean Cupressaceae forest</td>
<td>2-Coniferous</td>
</tr>
<tr>
<td>34</td>
<td>T3F</td>
<td>G3A</td>
<td>Dark taiga</td>
<td>2-Coniferous</td>
</tr>
<tr>
<td>35</td>
<td>T3G</td>
<td>G3B</td>
<td>Pinus sylvestris light taiga</td>
<td>2-Coniferous</td>
</tr>
<tr>
<td>36</td>
<td>T3J</td>
<td>G3Da</td>
<td>Pinus and Larix mire forest</td>
<td>2-Coniferous</td>
</tr>
<tr>
<td>37</td>
<td>T3K</td>
<td>G3Db</td>
<td>Picea mire forest</td>
<td>2-Coniferous</td>
</tr>
<tr>
<td>38</td>
<td>T3M</td>
<td>G3F1</td>
<td>Coniferous plantation of non site-native trees</td>
<td>2-Coniferous</td>
</tr>
</tbody>
</table>
For grasslands there are two Copernicus High Resolution Layers (HRL), namely for 2012 and 2015 that differ substantially. While HRL grassland 2012 focussed on natural and semi-natural grasslands, the HRL grassland 2015 focussed on all grasslands (from natural to managed grasslands) within one class called grasslands. Due to poorer classification results in 2012, the 2015 product is based on a longer time series of imagery from a number of different sensors. SAR radar and optical data were combined for the first time to improve the classification accuracy of grasslands. The main product for 2015 is a binary grassland/non-grassland product. Both HRL products of 2012 and 2015 have 20m pixels size.

![Figure 4.2](image)

Figure 4.2  the Dutch national land cover database LGN7 showing here only all grassland related land cover classes
Processing European habitat probability maps for EUNIS Forest (T), Heathland, scrub and tundra (S) and Grassland (R) habitat types based on vegetation relevés, environmental data and Copernicus land cover.

Figure 4.3  the Copernicus HRL grassland for 2012 showing only natural and semi-natural grasslands.

Figure 4.4  the Copernicus HRL grassland for 2015 showing all grasslands as one class.
Despite the poorer classification results for 2012 compared with the HRL grassland product from 2015, we decided to combine the two products in a new product HRL_grass20m that distinguished two classes namely 1) natural and semi-natural grasslands and 2) managed grasslands. The reason for this is that if we didn’t combine the two we would miss a lot of grassland areas for example in the dunes. The 2012 product did overrule 2015 for semi-natural grasslands. The example below for the Netherlands clearly shows that we would miss the dune grasslands if we did not integrate the 2012 HRL product.

Therefore on basis of the integration of HRL grassland 2012, see Figure 4.5, and HRL grassland 2015, see Figure 4.6, we made the new product HRL_grass20m with a 20 meter resolution and having two thematic grassland classes; 1) natural and semi-natural grasslands and 2) managed grasslands. For the HRL_grass20m database, see figure 4.7

Figure 4.5  the entire Copernicus HRL grassland database for 2012 showing only natural and semi-natural grasslands
Processing European habitat probability maps for EUNIS Forest (F), Heathland, scrub and tundra (S) and Grassland (R) habitat types based on vegetation relevés, environmental data and Copernicus land cover data.

**Figure 4.6** the entire Copernicus HRL grassland database for 2015 showing all grasslands as one class.

**Figure 4.7** Integrated grassland database based on Copernicus HRL grassland database for 2012 and 2015 distinguishing class 1) natural and semi-nature grassland and class 2) managed grasslands.
For the formation Heathland, scrub and tundra we had to use the most recent CORINE land cover information from 2018 since there is no associated Copernicus HRL.

![Corine land cover 2018](source: EEA, CLC2018_CLC2018_V2018_20.tif)

Table 4.2 shows the decision rules for each habitat type in their relation with CORINE land cover classes. So especially for the formation (S) Heathland, scrub and tundra, the relationship between habitat type and land cover type is more complicated than for the formation Forest (G) and Grasslands (R)

### Table 4.2  Decision rules EUNIS Heathland, scrub and tundra habitat types in relation to CLC2018

<table>
<thead>
<tr>
<th>Nr</th>
<th>EUNIS-3 code</th>
<th>EUNIS-3 habitat name</th>
<th>Relationship to CLC (D. Moss)</th>
<th>Relationship to CLC (releves)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S11</td>
<td>Shrub tundra</td>
<td>Sparsely vegetated (333)</td>
<td>322, 332, 333</td>
</tr>
<tr>
<td>2</td>
<td>S12</td>
<td>Moss and lichen tundra</td>
<td>Sparsely vegetated (333)</td>
<td>322, 332, 333</td>
</tr>
<tr>
<td>3</td>
<td>S21</td>
<td>Subarctic and alpine dwarf Salix scrub</td>
<td>Sparsely vegetated (333)</td>
<td>322, 333</td>
</tr>
<tr>
<td>4</td>
<td>S22</td>
<td>Alpine and subalpine ericoid heath</td>
<td>Moors and heathland (322)</td>
<td>321, 322, 332, 333</td>
</tr>
<tr>
<td>5</td>
<td>S23</td>
<td>Alpine and subalpine Juniperus scrub</td>
<td>Moors and heathland (322)</td>
<td>321, 322, 324, 333</td>
</tr>
<tr>
<td>6</td>
<td>S24</td>
<td>Subalpine genistoid scrub of the Amphi-Adriatic region</td>
<td>Moors and heathland (322)</td>
<td>321, 322, 324, 333</td>
</tr>
<tr>
<td>7</td>
<td>S25</td>
<td>Subalpine deciduous scrub</td>
<td>Moors and heathland (322)</td>
<td>321, 322, 324, 333</td>
</tr>
<tr>
<td>8</td>
<td>S26</td>
<td>Subalpine Pinus mugo scrub</td>
<td>Moors and heathland (322)</td>
<td>321, 322, 324, 333</td>
</tr>
<tr>
<td>9</td>
<td>S31</td>
<td>Lowland to montane temperate and submediterranean Juniperus scrub</td>
<td>Moors and heathland (322)</td>
<td>321, 322, 324, 333</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>10</td>
<td>S32</td>
<td>Temperate Rubus scrub</td>
<td>Moors and heathland (322)</td>
<td>321, 322, 324</td>
</tr>
<tr>
<td>11</td>
<td>S33</td>
<td>Lowland to montane temperate and submediterranean genistoid scrub</td>
<td>Moors and heathland (322)</td>
<td>321, 322, 323, 324</td>
</tr>
<tr>
<td>12</td>
<td>S35</td>
<td>Temperate and submediterranean thorn scrub</td>
<td>Moors and heathland (322)</td>
<td>321, 322, 324</td>
</tr>
<tr>
<td>13</td>
<td>S36</td>
<td>Low steppic scrub</td>
<td>Sparsely vegetated (333)</td>
<td>324, 333</td>
</tr>
<tr>
<td>14</td>
<td>S37</td>
<td>Corylus avellana scrub</td>
<td>?</td>
<td>311, 312, 313, 321, 324, 332</td>
</tr>
<tr>
<td>15</td>
<td>S38</td>
<td>Temperate forest clearing scrub</td>
<td>Sparsely vegetated (333)</td>
<td>311, 312, 313, 321, 322, 324</td>
</tr>
<tr>
<td>16</td>
<td>S41</td>
<td>Wet heath</td>
<td>Moors and heathland (322)</td>
<td>321, 322, 412</td>
</tr>
<tr>
<td>17</td>
<td>S42</td>
<td>Dry heath</td>
<td>Moors and heathland (322)</td>
<td>321, 322, 412</td>
</tr>
<tr>
<td>18</td>
<td>S51</td>
<td>Mediterranean maquis and arborescent matorral</td>
<td>Sclerophyllous vegetation (323)</td>
<td>323, 324</td>
</tr>
<tr>
<td>19</td>
<td>S52</td>
<td>Submediterranean pseudomaquis</td>
<td>Sclerophyllous vegetation (323)</td>
<td>311, 312, 313, 321, 323, 324</td>
</tr>
<tr>
<td>20</td>
<td>S53</td>
<td>Spartium junceum fields</td>
<td>Moors and heathland (322)</td>
<td>321, 322, 323, 324</td>
</tr>
<tr>
<td>21</td>
<td>S54</td>
<td>Thermo-Mediterranean arid scrub</td>
<td>Sclerophyllous vegetation (323)</td>
<td>323</td>
</tr>
<tr>
<td>22</td>
<td>S61</td>
<td>Western basiphilous garrigue</td>
<td>Sclerophyllous vegetation (323)</td>
<td>321, 322, 323, 324</td>
</tr>
<tr>
<td>23</td>
<td>S62</td>
<td>Western acidophilous garrigue</td>
<td>Sclerophyllous vegetation (323)</td>
<td>321, 323, 324, 331</td>
</tr>
<tr>
<td>24</td>
<td>S63</td>
<td>Eastern garrigue</td>
<td>Sclerophyllous vegetation (323)</td>
<td>321, 323, 324, 333</td>
</tr>
<tr>
<td>25</td>
<td>S65</td>
<td>Mediterranean gypsum scrub</td>
<td>Moors and heathland (322)</td>
<td>322, 323, 333</td>
</tr>
<tr>
<td>26</td>
<td>S66</td>
<td>Mediterranean halo-nitrophilous scrub</td>
<td>Moors and heathland (322)</td>
<td>322, 323</td>
</tr>
<tr>
<td>27</td>
<td>S71</td>
<td>Western Mediterranean spiny heath</td>
<td>Sclerophyllous vegetation (323)</td>
<td>323, 331</td>
</tr>
<tr>
<td>28</td>
<td>S72</td>
<td>Eastern Mediterranean spiny heath (phrygana)</td>
<td>Sclerophyllous vegetation (323)</td>
<td>321, 323, 331, 333</td>
</tr>
<tr>
<td>29</td>
<td>S73</td>
<td>Western Mediterranean mountain hedgehog-heath</td>
<td>Sclerophyllous vegetation (323)</td>
<td>321, 322, 323, 324, 333</td>
</tr>
<tr>
<td>30</td>
<td>S74</td>
<td>Central Mediterranean mountain hedgehog-heath</td>
<td>Sclerophyllous vegetation (323)</td>
<td>321, 323, 333</td>
</tr>
<tr>
<td>31</td>
<td>S75</td>
<td>Eastern Mediterranean mountain hedgehog-heath</td>
<td>Sclerophyllous vegetation (323)</td>
<td>322, 323, 324, 333</td>
</tr>
<tr>
<td>32</td>
<td>S91</td>
<td>Temperate riparian scrub</td>
<td>Moors and heathland (322)</td>
<td>321, 322, 331, 511</td>
</tr>
<tr>
<td>33</td>
<td>S92</td>
<td>Salix fen scrub</td>
<td>Moors and heathland (322)</td>
<td>321, 322, 323</td>
</tr>
<tr>
<td>34</td>
<td>S93</td>
<td>Mediterranean riparian scrub</td>
<td>Moors and heathland (322)</td>
<td>321, 322, 323</td>
</tr>
</tbody>
</table>
5 Habitat probability maps

The habitat probability maps are created by downscaling the habitat suitability maps with a 1km resolution by actual land cover. This report concerns European Forest, Heathland, scrub & tundra and grassland habitat types. For this purpose, we use the most actual land cover information. For forests and grasslands habitats the Copernicus high resolution layers (HRLs) forest and grasslands could be used with a 20 meter spatial resolution across Europe, while for the formation Heath, scrub and tundra, we had to use the CORINE land cover information at a 100 meter resolution.

As mentioned in Chapter 4 we used the Copernicus HRL Forest for 2015, the combined Copernicus HRL grasslands 2012 and 2015 and the CLC2018 for Heathland, scrub & tundra. Figure 5.1 shows the principle of the methodology that we follow. In principle the habitat suitability maps were integrated basis of the actual Copernicus land cover.

In principle, we used four models in ARCGIS PRO for each EUNIS formation: 1) Forests 2) Heathland, scrub and tundra and 3) Grasslands, namely:

1) Thresholding the habitat suitability maps with the 10 percentile threshold,
2) Preparing the actual land cover information,
3) Process the probability maps by integrating the actual land cover with the habitat suitability maps,
4) Export the probability maps to geotiffs.

Ad 1 and Ad2 models could be run relatively easily, but processing the probability maps at 20 meter resolution did costs approximately 8 hours processing time per habitat type (#120 habitat types).

Figure 5.1 Flowchart of the methodology implemented to obtain habitat probability maps
Processing European habitat probability maps for EUNIS Forest (T), Heathland, scrub and tundra (S) and Grassland (R) habitat types based on vegetation relevés, environmental data and Copernicus land cover.

Figure 5.2 Model 1. ARCGIS PRO graphical model for thresholding each habitat suitability map

The original 10p-thresholds for each of the 120 processed habitat types can be found in Table 1.2.

After preparing the actual land cover information, as said before, most computing time was spent on processing the habitat probability maps at 20 meter resolution across Europe.

Figure 5.3 Model 3. ARCGIS PRO graphical model to process the habitat probability maps
Figure 5.4  Figures summarizing all the methodological steps for a small area on the border of Poland and Slovakia for EUNIS habitat type E4.3b 'Temperate acidophilous alpine grasslands'.

a) Habitat distribution map

b) Habitat suitability map (1km resolution)

c) Copernicus HRL grassland integrated for 2012 and 2015.

d) Habitat probability map (20 m resolution)

e) Habitat probability map overlaid with recorded vegetation plots (distribution map)
Figure 5.4 makes it clear that going from habitat suitability maps to habitat probability maps through actual land cover information makes a big difference. It is also nice to see in Figure 5.4 that the final habitat probability represents well the actual distribution of the habitat as reflected by the distribution map (in-situ vegetation plot data used ground truth). But despite this fact, many grassland habitat probability maps in the Appendix I show local misfits between the probability maps and the recorded vegetation plots (distribution maps). This can be due to several reasons:

1) The geographic location of the vegetation plot is sometimes not accurate enough;
2) The Copernicus high resolution layer misses sometimes grassland patches;
3) The recorded vegetation plot has disappeared over the last twenty years.

Therefore we recommend always an independent assessment of the habitat probability maps based on e.g. Article 17 database.
### References


Hennekens, 2017. Distribution and habitat suitability maps of revised EUNIS grassland types. Internal report EEA.


Appendix 1 Forest habitat probability maps
T11 - [G11] Temperate Salix and Populus riparian forest

Willow- and poplar- (Salix- and Populus-) dominated forest of periodically-inundated terraces and shoals with deposition of nutrient-rich alluvium in the active floodplains of rivers through the lowlands of the boreal, nemoral, submediterranean and steppe zones.
35 Processing European habitat probability maps (ETC/BD)
T12 - [G12a] Alnus glutinosa-Alnus incana forest on riparian and mineral soils

Riparian and land-upheaval forests dominated by Alnus glutinosa, A. incana, and sometimes Fraxinus excelsior, typically without many softwood willows in the canopy and occurring throughout Europe along streams and small to medium rivers. The field layer can be quite species-rich, especially in moister situations, when more nutrient demanding herbs such as Urtica dioica and Filipendula ulmaria may be abundant.
Probability map

Value

97
0

France

Germany

Sources: EU, USGS, NASA

37 Processing European habitat probability maps (ETC/BD)
T13 - [G12b] Temperate hardwood riparian forest

Mixed broadleaved forests typical of less-frequently flooded, well-aerated mineral soils on floodplains of major European rivers. The canopy in high-forest stands can be very tall and multi-layered and is typically dominated by mixtures of Fraxinus excelsior, F. angustifolia, Alnus glutinosa, Populus alba, P. canescens, Quercus robur, Prunus padus, Ulmus glabra, U. minor and U. laevis. There is typically an abundant and varied understorey, with a range of small trees, shrubs and lianes.
Processing European habitat probability maps (ETC/BD)
**T14 - [G13] Mediterranean and Macaronesian riparian forest**

Deciduous broadleaved forest, most commonly dominated by poplars (Populus), willows (Salix) or oriental plane (Platanus orientalis), on periodically flooded alluvium or gravel terraces and streamsides in humid localities in the Mediterranean zone and Macaronesia. Also includes streamside forests with Rhododendron ponticum and birch (Betula pendula var. fontqueri) in Spain.
41 Processing European habitat probability maps (ETC/BD)
T15 - [G14] Broadleaved swamp forest on non-acid peat

Deciduous broadleaved forest, commonly dominated by alder (Alnus glutinosa, A. incana), oak (Quercus robur) or aspen (Populus tremula) on non-acid peat with ground water at or seasonally above the surface in swamps through the lowlands of the nemoral and boreal zones.
Probability map

Value

99

0

Netherlands

Denekamp

Sources: ESI, USGS, NOAA
T16 - [G15] Broadleaved mire forest on acid peat

Deciduous broadleaved or mixed forest on acid peat on or around active bogs and poor fens with nutrient-poor ground waters occurring through the atlantic and boreal zones and locally, where ground conditions permit, in the continental zone. Usually dominated by birch (Betula pubescens).
45 Processing European habitat probability maps (ETC/BD)
**T17 - [G16a] Fagus forest on non-acid soils**

Beech- (Fagus sylvatica and F. orientalis) dominated forest of base-rich to neutral, oligotrophic to mesotrophic, mineral soils occurring through the atlantic and continental zones, and reaching into the alpine and, at higher altitudes, the submediterranean region. Associated trees, including evergreen conifers like fir (Abies alba) and spruce (Picea abies) which figures at the altitudinal limit. The field layer can be species-rich.
47 Processing European habitat probability maps (ETC/BD)
**T18 - [G16b] Fagus forest on acid soils**

Beech- (Fagus sylvatica and F. orientalis) dominated woodland of oligotrophic, base-poor mineral soils through the atlantic and continental zones, into the alpine and, at higher altitudes, the submediterranean zone. Associated broadleaved trees are few and always subordinate in cover, though oaks may be co-dominant. Evergreen conifers like fir (Abies alba) and, at the altitudinal limit, spruce (Picea abies) can figure as minority canopy components. The field layer is generally species-poor.
49 Processing European habitat probability maps (ETC/BD)
T19 - [G17a] Temperate and submediterranean thermophilous deciduous forest

These thermophilous broadleaved deciduous forests form a wide, but interrupted, belt across the submediterranean zone of Europe, with milder winters and warmer drought-prone summers than sustain the broadleaved temperate forests, but colder, intermittently frosty and snowy winters than are typical for the evergreen broadleaved forests and scrub of the Mediterranean. To the north, they tend to occupy lower altitude, drier and warmer sites, to the south, rainier sites at higher altitudes.
51 Processing European habitat probability maps (ETC/BD)
T1A - [G17b] Mediterranean thermophilous deciduous forest

Mediterranean deciduous forests usually dominated by Quercus ithaburensis subsp. macrolepis forming open forest, the canopy may be pure or with other oaks. Stands are mostly on shallow soil at usually at altitudes less than 700 m.
53 Processing European habitat probability maps (ETC/BD)
T1B - [G18] Acidophilous Quercus forest

Oak-dominated forest (mainly Quercus robur and Q. petraea but also other regional species) of impoverished acid soils through the atlantic and continental zones, where beech (Fagus sylvatica) is a potential competitor and extending northwards into the boreal zone where Scot’s pine (Pinus sylvestris) increasingly figures in the canopy. Associated floras are generally rather poor but show towards the very humid western Atlantic seaboard extraordinary richness of ferns and cryptogams.
55 Processing European habitat probability maps (ETC/BD)
T1C - [G19a] Temperate and boreal mountain Betula and Populus tremula forest on mineral soils

Open, low canopy climax birch forests (Betula pubescens var. glabrata, Betula pubescens var. pumila, Betula litwinowii) with a heathy or herb-rich field layer in the boreal region, in temperate mountain ranges, and in the Caucasus.
57 Processing European habitat probability maps (ETC/BD)
T1D - [G19b] Southern European mountain Betula and Populus tremula forest on mineral soils

Diverse climax forests dominated by birch (Betula pendula and closely related species) or aspen (Populus tremula) on usually acidic mineral soils in humid ravines and gorges in the sub-alpine Pyrenees, Corsica, the Apennines and Sicily, with associated floras characteristic of the local climatic conditions.
Processing European habitat probability maps (ETC/BD)
T1E - [G1Aa] Carpinus and Quercus mesic deciduous forest

Deciduous broadleaved forests typical of somewhat to strongly impeded brown earth soils and gleys of quite low, moderate to high base-status and moderate to high nutrient content across the lowlands and foothills of the temperate zone of western, central and southern Europe, with local extensions into regions of submediterranean, Pannonian and boreal climate. Partially this includes alluvial Quercus/Carpinus-dominated forests in mountain valleys with infrequent inundation.
The canopy is typically of mixed composition with oaks figuring prominently, notably Quercus robur and Q. petraea but with regional contributions from other oaks, along with Carpinus betulus, Fraxinus excelsior, Acer pseudoplatanus, A. campestre, A. platanoides, Ulmus glabra, Tilia cordata and T. tomentosa. Typically, Fagus sylvatica is at most a minor component. The canopy can have a complex, multi-layered structure including shrubs and lianes while the herb layer can be species-rich with much regional variation in composition.
T1F - [G1Ab] Ravine forest

Forests on steep slopes, frequently in ravines, where deep, well drained and fertile soils develop which allow trees such as Fraxinus excelsior, Acer pseudoplatanus, A. platanoides, Ulmus glabra, Tilia platyphyllos and Tilia cordata to outcompete trees such as Fagus sylvatica and Quercus spp.
The herb layer is dominated by luxuriant nitrophilous herbs such as Urtica dioica, Aegopodium podagraria and Impatiens noli-tangere, moisture-loving vernal plants like Allium ursinum and, on the typically base-rich soils, Mercurialis perennis, Geranium robertianum, Brachypodium sylvaticum and Circaea lutetiana. In the southern part of its distribution thermophilous species such as Cotoneaster integerrimus, Sesleria caerulesa, Athericum ramosum and Vincetoxicum hirundinaria appear.
T1G - [G1Ba] Alnus cordata forest

Temperate nonriparian, nonmarshy forest dominated by Alnus cordata.
65 Processing European habitat probability maps (ETC/BD)
T1H - [G1C] Broadleaved deciduous plantation of non site-native trees

Cultivated deciduous broadleaved tree formations planted for the production of wood, composed of exotic species or of native species out of their natural range.
Processing European habitat probability maps (ETC/BD)
T21 - [G21] Mediterranean evergreen Quercus forest

Forest dominated by evergreen broadleaved oaks (most widely Quercus ilex) with associated sclerophyllous and laurophyllous trees and shrubs in the summer-drought climate of the mediterranean lowlands and foothills. The tree canopy is often low and much modified, with widespread transitions to scrubby maquis/matorral and open dehesa/montado wood pasture.
69 Processing European habitat probability maps (ETC/BD)
T22 - [G22] Mainland laurophyllous forest

Evergreen laurophyllous short-statute woodland, often dominant by bay (Laurus nobilis), firetree (Morella faya) and Portugal laurel (Prunus lusitanica subsp. lusitanica) in warm temperate oceanic and hyper-humid situations, now surviving as small relics in sheltered situations like ravines along the Atlantic coast of Portugal and Spain and in Sardinia, southern Italy and Sicily. Typically species-poor with an associated flora similar to T21.
Probability map

- T22

Value

100

0

Spain

71 Processing European habitat probability maps (ETC/BD)
T24 - [G24] Olea europaea-Ceratonia siliqua forest

Olive (Olea europea), carob (Ceratonia siliqua) and mastic (Pistacia lentiscus) forest with a tall, closed tree canopy in the drought-prone lowlands and foothills of the Mediterranean and Macaronesia.
Processing European habitat probability maps (ETC/BD)
T27 - [G26] Ilex aquifolium forest

Holly (Ilex aquifolium) dominated forest occurring in scattered localities across Europe and probably an arborescent survival of T3D Taxus forest at middle altitudes in the Mediterranean zone and of T17 and T18 beech forests and T1B oak forests in the nemoral lowlands.
T29 - [G28] Broadleaved evergreen plantation of non site-native trees

Cultivated evergreen broad-leaved tree formations planted for the production of wood, composed of exotic species, of native species out of their natural range, or of native species planted in clearly unnatural stands, often as monocultures.
77 Processing European habitat probability maps (ETC/BD)
T31 - [G31a] Temperate mountain Picea forest

Evergreen coniferous forest dominated by spruce (Picea abies and, in the Dinaric mountains, relict P. omorika), often with some fir (Abies alba) on usually acidic, even very oligotrophic, wet, cold or rocky soils in the montane and sub-alpine belts of nemoral mountains.
79 Processing European habitat probability maps (ETC/BD)
T32 - [G31b] Temperate mountain Abies forest

Forests of fir (Abies alba) in nemoral mountains, often with beech (Fagus sylvatica) towards the sub-montane limit, spruce (Picea abies) where site conditions are harsher at higher altitudes. On generally acidic soils though extending on to more base-rich and mesotrophic soils where distinctive contingents of herbs augment or replace the usually heathy field layer.
81 Processing European habitat probability maps (ETC/BD)
**T33 - [G31c] Mediterranean mountain Abies forest**

Evergreen coniferous forests of more sunless or fog-bound slopes and gullies in the lower to mid altitudinal belts of mediterranean mountains where firs of very limited distribution dominate in highly distinctive relic stands: Spanish fir (A. pinsapo), Greek fir (A. cephalonica), King Boris’s fir (A. borisii-regis), Apennine or Sicilian stands of silver fir (A. alba) and Sicilian fir (A. nebrodensis).
83 Processing European habitat probability maps (ETC/BD)
T34 - [G32] Temperate subalpine Larix, Pinus cembra and Pinus uncinata forest

Coniferous, in part deciduous, forest of larch (Larix decidua) or Arolla pine (Pinus cembra) in the mid sub-alpine belt of temperate mountains in the central Alps and Carpathians with long but shallow snow-lie and a short growing season. Dwarf mountain pine (P. mugo), spruce (Picea abies), fir (Abies alba), rhododendrons and other sub-shrubs are never more than subordinate but various whitebeams (Sorbus spp.) are characteristic associates.

84 Processing European habitat probability maps (ETC/BD)
85 Processing European habitat probability maps (ETC/BD)
T35 - [G34a] Temperate continental Pinus sylvestris forest

Forests dominated by pine (Pinus sylvestris), often with some birch (Betula pendula and B. pubescens), aspen (Populus tremula), juniper (Juniperus communis) and various whitebeams (Sorbus spp.), on acidic to base-rich soils through the north nemoral zone and into the hemi-boreal.
87 Processing European habitat probability maps (ETC/BD)
T36 - [G34b] Temperate and submediterranean montane Pinus sylvestris-Pinus nigra forest

Evergreen coniferous forests, generally dominated by either Scot’s pine (Pinus sylvestris) or black pine (P. nigra and, towards the southern limit, various subspecies), less commonly with some spruce (Picea abies) and deciduous associates, often in isolated and small stands on base-rich soils through the mountains of the south temperate and sub-mediterranean zones.
89 Processing European habitat probability maps (ETC/BD)
**T37 - [G34c] Mediterranean montane Pinus sylvestris-Pinus nigra forest**

Evergreen coniferous forest of more drought-prone situations at scattered localities through the mountains of the Mediterranean zone, dominated by black pine (Pinus nigra) and, except on Mediterranean islands, sometimes with subordinate Scot’s pine (Pinus sylvestris), both trees often occurring as vicariant forms in different localities.
Probability map

Value

T37
Serbia and Montenegro

Prob_T37_t_int

Bulgaria

Macedonia

Greece

Sources: Esri, USGS, NOAA

91 Processing European habitat probability maps (ETC/BD)
T39 - [G37] Mediterranean lowland to submontane Pinus forest

Evergreen coniferous forest dominated by various thermophilous pines: maritime pine (Pinus pinaster in western Mediterranean and warm Atlantic zones), Aleppo pine (P. halepensis) and stone pine (P. pinea all around the southern European coast) and Aegean pine (P. brutia in Greece and Anatolia), the first three often favouring unstable substrates or pre-climax situations.
T3A - [G37] Mediterranean lowland to submontane Pinus forest

Evergreen coniferous forest dominated by various thermophilous pines: maritime pine (Pinus pinaster in western Mediterranean and warm Atlantic zones), Aleppo pine (P. halepensis) and stone pine (P. pinea all around the southern European coast) and Aegean pine (P. brutia in Greece and Anatolia), the first three often favouring unstable substrates or pre-climax situations.
95 Processing European habitat probability maps (ETC/BD)
### T3C - [G39a] Taxus baccata forest

Evergreen woodlands overwhelmingly dominated by yew (Taxus baccata), sometimes with holly (Ilex aquifolium), whitebeam (Sorbus aria) and box (Buxus sempervirens), maybe in halted successions or as senescent survivals, occurring very locally on base-rich soils in the mediterranean zone and in the British Isles.
97 Processing European habitat probability maps (ETC/BD)
T3D - [G39b] Mediterranean Cupressaceae forest

Evergreen forests of cypress (Cupressus sempervirens), junipers (Juniperus drupacea, J. excelsa, J. foetidissima, J. thurifera) or alerce (Tetraclinis articulata) with a usually open canopy with scrubby understorey and grassy field layer, on shallow, usually base-rich soils, in dry rocky situations scattered through the mediterranean zone.
99 Processing European habitat probability maps (ETC/BD)
T3F - [G3A] Dark taiga

Forest naturally dominated by spruce (Picea abies, P. obovata), Siberian fir (Abies sibirica) or Siberian pine (Pinus sibirica) on more mesic soils through the north-eastern continental and boreal regions, often with a subordinate deciduous broadleaf component (e.g. Betula pendula and B. pubescens) in the canopy and understorey and varied field-layer with significant participation of dwarf shrubs, bryophytes and lichens.
101 Processing European habitat probability maps (ETC/BD)
**T3G - [G3B] Pinus sylvestris light taiga**

Forest naturally dominated by Scot’s pine (Pinus sylvestris) but often with some birch (Betula pendula and B. pubescens) on lithomorphic and podzolized soils of dry and barren situations through the northeastern continental and boreal regions with a generally heathy field layer but, when on eskers, a specialised herb flora.
Probability map

T3G

Prob_T3G_t_int

Value

77
0

Finnland

Talvekaski

Sources: EU, USGS, NOAA
T3J - [G3Da] Pinus and Larix mire forest

Open woodland dominated by pine (Pinus sylvestris, P. rotundata) or larch (Larix sibirica, L. decidua) on acid peat or around active bogs and poor fens with nutrient-poor ground waters occurring through the boreal zone and locally, where ground conditions permit, in the continental zone.
105 Processing European habitat probability maps (ETC/BD)
T3K - [G3Db] Picea mire forest

Open woodland dominated by spruce (Picea abies, P. obovata) on acid peat or around active bogs and poor fens with nutrient-poor ground waters occurring through the boreal zone and locally, where ground conditions permit, in the continental zone.
T3M - [G3F1] Coniferous plantation of non site-native trees

Cultivated stands of coniferous trees planted for the production of wood, composed of exotic conifer species or of European conifers out of their natural range.
109 Processing European habitat probability maps (ETC/BD)
Appendix 2 Shrubs habitat probability maps
**S11 – [F11] Shrub tundra**

Tundra with a usually extensive cover of sub-shrubs or low shrubs over herbs, mosses and lichens on sporadically permafrost soils of the southern arctic and subarctic zones, often grazed into grassy mosaics.
112 Processing European habitat probability maps (ETC/BD)
S12 – [F12]  Moss and lichen tundra

Tundra of the middle and northern high arctic zone where permafrost soils, often occurring in patterned ground, support a frequently sparse cover of mosses, lichens and low herbs.
Probability map
Distribution map

- S12
- Prob_S12_int

0 - 100
S21 – [F21] Subarctic and alpine dwarf Salix scrub

Salix-dominated dwarf scrub, often with abundant bryophytes and lichens, on skeletal calcareous or siliceous soils in late snow beds with a short growing-season, occurring in the subarctic north of the forest zone and in the high mountains of nemoral Europe, increasingly local and fragmentary to the south.
Processing European habitat probability maps (ETC/BD)
Alpine and subalpine ericoid heath

Dwarf-shrub vegetation dominated by ericoids and other woody species (not Juniperus or genistoids) occurring in high mountains throughout Europe, varying in dominants and associates according to regional climate, degree of exposure and snow lie, soil reaction, soil depth and moisture.
Processing European habitat probability maps (ETC/BD)
Alpine and subalpine Juniperus scrub

Juniper-dominated vegetation of the montane to sub-alpine belts of European mountains, occurring as primary vegetation tolerant of both high exposure and snow-lie, but also a secondary derivative of deforested, long-grazed and eroded ground at high altitudes.
120 Processing European habitat probability maps (ETC/BD)
S24 – [F22c] Subalpine genistoid scrub of the Amphi-Adriatic region

Genistoid heath and scrub of high mountains in Italy and the Balkans, often in primary grassy mosaics at higher altitudes, but also extending below the timberline where wood-cutting and grazing open up the forest cover and sustain the vegetation as an anthropogenic replacement.
S25 – [F23] Subalpine and subarctic deciduous scrub

Low scrub, including krummholz, dominated by various deciduous trees and shrubs, on moist but free-draining, sometimes quite fertile, soils on high mountain slopes throughout Europe, often with long snow-lie and prone to natural disturbance due to avalanche and scree slides, after which it is well able to recover and recolonise. The associated flora can be rich in tall mountain herbs. It can also be found as a secondary succession stage in abandoned subalpine pastures and meadows.
S26 – [F24] Subalpine Pinus mugo scrub

Pinus mugo krummholz on mineral soils with long snow-lie above the tree line through the mountains of central and south-eastern Europe. Woody and herbaceous associates and the sometimes abundant bryophyte layer vary according to the base-richness of the soils and ground moisture.
126 Processing European habitat probability maps (ETC/BD)
S31 –[F31a] Lowland to montane temperate and submediterranean Juniperus scrub

Juniperus communis scrub on nutrient-poor sandy and calcareous soils through the temperate and submediterranean lowlands and foothills of Europe. The juniper can be very patchy in occurrence, often related to past land-use, and with a striking variety of growth forms, the associated flora being very diverse according to soil base-status, sharing much in common, where the scrub is open, with local calcicolous grasslands or heath.
128 Processing European habitat probability maps (ETC/BD)
S32 – [F31b] Temperate Rubus scrub

Low Rubus-dominated scrub, deciduous or sometimes evergreen, of successions and ecotones in a wide variety of semi-natural landscapes through the atlantic zone and elsewhere in sub-montane Europe where a locally moist climate prevails. Rubus is an enormously diverse genus of often apomictic and endemic taxa with associated floras related to soil base-status and moisture.
Processing European habitat probability maps (ETC/BD)
S33 – [F31c] Lowland to montane temperate and submediterranean genistoid scrub

Low scrub dominated by various woody legumes on mostly sharply-draining, nutrient-poor acidic soils through the temperate and submediterranean lowlands and mediterranean foothills of Europe. To the north the vegetation is usually found in successions or ecotones within pastoral landscapes and is often rather species-poor; further south, the scrub can occur as a more persistent or repeatedly renewed habitat among rocky or unstable hill-slopes with richer associated floras.
132 Processing European habitat probability maps (ETC/BD)
S35 – [F31d] Temperate and submediterranean thorn scrub

Scrub dominated by a diversity of mostly thorny shrubs, small trees and saplings, in successions and ecotones on mesic soils in a wide variety of semi-natural landscapes through the temperate and submediterranean lowlands of Europe but sometimes extending to higher altitudes, as with the Balkan šibljak. The dominants and associated floras vary widely with differences in regional climate and soils.
134 Processing European habitat probability maps (ETC/BD)
S36 – [F31f]  Low steppic scrub

Low scrub, dominated by various, often clonal, shrubs frequently forming patches in locally mesic and sheltered situations within the dry grasslands of the steppe zone of central and eastern Europe. It can form a persistent natural landscape element or develop after abandonment of pasturing.
Probability map
Distribution map

S36
Prob_S36_int
100
0

Slovakia

Hungary

136 Processing European habitat probability maps (ETC/BD)
S37 – [F31g] Corylus avellana scrub

Low scrub dominated by Corylus avellana, permanently maintained by exposure to winds and on shallow soils along the north Atlantic coast and locally on rocky slopes and cliffs through the continental region.
Probability map
Distribution map
S37
Prob_S37_int
100
0

France
Limoges

Source: G 1020939964803 USGS ERIM, LR86 NPS
S38 – [F31h] Temperate forest clearing scrub

Often dense scrub of shrubs and small trees invading after natural or anthropogenic clearance in forests of the temperate zone.

Distribution map

Probability map

Prob_S38_int

100

0
Processing European habitat probability maps (ETC/BD)
**S41 – [F41] Wet heath**

Heath with prominent Erica tetralix on shallow, acid, nutrient-poor peats and peaty mineral soils, kept moist for much of the year and often seasonally waterlogged, through the atlantic and subatlantic lowlands and foothills of Europe.
Typically occurring in wet depressions and seepage areas within dry heaths or as a marginal zone around bogs where drainage of deeper peats can increase its extent. In milder oceanic climates, other Erica and Ulex spp. occur in richer humid heath. Frequently influenced by grazing and sod-cutting.
S42 – [F42] Dry heath

Heath dominated by various ericaceous sub-shrubs on free-draining, nutrient-poor, acid sands and siliceous soils through the lowlands and foothills of western and central Europe, extending northwards in more oceanic situations and into continental regions at higher rainier altitudes.
Very often influenced by grazing and burning and frequently a secondary vegetation type derived by clearance of acidophilous forest and maintained anthropogenically.
**SS1 – [F51] Mediterranean maquis and arborescent matorral**

Evergreen sclerophyllous or laurophyllous shrub vegetation forming a dense closed canopy, with or without low emergent trees, on a wide variety of substrates and soils through the thermo- to mesomediterranean belts.
May be permanent primary vegetation on xeric sites but is usually derived by degradation of evergreen deciduous or coniferous forest and much influenced in structure and composition by grazing and fire.
SS2 – [F53] Submediterranean pseudomaquis

Mixed deciduous and evergreen scrub of shallow, rocky, mostly calcareous soils in the lowlands and foothills of southern Europe, particularly the east. Usually derived by forest degradation and much affected in structure and composition by grazing, fire and logging.
148 Processing European habitat probability maps (ETC/BD)
**S53 – [F54] Spartium junceum scrub**

Scrub dominated by Spartium junceum, typical of disturbed, open, sunny situations on a wide variety of soils through the mediterranean and submediterranean zones, where its rapid establishment is favoured by post-fire seed germination, aggressive rooting, nitrogen-fixation and unpalatability.
Processing European habitat probability maps (ETC/BD)
**S54 – [F55] Thermomediterranean arid scrub**

Scrub with a usually low and rather open cover of shrubs with sub-shrubs, dwarf shrubs and herbs between, on dry soils of varied composition through the thermomediterranean zone, and of very diverse local composition. Primary and permanent in more arid and exposed situations, but can be successional to forest and often much affected by grazing.
S61 – [F61a] Western basophilous garrigue

Sub-shrub vegetation dominated by nanophanerophytes and chamaephytes on thin, base-rich soils through the western thermo- to mesomediterranean belts, very diverse in composition with differences in local climate and soils. In rockier situations, it can be a permanent coloniser but is often derived from forest clearance and is much affected by grazing and fire.
Western acidophilous garrigue

Sub-shrub vegetation dominated by nanophanerophytes on thin acidic soils, both hard silicate and soft sands, through the western thermo- to lower supramediterranean belts, very diverse in composition with differences in local climate and soils. In rockier situations, it can be a permanent coloniser but is often derived from forest clearance or abandonment of farm fields and is much affected by grazing and fire.
S63 – [F62] Eastern garrigue

Low, mostly evergreen sclerophyllous scrub on diverse soils through the eastern meso-, thermo- and occasionally supramediterranean belts, including around the Black Sea, where deciduous species can prevail. Derived by forest degradation and usually maintained by grazing and fire, their structure and composition vary greatly with local climate and human impacts.
S65- [F67] Mediterranean gypsum scrub

Open chamaephyte scrub with a lichen crust and rainy-spring annual herb flora, on gypsum-rich substrates in areas with a dry to semi-arid Mediterranean climate in the Iberian Peninsula. The extreme climatic and edaphic conditions maintain the habitat as naturally stable but it can bear some light grazing.
Processing European habitat probability maps (ETC/BD)
S66 – [F68a] Mediterranean halo-nitrophilous scrub

Perennial scrubby vegetation with nitrophilous and salt-tolerant associates in often artificially-disturbed places through the semi-arid thermo- and inframediterranean belts where the dry climate slows the decomposition of litter and aids precipitation of salt from the soil.
Processing European habitat probability maps (ETC/BD)
S71 – [F71] Western Mediterranean spiny heath

Low scrub of often spiny, cushion-forming plants on thin soils on wind-exposed and spray-splashed tops of rocky cliffs on Corsica, Sardinia, Pantelleria and in the Gulf of Taranto.
S72 – [F73] Eastern Mediterranean spiny heath (phrygana)

Low scrub dominated by thorny hemispherical chamaephytes on various base-rich and acidic substrates in the thermo-, meso- and supramediterranean belts of mainland Greece, Anatolia, the Aegean and Ionian islands, Crete, Cyprus and the north-east Mediterranean coast, rarely also in Sicily. Can be of primary origin or result from clearance of evergreen sclerophyll forest.
Probability map
Distribution map

S72
Prob_S72_int
100
0

Sources: Esri, USGS, NOAA. Sources: Esri, Garmin, USGS, NPS.

Greece
S73 – [F74a] Western Mediterranean mountain hedgehog-heath

Heath of often spiny hedgehog sub-shrubs on base-rich and acidic soils in the cold and droughty upper supra- and oromediterranean belts of the Iberian Peninsula, historically sustaining transhumance pastoralism but often extending down from crests and steep slopes due to grazing and burning.
Probability map
Distribution map

S73
Prob_S73_int

100
0

Spain

Sources: Esri, USGS, NOAA, Sources: Esri, DeLorme, USGS, NPS

168 Processing European habitat probability maps (ETC/BD)
S74 – [F74b] Central Mediterranean mountain hedgehog-heath

Heath of often spiny hedgehog sub-shrubs on base-rich and acidic soils in windy and sunny situations in the supra- and oromediterranean belts of Corsica, Sardinia, Elba, Sicily and the southern mainland Mountains of Italy. Downslope expansion below the timberline can follow clearance and grazing.
Probability map
Distribution map
S74
Prob_S74_int
100
0

France
Ajaccio
S75 – [F74c] Eastern Mediterranean mountain hedgehog–heath

Heath of often spiny hedgehog sub-shrubs on mostly base-rich soils in dry mountains of the supra- and oromediterranean belts of the east Mediterranean. Downslope expansion below the timberline can follow clearance and grazing.
172 Processing European habitat probability maps (ETC/BD)
S91 – [F91] Temperate riparian scrub

Scrub of Salix spp. and Myricaria germanica developed on the mineral sediments of shoals and banks of lowland rivers through the temperate zone, re-establishing after seasonal flooding or succeeding to riparian and gallery forest where the sediments stabilise.
174 Processing European habitat probability maps (ETC/BD)
S92 – [F92] Salix fen scrub

Scrub dominated by various Salix spp. on peaty and mineral soils maintained in a permanently waterlogged state by high ground water in floodplain backwaters, around lakes and ponds, among mires and dunes, and in abandoned wet meadows and pastures, occurring through the lowlands of Atlantic, boreal and continental Europe and extending into the Mediterranean region at higher altitudes.
Associated floras vary according to the base status of the ground waters and soils.
**S93 – [F93] Mediterranean riparian scrub**

Usually open scrub of Tamarix spp., Nerium oleander, Vitex agnus-castus and similar shrubs and small trees on seasonally droughted and irregularly flooded riverbeds, streamsides and depressions through the thermo- and mesomediterranean belts.
Processing European habitat probability maps (ETC/BD)
Appendix 3 Grass habitat probability maps
R11 - [E11a] Pannonian and Pontic sandy steppe

Rather open steppe grassland dominated by perennial tussock grasses and herbs, with frequent spring annuals and cryptogams, typical of nutrient-poor, sandy soils on plains and dunes through the Pannonian, Pontic and southern Baltic regions. The climate is strongly continental with cold winters, often with long frosts and shallow snow, and hot, droughty summers. Traditionally used for extensive grazing by stock, particularly sheep, but now widely abandoned.
Probability Map

Distribution map

- R11

Probe: R11_int

Value

- 100
- 0

Poland

Sources: ESRI, USGS, NOAA
R12- [E11b] Cryptogam- and annual-dominated vegetation on siliceous rock outcrops

Open pioneer grassland dominated by perennial succulents and annuals, with subordinate small tussock grasses, sometimes geophytes and often a prominent contingent of cryptogams.
Typically forming small stands on very shallow and skeletal, impoverished, acid soils on siliceous rock outcrops, eroded slopes and disturbed or artificial habitats like soil heaps and wall tops, the habitat occurs throughout temperate and boreal Europe up to the sub-alpine level, in situations where the permeable soils dry quickly in summer, but where spring rains can permit a quick flush of growth by the annuals.
R13 - [E11d] Cryptogam- and annual-dominated vegetation on calcareous and ultramafic rock outcrops

Open pioneer grassland with perennial succulents and spring annuals, subordinate small tussock grasses and herbs, and often with a very prominent and rich contingent of cryptogams. Typically found in small patches on very shallow and skeletal, impoverished, base-rich soils on a wide variety of base-rich and sometimes ultramafic bedrocks, and similar artificial habitats like quarry spoil and wall-tops.
It is found from the hemiboreal to the submediterranean, occurring mainly at higher altitudes further south.
R14 - [E11e] Perennial rocky grassland of the Italian Peninsula

Unique to base-rich bedrocks in the Italian Peninsula (and maybe Sicily) and best developed within the submediterranean bioclimatic zone, this grassland is variously dominated by perennial grasses and herbs, or mat formers and sub-shrubs on steeper, rockier ground.
Generally species-rich, and sometimes with contingents of annuals and, in disturbed places, geophytes, the habitat sometimes hosts endemic plants. Developed through clearance of broadleaved and mixed forest it is maintained by traditional grazing in a distinctive cultural landscape.
R16 – [E11g] Perennial rocky grassland of Central and South-Eastern Europe

Open grassland generally dominated by perennial grasses with rich mixtures of associated rosette herbs, mat-formers and geophytes, and towards southern Europe especially, annuals.
It occurs on shallow, impoverished soils over both calcareous and siliceous bedrocks, through the lowlands and submontane zone of central and southern Europe, best developed on steeper ground uncongenial for agriculture, but extended where forest clearance and grazing, particularly by goats, have been part of traditional farming.
R17 – [E11h] Heavy-metal dry grassland of the Balkans

Grassland confined to droughty, nutrient-poor soils rich in heavy metals derived from ultramafic rocks in the mountains of the Balkans and Cyprus with an open cover of grasses and forbs, including many endemics.
R18 - [E11i] Perennial rocky calcareous grassland of subatlantic-submediterranean Europe

Open grasslands, dominated by perennials and especially rich in mat-formers, typical of rudimentary, shallow, nutrient-poor, base-rich soils over sloping, rubbly limestone terrain through the lowland to sub-montane levels in subatlantic and submediterranean Europe where traditionally maintained by extensive grazing.
Processing European habitat probability maps (ETC/BD)
R19 – [E11j] Dry steppic submediterranean pasture of the Amphi-Adriatic region

Dry steppic pasture typical of sharply-draining, base-rich soils developed over valley sides, dolines and sink-holes around the Adriatic coasts where the submediterranean climate is characterised by late autumn and spring rains and summer drought. Dominated by often rich mixtures of graminoids, forbs and mat-formers, the habitat is dependent on extensive grazing and now often survives patchily among mosaics of scrub and forest.
195 Processing European habitat probability maps (ETC/BD)
R1A – [E12a] Semi-dry perennial calcareous grassland (meadow steppe)

Semi-natural grassland on deeper and not so drought-prone, nutrient-poor, base-rich soils over limestones throughout the lowlands and sub-montane levels of submediterranean to hemiboreal Europe.
Generally closed and dominated by mixtures of graminoids and forbs, often extremely species-rich, with many rare plants and sometimes striking contingents of orchids and varying much across the large range with different sets of continental or sub-mediterranean companions. Dependent on extensive grazing, usually with sheep, or on an annual mowing, and often developed over centuries of traditional pastoralism, contributing to some striking cultural landscapes.
R1B – [E12b] Continental dry grassland (true steppe)

Steppe and steppe-like grassland on mostly base-rich soils over limestones, of varying depth and stoniness, occurring through the continental lowlands to sub-montane belts of Europe. Dominated by plants adapted to long periods of summer drought, mostly tall tussock grasses and perennial forbs, it shows wide variation in species composition and particular topographic location across the substantial range. In more extreme situations, the grasslands are natural, but they often sustain extensive grazing.
R1D – [E13a] Mediterranean closely grazed dry grassland

Heavily-grazed pasture of the Mediterranean basin, mostly on silt and clay soils in the lowlands, dominated by rosette plants and small grasses tolerant of intensive herbivory and trampling. The soils are dry in summer which helps exclude nitrophilous plants that might be encouraged by dunging but, refreshed by autumn rains, the herbage remains green and productive through the winter, providing valuable forage. Companion plants vary widely across the large range.
Bulgaria

Probability Map

Distribution map
- R1D

Prob_R1D_t_int

Value
- 100
- 0

Source: Esri, USGS, NOAA
R1E – [E13b] Mediterranean tall perennial dry grassland

Grassland of impoverished, base-rich soils over various calcareous bedrocks through the Mediterranean region, where grazing and trampling sustain open or closed swards generally dominated by tall, dense tussock grasses that lend a steppe-like character. Summer drought and disturbance help prevent reversion to forest but can encourage the invasion of aliens.
Probability Map
Distribution map
- R1E

Prob_R1E_t_int
Value

99

Greece

Sources: Esri, USGS, NOAA
R1F – [E13c] Mediterranean annual-rich dry grassland

Usually ephemeral vegetation related to the yearly cycle of spring rains and summer drought through the Mediterranean zone where a high diversity of small annual plants make a brief colourful appearance on bare patches of mainly base-rich soils. The species composition varies greatly, according to the particular regional terrain and climate and the impact of traditional pastoralism.
R1G – [E15a] Iberian oromediterranean siliceous dry grassland

Grassland of base-poor soils over siliceous bedrocks on the slopes and crests of high mountains in the Iberian Peninsula with a short growing season and harsh winters with strong winds which blow the ground free of snow and leave the surface subject to deep cold and the development of freeze-thaw features. The vegetation cover, moderately open to closed, is dominated by prostrate or dwarf grasses and forbs, and includes many endemics.
207 Processing European habitat probability maps (ETC/BD)
R1H - [E15b] Iberian oromediterranean basophilous dry grassland

Grassland of base-rich soils over calcareous bedrocks on the slopes and crests of high mountains in the Iberian Peninsula and France, with a short growing season and harsh winters when strong winds blow the ground free of snow and leave the surface subject to deep cold which encourages the development of freeze-thaw features. The vegetation cover, moderately open to closed, is dominated by prostrate or dwarf grasses and forbs, and includes many endemics.
R1J – [E15c] Cyrno-Sardean oromediterranean siliceous dry grassland

Grassland of base-poor soils over siliceous bedrocks on the slopes and crests of high mountains in Corsica and (probably) Sardinia, with a short growing season and harsh winters when strong winds blow the ground free of snow and leave the surface subject to deep cold which encourages the development of freeze-thaw features. The cover of vegetation is intermediate to complete, dominated by prostrate herbs, cushion plants and dwarf shrubs, and includes many endemics.
R1K – [E15d] Balkan and Anatolian oromediterranean dry grassland

Closed grassland of deeper acid soils occurring over various bedrocks above the tree-line on high mountain slopes and hollows in Greece and Anatolia where snow accumulates and provides springtime irrigation with melt-water. The vegetation is species-rich but the dominants and associates vary from place to place. It provides valuable summer grazing for traditional pastoralism.
Processing European habitat probability maps (ETC/BD)
R1M – [E17] Lowland to montane, dry to mesic grassland usually dominated by Nardus stricta

Usually dominated by the tightly tussocky Nardus stricta, this grassland is characteristic of nutrient-poor, acidic soils, sometimes seasonally wet, on siliceous substrates through the entire lowlands and sub-montane zone of temperate Europe, though optimally developed in the cooler and rainier climate of the atlantic zone. Other grasses may share dominance but the associated flora is generally rather species-poor and related to the type and intensity of grazing.
Probability Map

Distribution map

Prob_R1M_t_int

Value

99

0

Sources: Est, MAAP, ICLEI
R1N – [E18] Open Iberian supramediterranean dry acid and neutral grassland

Dominated by small tussock grasses, forbs and mat-formers, including many endemics, this grassland occurs on shallow skeletal soils, nutrient-poor and drought-prone, developed over outcrops of siliceous and ultramafic bedrocks at moderate to high altitudes in the western Iberian Peninsula. Traditionally part of pastoral landscapes, grazed mostly by sheep.
217 Processing European habitat probability maps (ETC/BD)
R1P – [E19a] Oceanic to subcontinental inland sand grassland on dry acid and neutral soils

Moderately open to closed grassland on nutrient-poor sandy soils, mostly acid to neutral though sometimes calcareous, on plains, river terraces and cliffs through the lowlands and sub-montane belts of temperate Europe. Narrow-leaved, tussocky graminoids dominate, associated herbs can be very numerous and more open swards can have rich annual and cryptogam floras.
Across the wide range, there is considerable variety among the dominants and companions and the extreme topoclimate can provide a western outpost for steppe elements.
R1Q – [E19b] Inland sanddrift and dune with siliceous grassland

Usually sparse grasslands on sand drifts among inland dunes and other open landscapes, mainly in the north central European lowlands, where the nutrient-poor and highly acidic surface is prone to wind erosion and hot droughty summers, forming a highly distinctive ‘Atlantic desert’ landscape.
Soil development is very slow, pioneer moss vegetation succeeded by an open cover of small tussocky grasses, often with rich contingents of lichens on the compacted surface. Military training zones and abandoned lignite areas provide new situations.
R1R – [E1A] Mediterranean to Atlantic open, dry, acid and neutral grassland

Usually ephemeral vegetation related to the yearly cycle of spring rains and summer drought through the western Mediterranean and more fragmentarily into the Atlantic and continental zones where a high diversity of small annual plants make a brief colourful appearance on bare patches of nutrient-poor, acidic soils. Typically, the habitat occurs as small patches in intimate mosaics with heath and scrub and has provided a valuable supplementary resource for sheep at lambing time.
R1S – [E1B] Heavy-metal grassland in Western and Central Europe

Short open sward with a distinctive metallophyte component, occurring on shallow, skeletal soils over natural rock exposures with heavy metals in western and central Europe, on mine spoil or ground contaminated by dust and waters from such sources. Typically occurs locally in other landscapes, colonising slowly and sustained by the extreme environment, though also sometimes dependent on grazing by wild herbivores for maintaining early successional stages which are richer in cryptogams.
225 Processing European habitat probability maps (ETC/BD)
R21 – [E21] Mesic permanent pasture of lowlands and mountains

The most common and widespread kind of traditionally managed pasture on deeper, well-drained mesic soils throughout temperate Europe, with many local types related to regional climate, terrain and pastoral traditions. Typically dominated by mixtures of productive grasses and herbs, it can be species-rich with distinctive scarce and rare plants where low input grazing and dunging are maintained.
Often once part of wider pastoral landscapes with distinctive associated meadows, it is now widely transformed by intensive grazing and transitions are commonplace.
R22 – [E22] Low and medium altitude hay meadow

The most common and widespread kind of traditionally managed meadow in deeper, well-drained mesic soils throughout the lowlands and foothills of temperate Europe, with many local types differing according to regional climate, terrain and mowing traditions. Typically dominated by mixtures of productive grasses and herbs, it can be very species-rich with distinctive scarce and rare plants where traditional regimes of mowing, grazing and dunging are maintained.
Often once part of wider agricultural landscapes with distinctive associated pastures, it is now widely transformed by shifts to silage production and transitions to intensive silage grasslands are commonplace.
R23 – [E23] Mountain hay meadow

The typical kind of traditionally-managed meadow on deep, well-drained, mesic soils throughout the mountains of northern and central Europe where there is a short cool growing season. There are many local types differing according to regional climate, terrain and farming traditions but the vegetation is typically dominated by mixtures of productive grasses and herbs, and can be species-rich with distinctive scarce and rare plants where traditional regimes of mowing, grazing and dunging are maintained.
Often once part of wider agricultural landscapes with distinctive associated pastures, good examples of the habitat now often survive more fragmentarily and transitions to improved silage grassland are widespread.
R24 – [E24] Iberian summer pasture (vallicar)

Highly distinctive tall grass pasture and meadow associated with traditional cattle rearing in the lowlands and foothills of western Iberia where a mediterranean or submediterranean climate and the long-established grazing and occasional mowing regimes sustain a striking contingent of regional plants and association with dehesa.
The substrate is sandy or clayey, often subject to temporary flooding with rapid dessication, conditions which affect the pattern of grass dominance.
R31 - [E31a] Mediterranean tall humid inland grassland

Rush- and tall grass-dominated vegetation of seasonally waterlogged soils, mostly acidic, occurring in depressions throughout the Mediterranean basin. Though not dependent on grazing, it can be a valuable source of fodder for cattle and sheep in traditional pastoral systems during summer when other pastures are dried up.
Probability Map
Distribution map

Value

Spain

235 Processing European habitat probability maps (ETC/BD)
R32 - [E32a] Mediterranean short moist grassland of lowlands

Short species-rich grassy sward, traditionally sustained by heavy grazing, on clay soils through the Mediterranean region where there is winter waterlogging and distinctive surface cracking in the droughty summer.
Probability Map
Distribution map
- R32
- Prob_R32_t_int
Value
- 100
- 0

Croatia
R33 - [E32b] Mediterranean short moist grassland of mountains

Closed tussocky grassland of moist ground at high altitudes in the west Mediterranean which, remaining green through the summer, provide valuable grazing for transhumant cattle and sheep.
239 Processing European habitat probability maps (ETC/BD)
R34 - [E33] Submediterranean moist meadow

Moist meadows of sandy to clayey, mesotrophic to eutrophic soils on riverside terraces and gentle slopes, mainly within the lowlands and sub-montane zone of south-eastern Europe, extending westwards to central Italy. Winter and spring flooding is common but later in the season the ground may dry up and become locally saline. The species composition reflects regional differences in temperature and rainfall but patterns of mowing and grazing can also affect the species composition.
241 Processing European habitat probability maps (ETC/BD)
R35 - [E34a] Moist or wet mesotrophic to eutrophic hay meadow

Meadows of moist, sometimes seasonally flooded, nutrient-rich soils on floodplains and in brook-valleys throughout lowland and submontane Europe. Traditionally cut for hay, though sometimes also light grazed in late summer and autumn, the vegetation is often species-rich with a diverse associated invertebrate fauna attracted by the abundance of flowers.
Often once part of wider agricultural landscapes with distinctive associated pastures, good examples of the habitat now often survive more fragmentarily and transitions to improved silage grassland on flood-protected land are widespread.
R36 - [E34b] Moist or wet mesotrophic to eutrophic pasture

Pastures of moist to wet, mesotrophic to eutrophic soils, generally inundated during winter and spring, on floodplains, lake shores and ditchesides throughout temperate Europe, sometimes with a brackish influence.
Grazing is mostly by cattle which can strongly affect the nutrient status and compaction of the soil and plants tolerant of inundation and trampling dominate here with a paucity of attractive flowers and a poor associated invertebrate fauna.
R37 - [E35] Temperate and boreal moist or wet oligotrophic grassland

Meadows and pastures of less nutrient-rich soils, wet for much of the year, though not inundated by flood-waters and drying out in summer, especially in more continental regions. The soils may be somewhat acidic to base-rich, sometimes peaty above, and through the lowlands and sub-montane zones of Europe, they have been part of wider landscapes among fens and drier grasslands.
Less productive than flood meadows, they are mown just once a year, and towards the west of the range, often just lightly grazed, but they can be species-rich with some characteristic and striking species.
Vegetation on skeletal, sometimes humic, soils developed beneath late-lying snow patches in boreal and arctic mountains and the subarctic lowlands of Europe. Dominated by grasses, sedges, herbs and cryptogams, the species composition depends on regional climate, altitude, bedrock and soil type, and sometimes includes endemics, particular on high south European peaks.
249 Processing European habitat probability maps (ETC/BD)
R42 – [E43a] Boreal and arctic acidophilous alpine grassland

Boreal and arctic acidophilous alpine grasslands, dominated by low graminoids and herbs, characteristic of shallow mostly base-poor soils with thick late snow-lie, occurring through the high mountains of Fennoscandia, Iceland and Scotland.
251 Processing European habitat probability maps (ETC/BD)
R43 – [E43b] Temperate acidophilous alpine grassland

Grassland and dwarf chamaephyte vegetation on skeletal and shallow soils over predominantly siliceous bedrocks in the alpine belt throughout the temperate mountains of Europe, typical of the highest summits and ridges, often very exposed to strong winds and largely blown clear of snow in the winter.
253 Processing European habitat probability maps (ETC/BD)
R44 – [E44a] Arctic-alpine calcareous grassland

Grasslands on shallow, highly calcareous soils on limestone or dolomite slopes and ridges in the alpine or subalpine belts of the high mountains of the nemoral zone, being best developed in the Alps, but occurring also in the Carpathians and Pyrenees, with small fragmentary stands also in the Sudetes and in Scotland.
Grasses and sedges dominate, along with numerous small herbs, the cover varying from sparse to complete according to the soil depth.
R45 – [E44b] Alpine and subalpine calcareous grassland of the Balkans and Apennines

Grass-dominated vegetation of base-rich soils in the high mountains in the Balkans and Apennines including both primary vegetation above the tree-line but also secondary grasslands maintained by grazing at lower altitudes.
Probability Map
Distribution map

- R45
- Prob_R45_t_int

Value

100
0

Italy

[Map showing distribution of European habitat probability with various locations marked on a map of Italy.]
R51 – [E52a] Thermophilous forest fringe of base-rich soils

Fringe communities on neutral to base-rich, only moderately nutrient-rich, soils in the transition zone between forests and open habitats or in similar situations alongside cliffs and on roadsides, occurring across large parts of lowland north-west Europe, but also extending into more continental regions where they fringe more open thermophilous forests, and into cooler montane levels to the south and south-east.
Typically comprising half-shade plants, other species of neighbouring habitats can also find a place and, in calcareous landscapes, the vegetation can be more species-rich, harbouring a lot of rare and/or endangered species. Dependent on grazing or mowing for preventing succession.
**R52 – [E52b] Forest fringe of acidic nutrient-poor soils**

Fringe vegetation of semi-shaded forest margins and similar situations on acidic, nutrient-poor soils in the cooler atlantic and subatlantic regions of Europe, becoming rare and more species-poor further east. It is generally dominated by bulky grasses and tall herbs, rather species-poor, and ultimately dependent on extensive grazing or occasional mowing to prevent encroachment by shrubs and trees that threaten denser shade.
Probability Map
Distribution map
- R52
Prob_R52_t_int
Value
100
0
France
Condé-sur-Noireau
Pont-de-Duilly
Souven EU 2003, NOV8

261 Processing European habitat probability maps (ETC/BD)
R54 – [E53] Pteridium aquilinum vegetation

Dense species-poor stands of bracken (Pteridium aquilinum), naturally a lowland European forest fern which, when not held in check by dense shade and lacking the traditional management of cutting and trampling by cattle, readily establishes itself as a dominant, spreading vigorously by rhizome extension and producing deep litter, a feature now of many pastoral landscapes less traditionally managed than before.
Processing European habitat probability maps (ETC/BD)
R55 – [E54] Lowland moist or wet tall-herb and fern fringe

Tall-herb and fern-dominated communities of moist, sometimes flooded, nutrient-rich soils in the lowlands and lower mountain areas of Europe, up to the subalpine zone, through the nemoral, boreal and submediterranean regions.
The relatively species-rich vegetation may be found in river floodplains, along smaller watercourses, in the shade at the edge of forests, often as narrow strips, and, as secondary vegetation after the abandonment of pastures and especially meadows. The species composition is quite diverse, depending on the altitude, geographic distribution and location in the landscape.
R56 – [E55] Montane to subalpine moist or wet tall-herb and fern fringe

Tall forb and fern vegetation of moist, fertile soils in relatively cool and humid situations through high levels of the mountain ranges of Europe, having its optimum in the subalpine zone but also occurring in the arctic lowlands of Scandinavia.
Typically found as strips along streams and on the edges of forests, in the shelter of large rocks, on mountain ledges and under scrub, sometimes also fringing snow beds where it benefits from protection from winter frosts. The vegetation is often very rich in species and hosts many local and regional endemics, as well as widespread montane plants. Vulnerable to grazing by wild herbivores and stock, but often protected by its remoteness.
R57 – [E56] Herbaceous forest clearing vegetation

Short-lived herbaceous communities colonizing recent forest clearings
Probability Map
Distribution map
- R57
Prob_R57_int
Value
0
100
France

Sources: [Credit Information]
R61 - [E61] Mediterranean inland salt steppe

Halophyte vegetation of inland situations in the Mediterranean region where the soils of flats or gentle hollows are permeated by waters laden with soluble salts from underlying substrates, and are then subject to extreme summer drought, with surface efflorescence of crystalline deposits.
The vegetation can be rich in endemics, but the particular species composition depends on the regional climate and local soil conditions and there is often a distinctive seasonal pattern of growth and zonation around the hollows. In some regions, the vegetation has provided valuable grazing for sheep and goats in summer drought.
R62 - [E62] Continental inland salt steppe

Salt steppe of the Pannonian biogeographic region, characteristic of solonetz soils, saturated, even shallow flooded, by soluble carbonates in spring, then drying in summer with surface cracking.
According to variations in salinity, slope and erosion by spring floods, the vegetation is a complex mosaic of grasslands and more halophytic herb communities, rich in endemic species and plant communities. Traditionally part of the pastoral landscape of older breeds of cattle.
R63 – [E63] Temperate inland salt marsh

Inland salt marsh and meadow of temperate and continental regions, characteristic of situations where fossil salt lies close to the surface or where relict sea water is present, resulting in brackish or saline ground and surface water. In more continental regions inland salt pans are more common, where the habitat is found in depressions within a matrix of salt steppes and as sub-halophytic meadows.
Elsewhere in Europe, the habitat can be found in association with a variety of salty bedrocks and also on abandoned salt workings. The species composition is very varied according to the regional climate and particular site conditions.