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Processing European habitat probability maps at 20m resolution for EUNIS grassland types based on vegetation relevés, environmental data and Copernicus HRL grassland

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1 Background and objectives

1.1 Objectives

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 high-resolution habitat probability maps for grassland habitat types.** Starting point are the habitat suitability maps 'Distribution and habitat suitability maps of revised EUNIS grassland types' delivered within the 2017 EEA contract by Stephan Hennekens (Hennekens & Schaminée, 2018). For the habitat suitability maps of grasslands the EEA report of Schaminée et al. (2018) ('Review of grassland habitats and development of distribution maps of heathland, scrub and tundra habitats of EUNIS habitats classification') was used as the point of departure. This concerns a review – on the basis of in situ vegetation measurements across Europe – of the description and classification of habitat group E of EUNIS (Grasslands) as well as grasslands included under habitat group B (B1.4 Coastal stable dune grassland and B1.9 Machair grassland). Grasslands are of great importance in European nature policy, of widespread distribution, housing a large proportion of the biodiversity in this part of the world, and everywhere under threat. The existing descriptions are insufficient and inadequately supported by in situ vegetation data which limit the usability of the EUNIS habitat classification (Schaminée et al., 2018).

The floristic composition of the EUNIS grassland types has been determined on the basis of the floristic composition of the corresponding phytosociological alliances. As a basis for the analysis, a database of 1,190,000 relevés has been compiled, in TURBOVEG format of which 370,000 relevés could be assigned to grasslands (Schaminée et al., 2018).

Table 1.1 shows the 50 grassland habitat types for which habitat suitability maps have been produced (Hennekens, 2017). These 50 grassland habitat suitability maps have been used as an input in combination with the Copernicus High resolution layers for grassland for the production of the grassland habitat probability maps.

Table 1.1 List EUNIS grassland habitat types at level 3

	EUNIS-L3 code	Total # of vegetation plots	Description
1	B1.4a	3550	Atlantic and Baltic coastal dune grassland (grey dune)
2	B1.4b	5241	Mediterranean and Macaronesian coastal dune grassland (grey dune)
3	B1.4c	547	Black Sea coastal dune grassland (grey dune)
4	E1.1a	790	Pannonian and Pontic sandy steppe
5	E1.1b	1180	Cryptogam- and annual-dominated vegetation on siliceous rock outcrops
6	E1.1d	1922	Cryptogam- and annual-dominated vegetation on calcareous and ultramafic rock outcrops
7	E1.1e	422	Perennial rocky grassland of the Italian Peninsula
8	E1.1f	169	Continental dry rocky steppic grassland and dwarf scrub on chalk outcrops
9	E1.1g	1623	Perennial rocky grassland of Central Europe and the Carpathians
10	E1.1h	86	Heavy-metal dry grassland of the Balkans
11	E1.1i	2179	Perennial rocky calcareous grassland of subatlantic-submediterranean Europe
12	E1.1j	337	Dry steppic, submediterranean pasture of South-Eastern Europe
13	E1.2a	41008	Semi-dry perennial calcareous grassland
14	E1.2b	5107	Continental dry steppe
15	E1.3a	522	Mediterranean closely grazed dry grassland
16	E1.3b	1000	Mediterranean tall perennial dry grassland
17	E1.3c	930	Mediterranean annual-rich dry grassland
18	E1.5a	676	Iberian oromediterranean siliceous dry grassland
19	E1.5b	902	Iberian oromediterranean basiphilous dry grassland
20	E1.5c	22	Cyrno-Sardean-oromediterranean siliceous dry grassland
21	E1.5d	106	Greek and Anatolian oromediterranean siliceous dry grassland
22	E1.7	2014	Lowland to submontane, dry to mesic Nardus grassland
23	E1.8	245	Open Iberian supra-mediterranean dry acid and neutral grassland
24	E1.9a	4346	Oceanic to subcontinental inland sand grassland on dry acid and neutral soils
25	E1.9b	2286	Inland sanddrift and dune with siliceous grassland
26	E1.A	2066	Mediterranean to Atlantic open, dry, acid and neutral grassland
27	E1.B	133	Heavy-metal grassland in Western and Central Europe
28	E2.1	30390	Mesic permanent pasture of lowlands and mountains
29	E2.2	60857	Low and medium altitude hay meadow
30	E2.3	2146	Mountain hay meadow

31	E2.4	46	Iberian summer pasture (vallicar)
32	E3.1a	713	Mediterranean tall humid inland grassland
33	E3.2a	144	Mediterranean short moist grassland of lowlands
34	E3.2b	1152	Mediterranean short moist grassland of mountains
35	E3.3	1096	Submediterranean moist meadow
36	E3.4a	22215	Moist or wet mesotrophic to eutrophic hay meadow
37	E3.4b	11179	Moist or wet mesotrophic to eutrophic pasture
38	E3.5	7401	Temperate and boreal moist or wet oligotrophic grassland
39	E4.1	1339	Vegetated snow-patch
40	E4.3a	18	Boreal and arctic acidophilous alpine grassland
41	E4.3b	8422	Temperate acidophilous alpine grassland
42	E4.4a	3329	Arctic-alpine calcareous grassland
43	E4.4b	531	Alpine and subalpine calcareous grassland of the Balkan and Apennines
44	E5.2a	845	Thermophilous woodland fringe of base-rich soils
45	E5.2b	134	Thermophilous woodland fringe of acidic soils
46	E5.4	11159	Lowland moist or wet tall-herb and fern fringe
47	E5.5	788	Subalpine moist or wet tall-herb and fern fringe
48	E6.1	640	Mediterranean inland salt steppe
49	E6.2	1242	Continental inland salt steppe
50	E6.3	982	Temperate inland salt marsh

The only habitat suitability maps that has not been used is E1.1f 'Continental dry rocky steppic grassland and dwarf scrub on chalk outcrops' since this type seems to occur only outside the EU27.

1.2 Content of the report

This report on the production of the EUNIS 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 maps, followed by habitat suitability and finally the habitat probability. The integration of in-situ vegetation relevés, environmental data layers and remotely sensed information, such as the 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 how the habitat probability maps (20 m resolution) have been derived from the 1km resolution habitat suitability maps.

Annex I shows all 49 produced European grassland habitat probability maps at 20 meter resolution, including the habitat distribution (in-situ vegetation plots) and a detailed example of the habitat probability maps. Annex I contains in total 147 maps (49 x 3).

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 plots which can be assigned to the 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 information on land cover.

2.2 Methodology

Distribution → ***Suitability →*** ***Probability***

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), and in some cases abiotic data (e.g. distance to rivers, presence of podzolls), is used to filter the suitability map to eventually get to a refined **probability map,** see Figure 2.1. 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. 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).

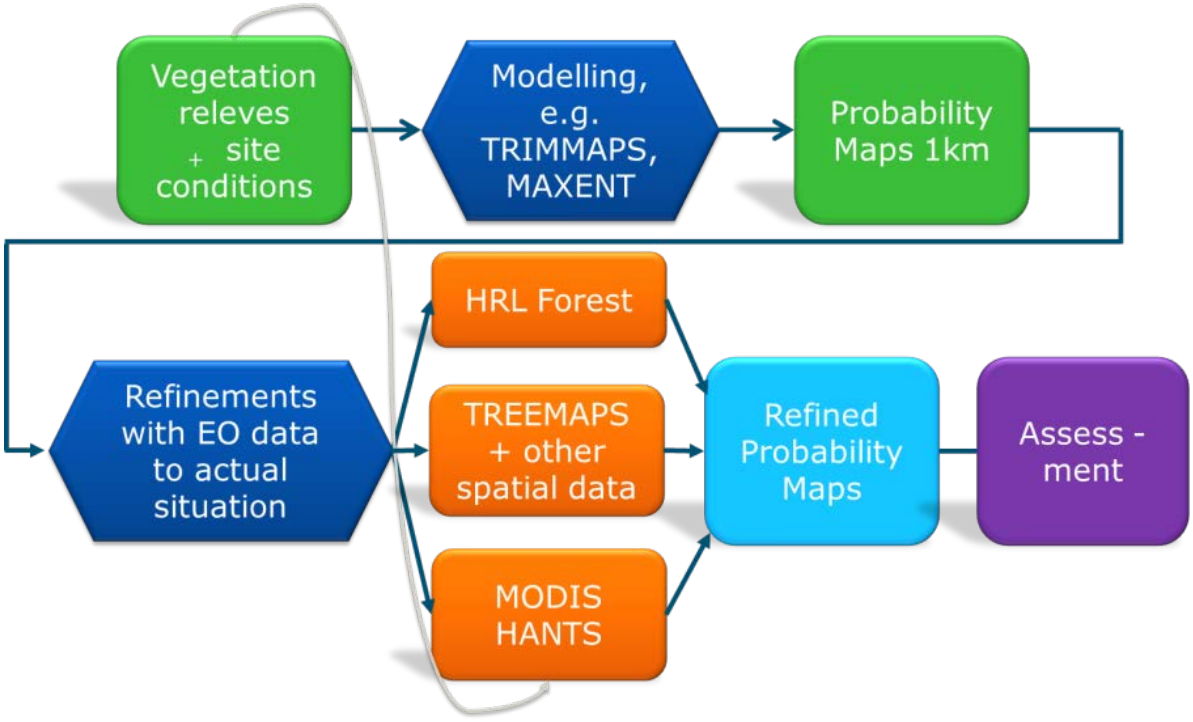


Figure 2.2 General workflow for the processing of refined EUNIS forest habitat probability maps (Mücher et al., 2015)

3 Habitat suitability maps

For the 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 method 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. These layers were selected from meaningful environmental predictors commonly used for modelling non-tropical plant and vegetation diversity, and are not mutually strongly correlated.

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

- Potential Evapotranspiration
  http://www.cgiar-csi.org/data/global-aridity-and-pet-database
- Solar radiation
  http://www.worldgrids.org/doku.php?id=wiki:inmsre3
- 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
- Distance to water (rivers, lakes, sea)
  derived from the shapefile 'Inland_Waters.shp'
- 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

Compared with the habitat suitability models set up for the EUNIS forest types (Schaminée et al. 2014) we now applied 8 recently published soil parameters (Hengl et al. 2014), instead of only one (soil pH). The same set has also been applied for the grassland habitat types.

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 10,000 locations for the background data, assuming biased and non-biased presence data. For the first approach, 10,000 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 10,000 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. This evaluation was based on the expert knowledge of the team members of the distribution of grassland types by assessing (i) the distribution of the available presence data as an estimate of geographic bias, (ii) the realism of the habitat suitability maps to reflect known distribution of grasslands, and (iii) the environmental predictors that contribute most substantially to the models. The best performing model was then selected by consensus of the expert team for each habitat type.

For 3 EUNIS types (E1.5e, E.1F, E5.2) insufficient data was available to create a model.
For each EUNIS grassland type the following data are presented:

1. **A distribution map** showing the location of the relevés that have been assigned to the EUNIS type concerned and therefore used as presence data.
2. **A habitat suitability map** with colours varying from grey, through green to red, indicating increasingly favourable ecological conditions for the type (expressing the logistic output of the model between 0 and 1).

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/). 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.

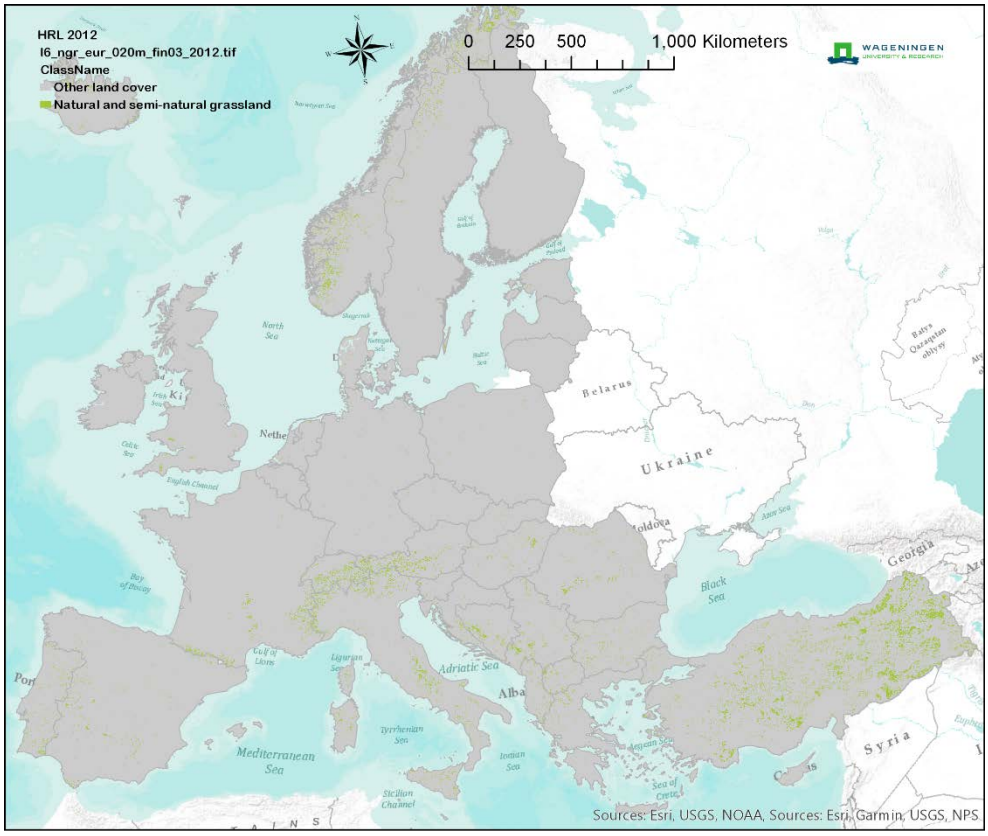


Figure 4.4 The entire Copernicus HRL grassland database for 2012 showing only natural and semi-natural grasslands

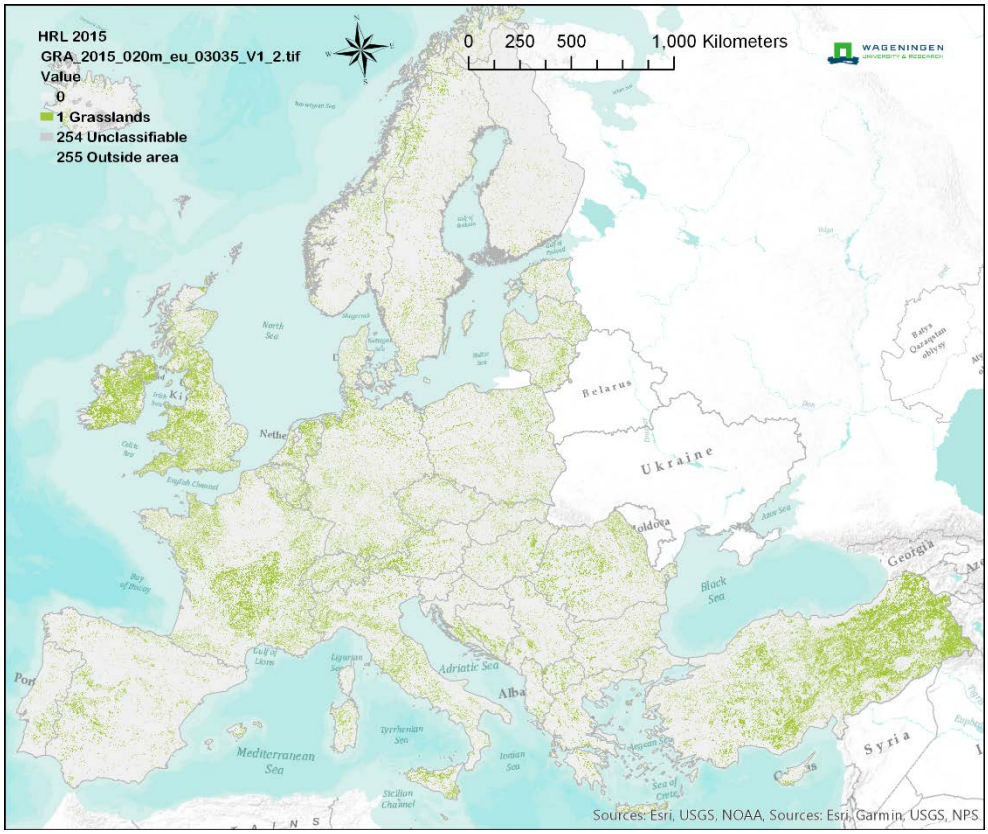


Figure 4.5 The entire Copernicus HRL grassland database for 2015 showing all grasslands as one class

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 glass 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 for the Netherlands clearly shows that we would miss the dune grasslands if we did not integrate the 2012 HRL product.

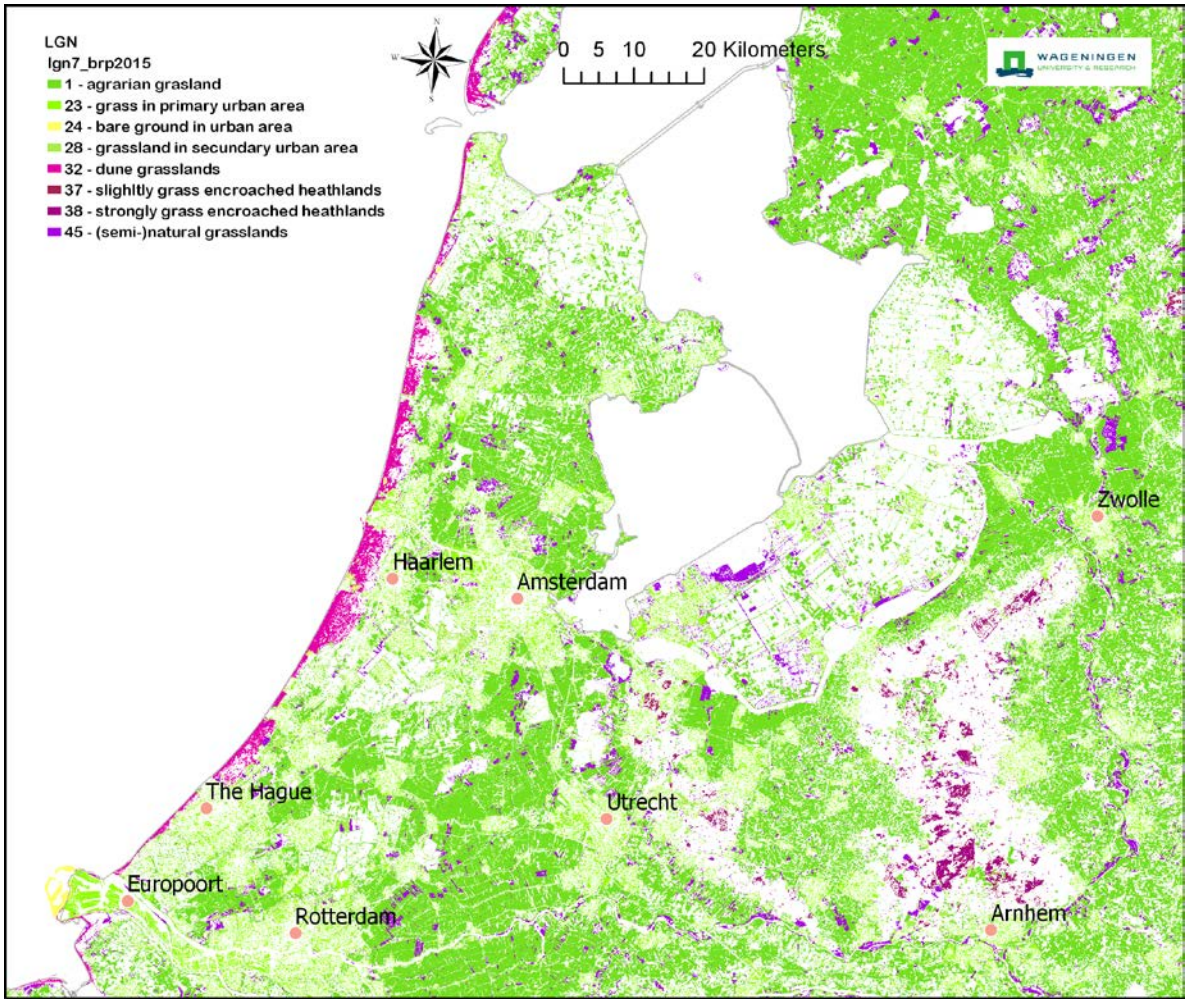


Figure 4.1 The Dutch national land cover database LGN7 showing here only all grassland related land cover classes

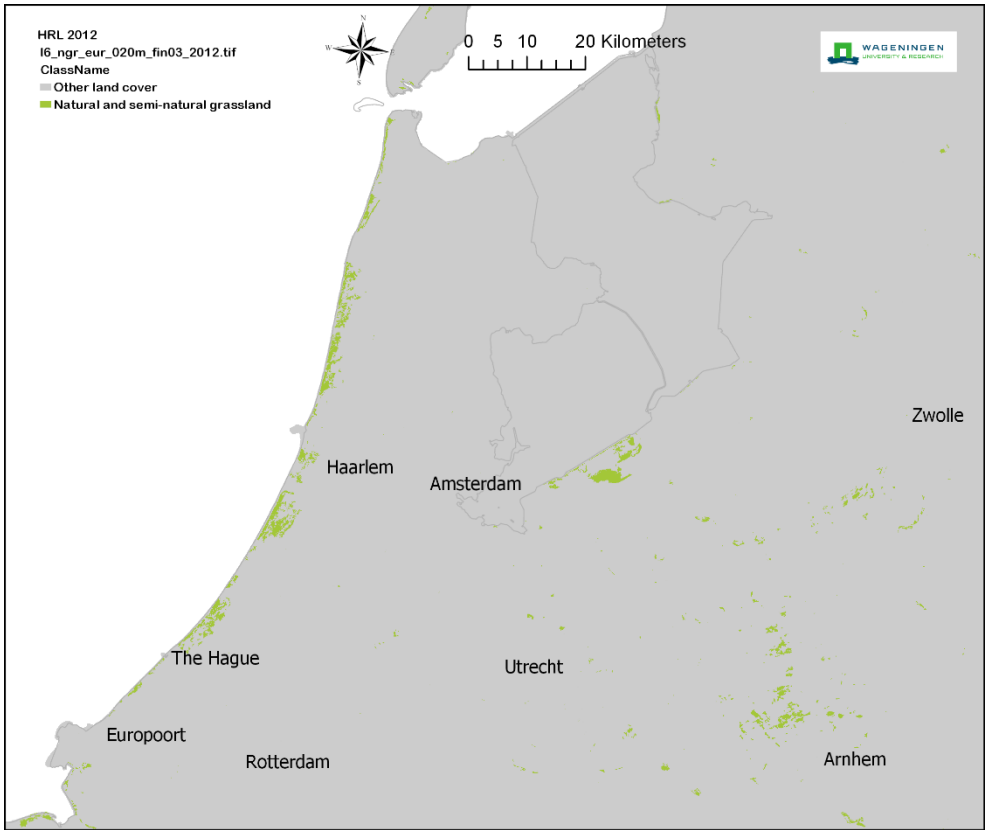


Figure 4.2 The Copernicus HRL grassland for 2012 showing only natural and semi-natural grasslands

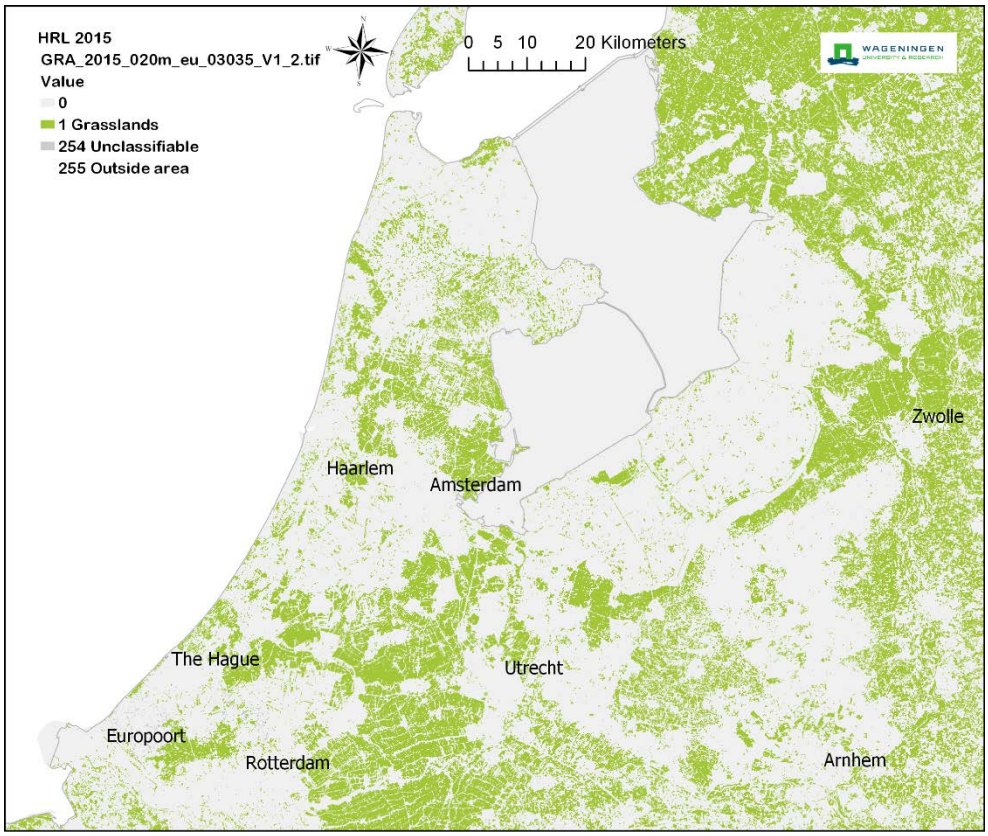


Figure 4.3 The Copernicus HRL grassland for 2015 showing all grasslands as one class

Therefore on basis of HRL grassland 2012, and HRL grassland 2015 we made the new product HRL_grass20m with a 2 meter resolution and having two thematic grassland classes; 1) natural and semi-natural grasslands and 2) managed grasslands.

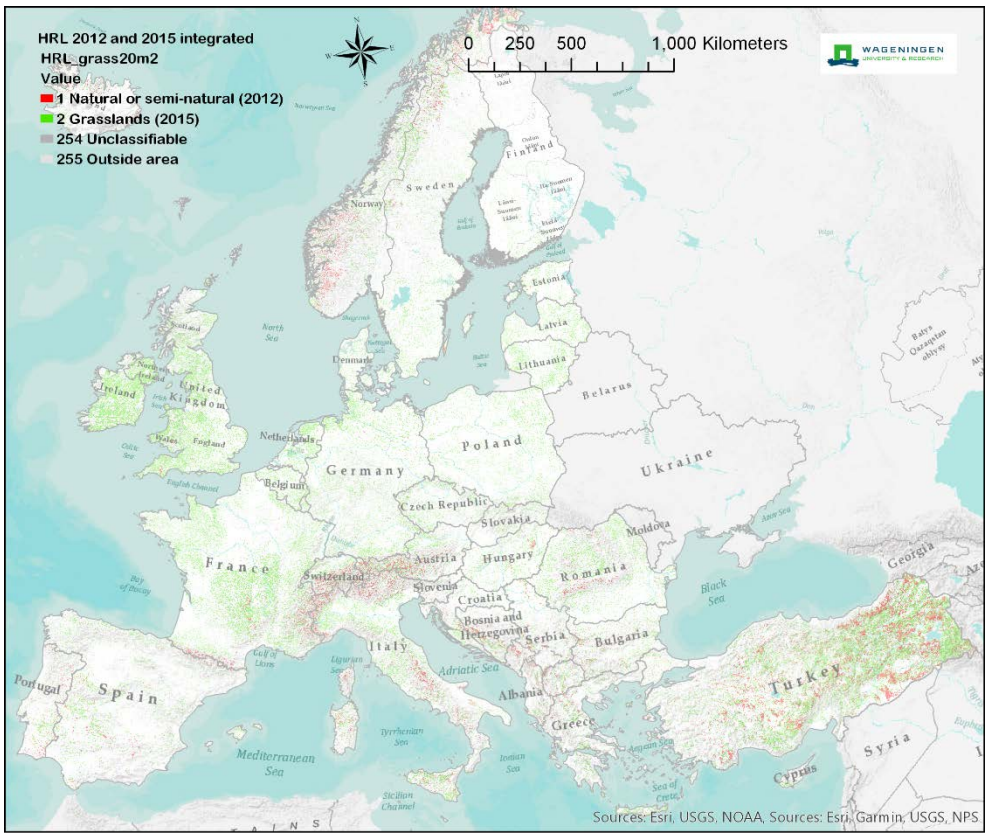


Figure 4.6 Integrated grassland database based on Copernicus HRL grassland database for 2012 and 2015 distinguishing class 1 natural and semi-nature grassland and class 2 2 managed grasslands

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 grassland habitat types and therefore we would like to use very high resolution land cover maps for grasslands. Since most grassland habitats are quite fragmented in small patches across Europe we would like to use land cover information with the highest possible spatial resolution. 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. As mentioned in Chapter 4 we are using the two Copernicus HRL grasslands 2012 and 2015 as an input in combination with the habitat suitability maps to produce the habitat probability maps at 20 meter resolution. Figure 9 shows the principle of the methodology that we follow. In fact we mask the grassland habitat suitability maps on basis of the Copernicus HRL grassland.

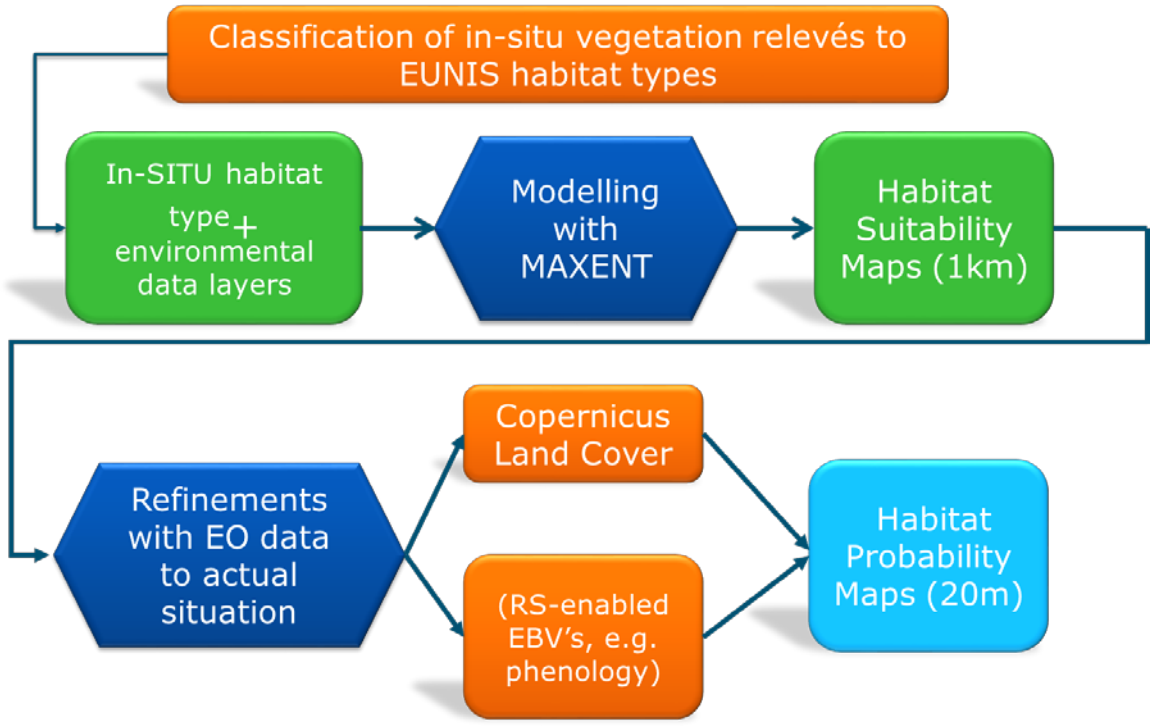


Figure 5.1 Flowchart of the methodology implemented to obtain habitat probability maps

But before using the Copernicus HRL grassland integrated for 2012 and 2015 (HRL_grass20m) we had to post-process the habitat suitability maps using the 10 percent training presence as a threshold, (see Table 5.1).

Table 5.1 All grassland habitat suitability maps with their 10 percentile training presence threshold. All values below the specific threshold were set to zero for each suitability map

	EUNIS-code	EUNIS-description	10 percentile training presence Cloglog threshold
1	B14a	Atlantic and Baltic coastal dune grassland (grey dune)	0.3243
2	B14b	Mediterranean and Macaronesian coastal dune grassland (grey dune)	0.2607
3	B14c	Black Sea coastal dune grassland (grey dune)	0.6043
4	E11a	Pannonian and Pontic sandy steppe	0.2926
5	E11b	Cryptogam- and annual-dominated vegetation on siliceous rock outcrops	0.227
6	E11d	Cryptogam- and annual-dominated vegetation on calcareous and ultramafic rock outcrops	0.3065
7	E11e	Perennial rocky grassland of the Italian Peninsula	0.4326
8	E11f	Continental dry rocky steppic grassland and dwarf scrub on chalk outcrops	0.4287
9	E11g	Perennial rocky grassland of Central Europe and the Carpathians	0.3187
10	E11h	Heavy-metal dry grassland of the Balkans	0.2626
11	E11i	Perennial rocky calcareous grassland of subatlantic-submediterranean Europe	0.2984
12	E11j	Dry steppic, submediterranean pasture of South-Eastern Europe	0.2955
13	E12a	Semi-dry perennial calcareous grassland	0.4162
14	E12b	Continental dry steppe	0.3365
15	E13a	Mediterranean closely grazed dry grassland	0.3144
16	E13b	Mediterranean tall perennial dry grassland	0.3771
17	E13c	Mediterranean annual-rich dry grassland	0.3211
18	E15a	Iberian oromediterranean siliceous dry grassland	0.3453
19	E15b	Iberian oromediterranean basiphilous dry grassland	0.3284
20	E15c	Cyrno-Sardean-oromediterranean siliceous dry grassland	0.5426
21	E15d	Greek and Anatolian oromediterranean siliceous dry grassland	0.2851
22	E17	Lowland to submontane, dry to mesic Nardus grassland	0.2744
23	E18	Open Iberian supra-mediterranean dry acid and neutral grassland	0.1998
24	E19a	Oceanic to subcontinental inland sand grassland on dry acid and neutral soils	0.2734
25	E19b	Inland sanddrift and dune with siliceous grassland	0.2629
26	E1A	Mediterranean to Atlantic open, dry, acid and neutral grassland	0.3317
27	E1B	Heavy-metal grassland in Western and Central Europe	0.0592
28	E21	Mesic permanent pasture of lowlands and mountains	0.4014
29	E22	Low and medium altitude hay meadow	0.4293
30	E23	Mountain hay meadow	0.4266
31	E24	Iberian summer pasture (vallicar)	0.3537
32	E31a	Mediterranean tall humid inland grassland	0.3896
33	E32a	Mediterranean short moist grassland of lowlands	0.2627
34	E32b	Mediterranean short moist grassland of mountains	0.3683
35	E33	Submediterranean moist meadow	0.2854
36	E34a	Moist or wet mesotrophic to eutrophic hay meadow	0.4373

37	E34b	Moist or wet mesotrophic to eutrophic pasture	0.3983
38	E35	Temperate and boreal moist or wet oligotrophic grassland	0.3776
39	E41	Vegetated snow-patch	0.3813
40	E43a	Boreal and arctic acidophilous alpine grassland	0.0415
41	E43b	Temperate acidophilous alpine grassland	0.4105
42	E44a	Arctic-alpine calcareous grassland	0.341
43	E44b	Alpine and subalpine calcareous grassland of the Balkan and Apennines	0.3112
44	E52a	Thermophilous woodland fringe of base-rich soils	0.2991
45	E52b	Thermophilous woodland fringe of acidic soils	0.1889
46	E54	Lowland moist or wet tall-herb and fern fringe	0.4365
47	E55	Subalpine moist or wet tall-herb and fern fringe	0.313
48	E61	Mediterranean inland salt steppe	0.2427
49	E62	Continental inland salt steppe	0.3464
50	E63	Temperate inland salt marsh	0.1744

In a next step we did calculate in ARGIS Pro all habitat probability maps by masking the habitat suitability maps with the Copernicus grassland layers 2012 and 2015. For class 1 'semi-natural and natural grasslands' we multiplied the habitat suitability with value 1.0 and for class 2 'managed grassland' we multiplied the habitat suitability with value 0.6, indicating that semi-natural and natural grasslands have a higher chance to find the proper EUNIS habitat. Although the author is aware that these values are indicative and that the land cover class 1 has a lower classification accuracy than class 2.

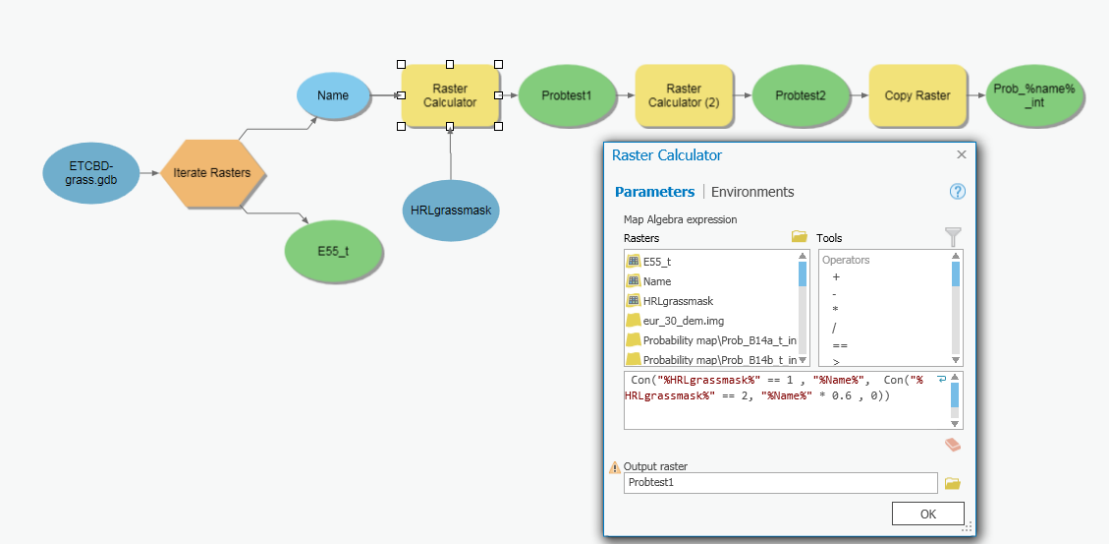
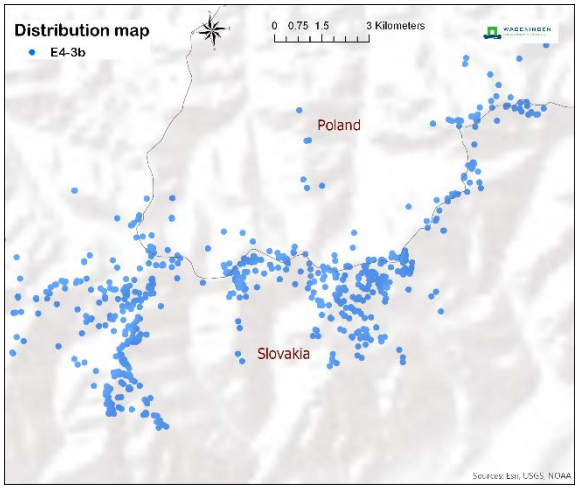


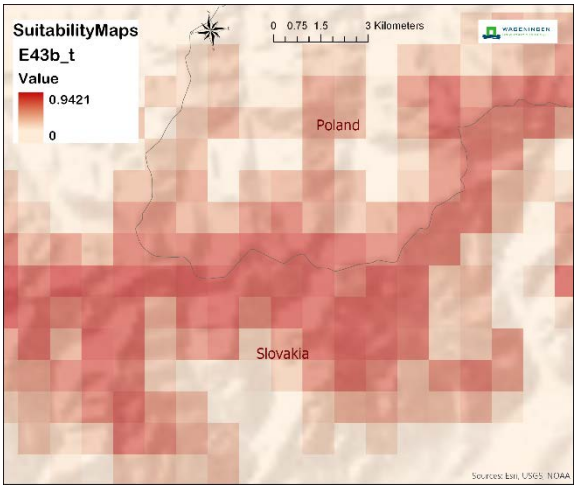
Figure 5.2 ARGIS Pro graphic model for calculating the probability maps on basis of the suitability maps and Copernicus HRL grassland

The result of this model is given in the figure below.

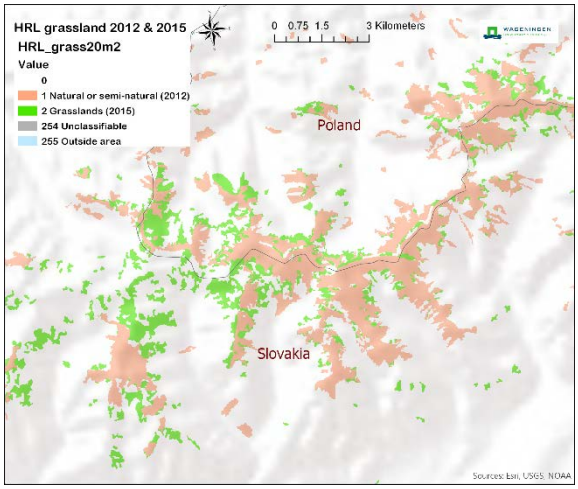
Figure 5.3 **Figures sumarizing all the methodological steps for a small area on the border of Poland and Slovakia for EUNIS habitat type E4.3b *'Temperate acidophiluous alpine grasslands'***



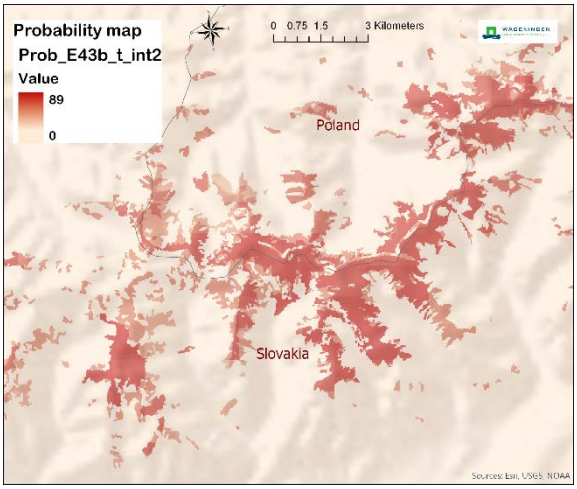
a) Habitat distribution map



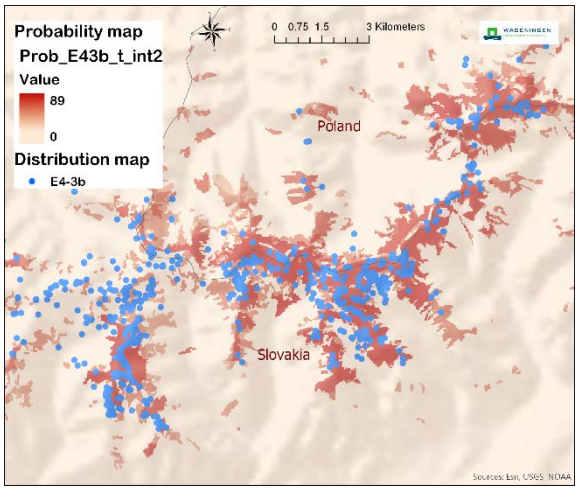
b) Habitat suitability map (1km resolution)



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 (distrubution map)

Figure 5.3 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 that the final habitat probability represents well the actual distribution of the habitat as reflected by the distribution map. 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.

Appendix I shows all 49 produced European grassland habitat probability maps at 20 meter resolution, including the habitat distribution (in-situ vegetation plots) and a detailed example of the habitat probability maps. Annex I contains in total 147 maps (49 x 3).

6 References

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

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

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

Janssen, J.A.M., J.S. Rodwell, M. García Criado, S. Gubbay, T. Haynes, A. Nieto, N. Sanders, F. Landucci, J. Loidi, A. Ssymank, T. Tahvanainen, M. Valderrabano, A. Acosta, M. Aronsson, G. Arts, F. Attorre, E. Bergmeier, R.-J. Bijlsma, F. Bioret, C. Biţă-Nicolae, I. Biurrun, M. Calix, J. Capelo, A. Čarni, M. Chytrý, J. Dengler, P. Dimopoulos, F. Essl
, H. Gardfjell, D. Gigante, G. Giusso del Galdo, M. Hájek, F. Jansen, J. Jansen, J. Kapfer, A. Mickolajczak, J.A. Molina, Z. Molnár, D. Paternoster, A. Piernik, B. Poulin, B. Renaux, J.H.J. Schaminée, K. Šumberová, H. Toivonen, T. Tonteri, I. Tsiripidis, R. Tzonev and M. Valachovič. (2016). European Red List of Habitats. Part 2: Terrestrial and freshwater habitats. European Commission, Brussels.

Moss, D. 2012. A crosswalk between EUNIS habitats Classification and Corine Land Cover. European Topic Centre on Biological Diversity http://biodiversity.eionet.europa.eu

Mücher, C.A., Hennekens, S.M., Schaminée, J.H.J., Halada, L. & Halabuk, A., 2015. Modelling the spatial distribution of EUNIS forest habitat types. Internal report ETC/BD for task 1.7.5.C.

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

Schaminée, J.H.J., Chytrý, M., Hennekens, S.M., Janssen, J.A.M., Jiménez-Alfaro, B., Knollová, I., Mucina, L., Rodwell, J.S. & Tichý, L., 2014. Vegetation analysis and distribution maps for EUNIS habitats. Report for the European Environmental Agency (EEA/NSV/14/006), Copenhagen.

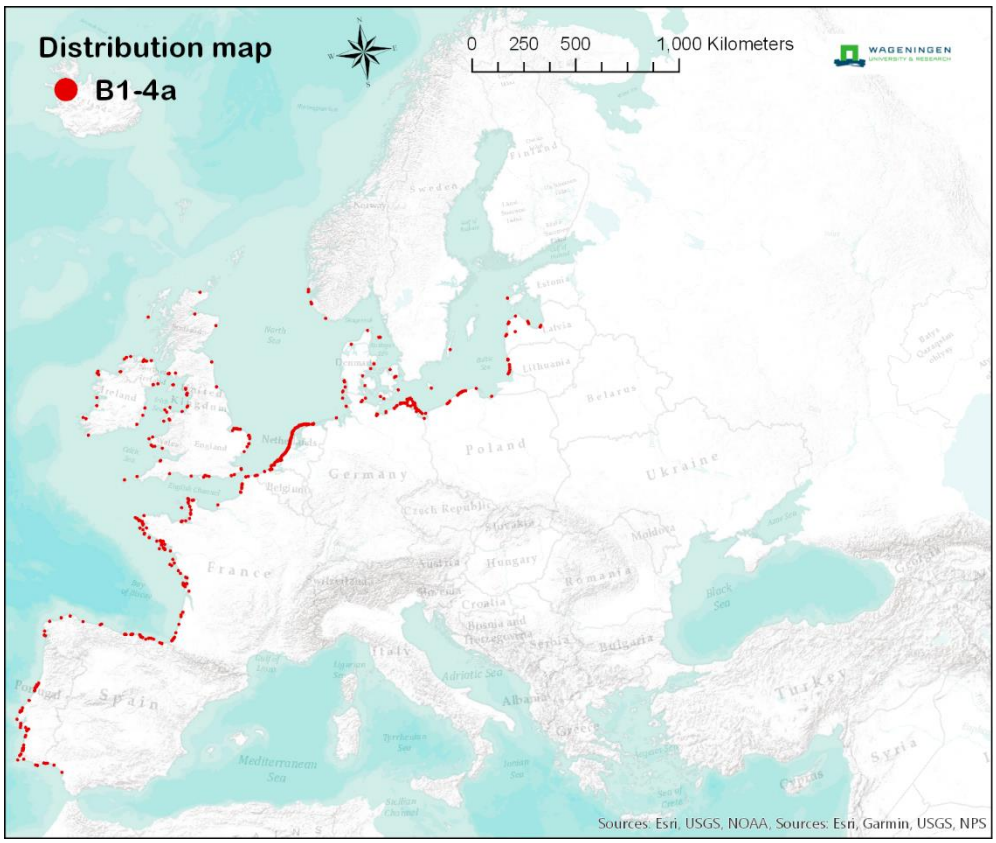
Schaminée, J.H.J., Chytrý, M., Hennekens, S.M., Janssen, J.A.M., Jiménez-Alfaro, B., Knollová, I., Mucina, L., Rodwell, J.S. & Tichý, L., 2018. Review of grassland habitats and development of distribution maps of heathland, scrub and tundra habitats of EUNIS habitats classification. Report for the European Environmental Agency (Report EEA/NSV/15/005), Copenhagen.

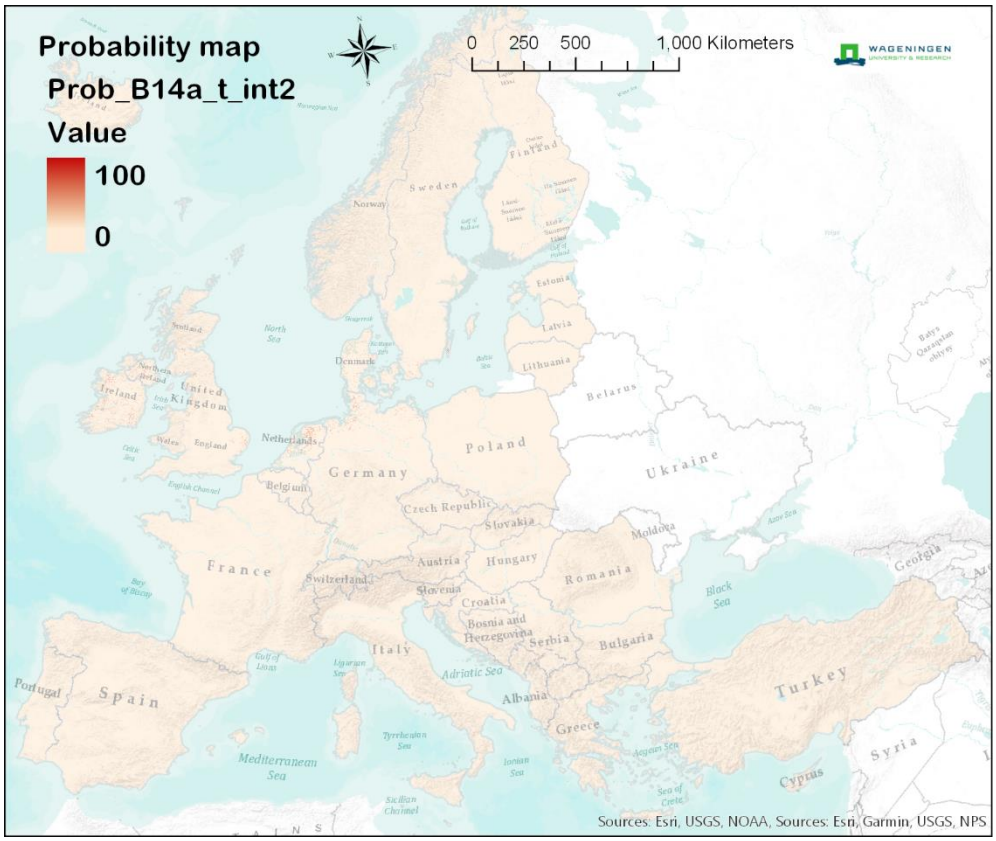
7 Appendix I: The results: the EUNIS grassland habitat probability maps

B1.4a	Atlantic and Baltic coastal dune grassland (grey dune)
B1.4b	Mediterranean and Macaronesian coastal dune grassland (grey dune)
B1.4c	Black Sea coastal dune grassland (grey dune)
E1.1a	Pannonian and Pontic sandy steppe
E1.1b	Cryptogam- and annual-dominated vegetation on siliceous rock outcrops
E1.1d	Cryptogam- and annual-dominated vegetation on calcareous and ultramafic rock outcrops
E1.1e	Perennial rocky grassland of the Italian Peninsula
E1.1g	Perennial rocky grassland of Central Europe and the Carpathians
E1.1h	Heavy-metal dry grassland of the Balkans
E1.1i	Perennial rocky calcareous grassland of subatlantic-submediterranean Europe
E1.1j	Dry steppic, submediterranean pasture of South-Eastern Europe
E1.2a	Semi-dry perennial calcareous grassland
E1.2b	Continental dry steppe
E1.3a	Mediterranean closely grazed dry grassland
E1.3b	Mediterranean tall perennial dry grassland
E1.3c	Mediterranean annual-rich dry grassland
E1.5a	Iberian oromediterranean siliceous dry grassland
E1.5b	Iberian oromediterranean basiphilous dry grassland
E1.5c	Cyrno-Sardean-oromediterranean siliceous dry grassland
E1.5d	Greek and Anatolian oromediterranean siliceous dry grassland
E1.7	Lowland to submontane, dry to mesic Nardus grassland
E1.8	Open Iberian supra-mediterranean dry acid and neutral grassland
E1.9a	Oceanic to subcontinental inland sand grassland on dry acid and neutral soils
E1.9b	Inland sanddrift and dune with siliceous grassland
E1.A	Mediterranean to Atlantic open, dry, acid and neutral grassland
E1.B	Heavy-metal grassland in Western and Central Europe
E2.1	Mesic permanent pasture of lowlands and mountains
E2.2	Low and medium altitude hay meadow
E2.3	Mountain hay meadow
E2.4	Iberian summer pasture (vallicar)
E3.1a	Mediterranean tall humid inland grassland
E3.2a	Mediterranean short moist grassland of lowlands
E3.2b	Mediterranean short moist grassland of mountains
E3.3	Submediterranean moist meadow
E3.4a	Moist or wet mesotrophic to eutrophic hay meadow
E3.4b	Moist or wet mesotrophic to eutrophic pasture
E3.5	Temperate and boreal moist or wet oligotrophic grassland
E4.1	Vegetated snow-patch
E4.3a	Boreal and arctic acidophilous alpine grassland
E4.3b	Temperate acidophilous alpine grassland
E4.4a	Arctic-alpine calcareous grassland
E4.4b	Alpine and subalpine calcareous grassland of the Balkan and Apennines
E5.2a	Thermophilous woodland fringe of base-rich soils
E5.2b	Thermophilous woodland fringe of acidic soils

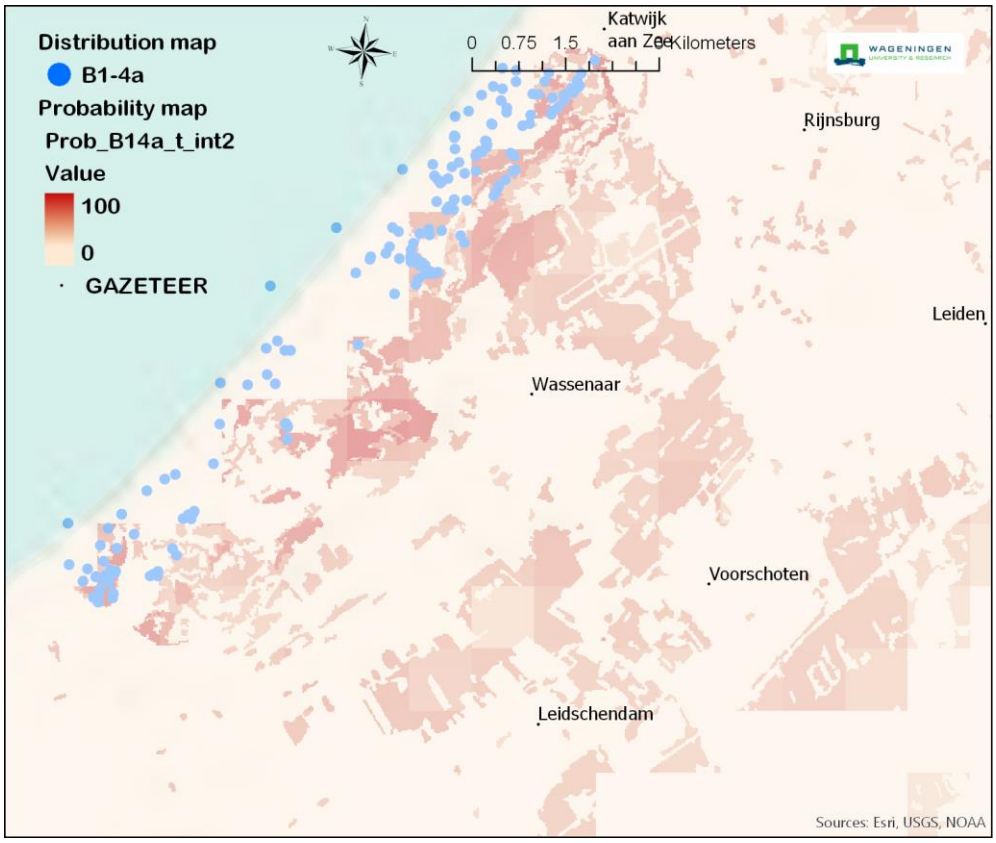
E5.4 Lowland moist or wet tall-herb and fern fringe
E5.5 Subalpine moist or wet tall-herb and fern fringe
E6.1 Mediterranean inland salt steppe
E6.2 Continental inland salt steppe
E6.3 Temperate inland salt marsh

B1.4a Atlantic and Baltic coastal dune grassland (grey dune)

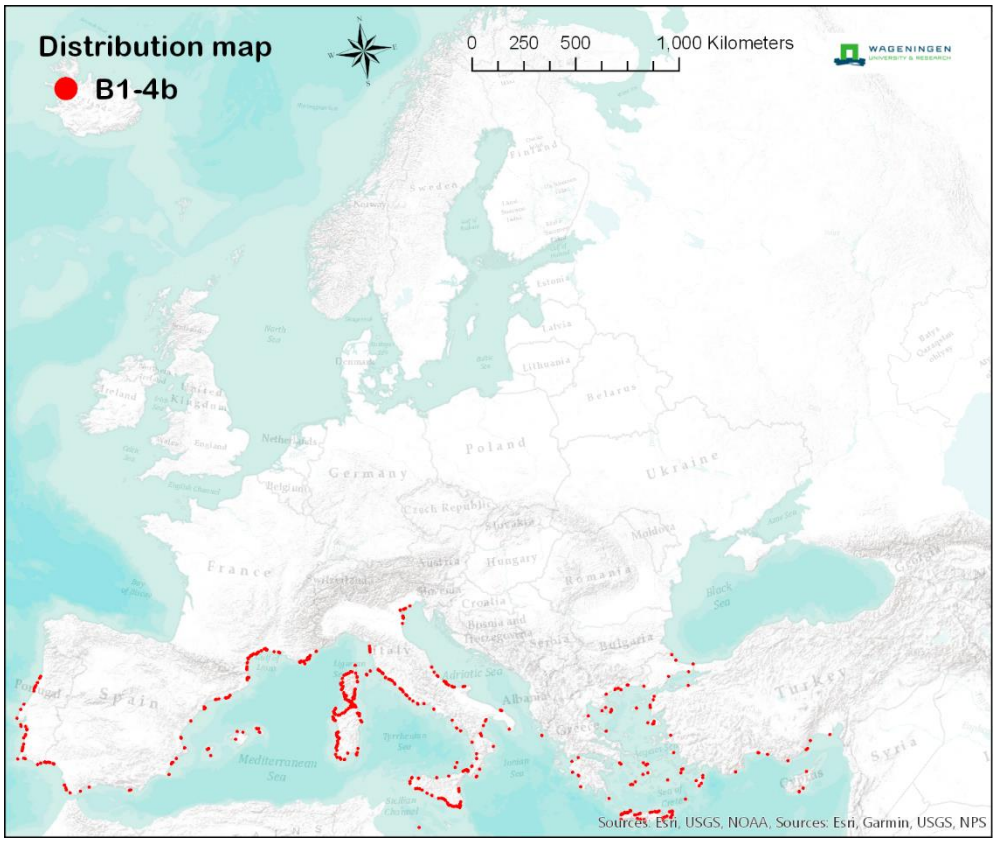


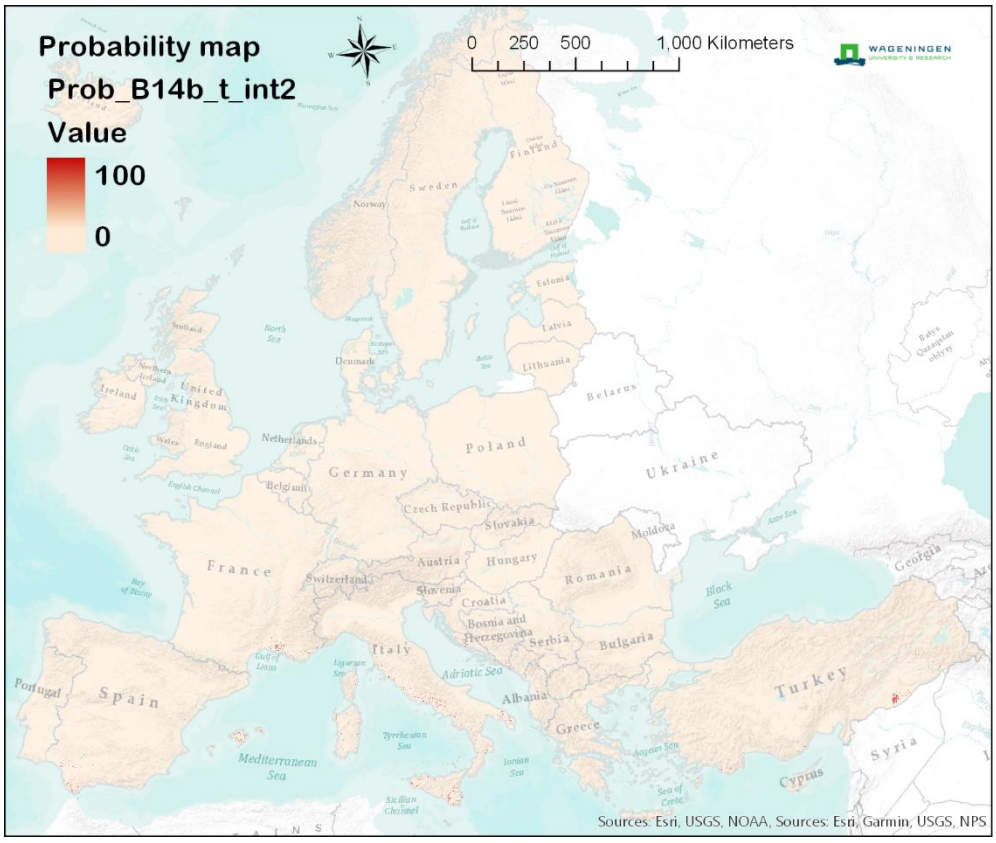


Example detail of the European habitat probability map at 20 m resolution for B1.4a Atlantic and Baltic coastal dune grassland (grey dune)

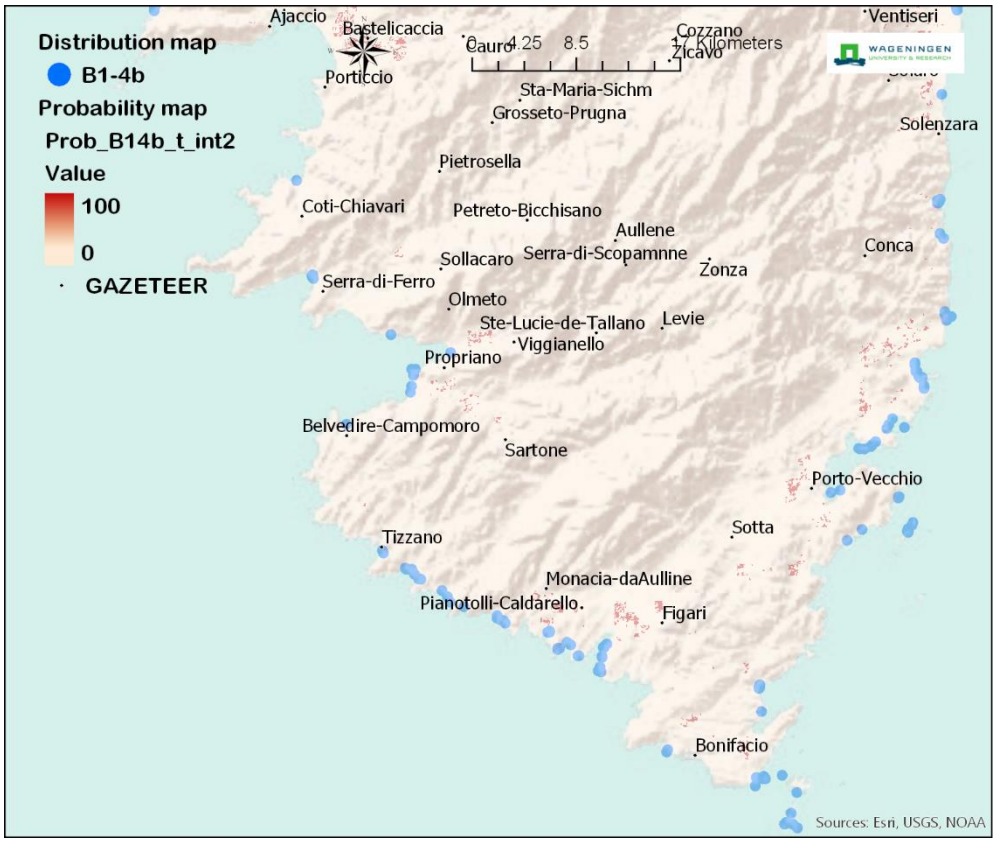


B1.4bMediterranean and Macaronesian coastal dune grassland (grey dune)

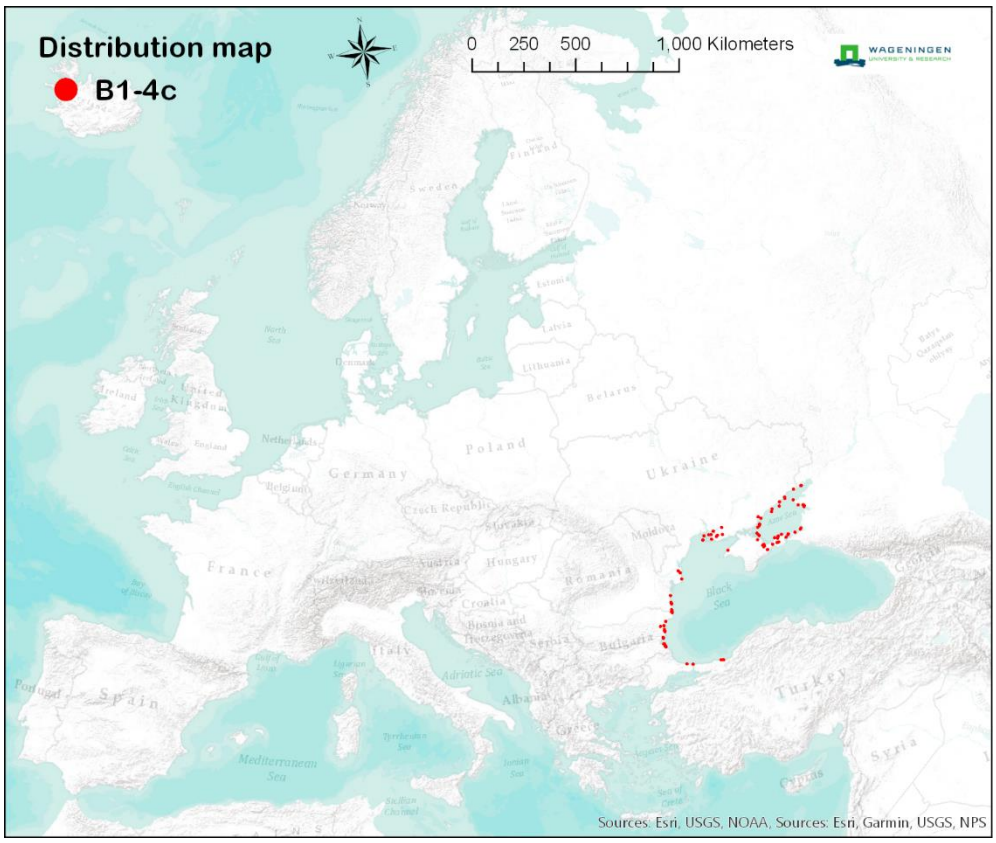


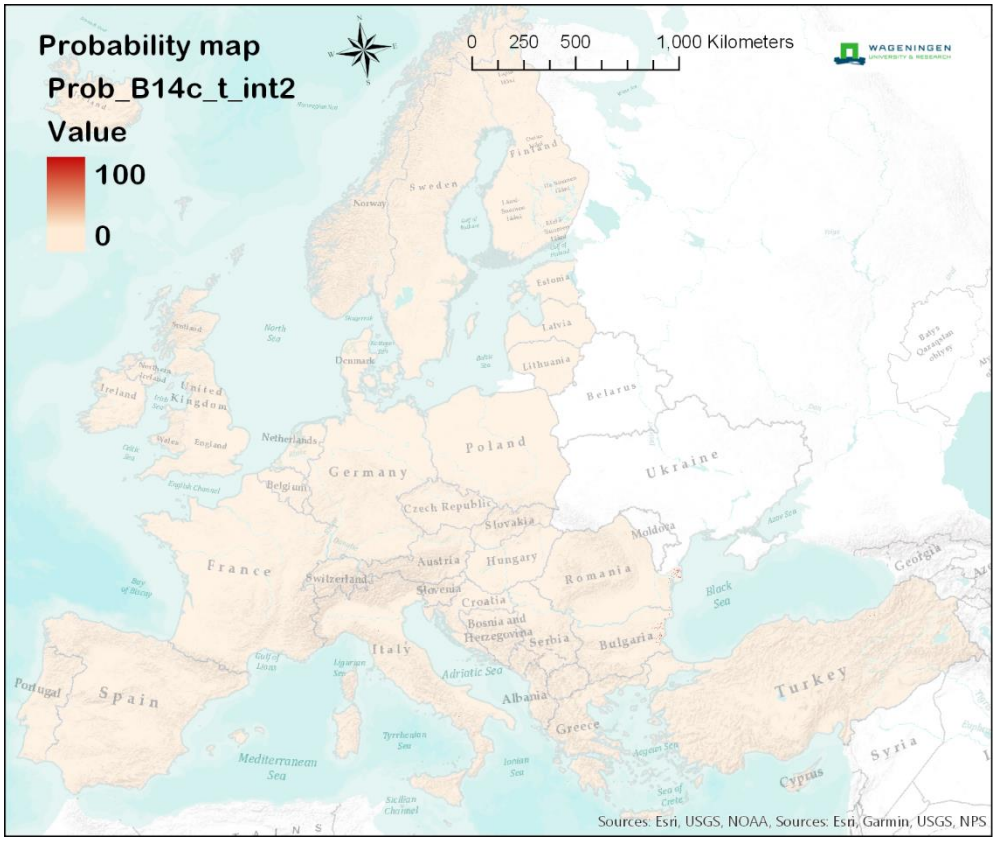


Example detail of the European habitat probability map at 20 m resolution for B1.4b Mediterranean and Macaronesian coastal dune grassland (grey dune)

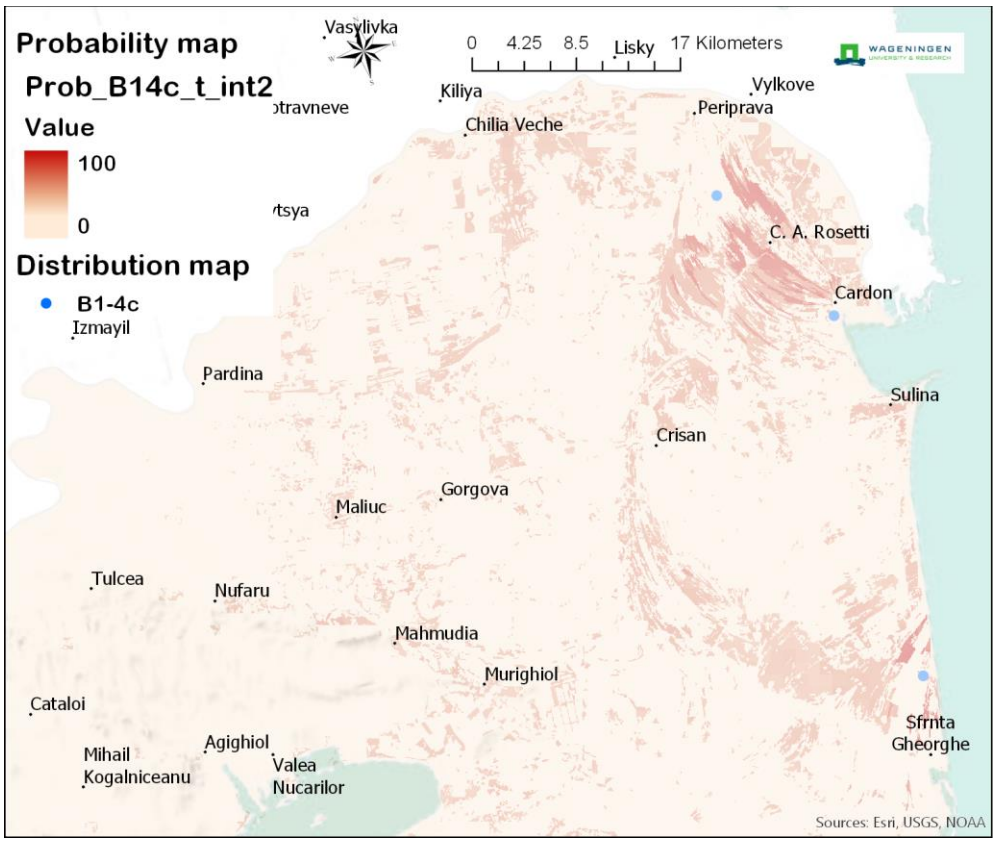


B1.4c Black Sea coastal dune grassland (grey dune)

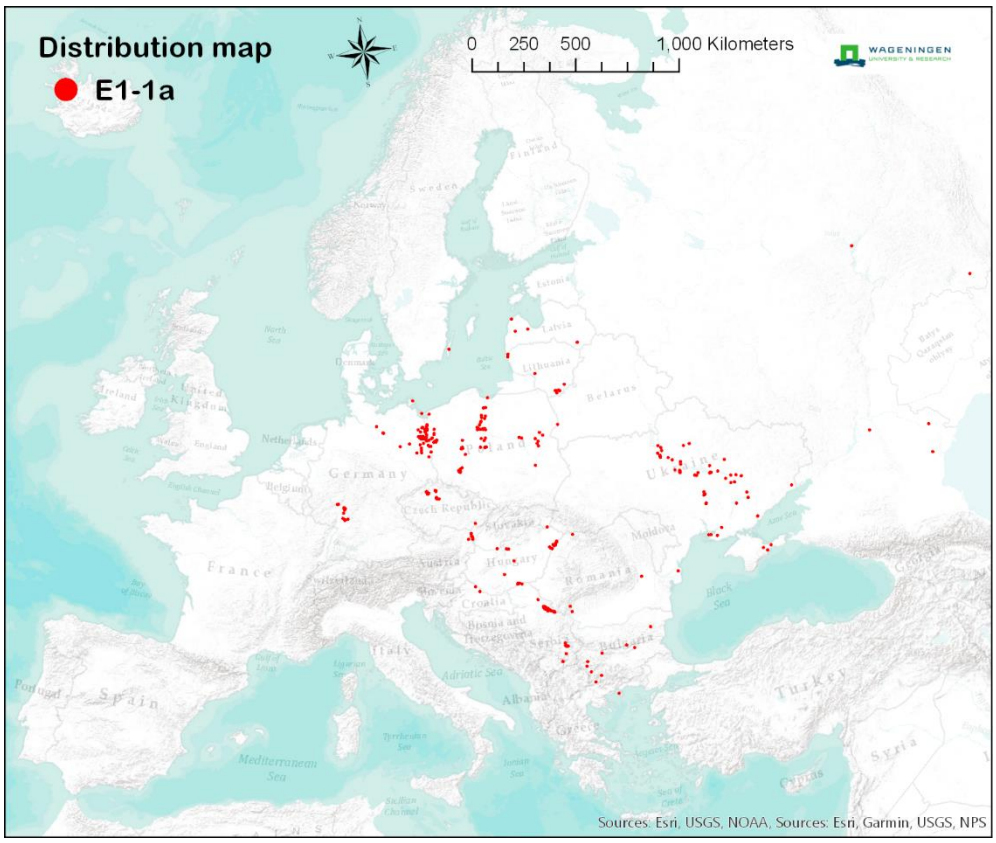


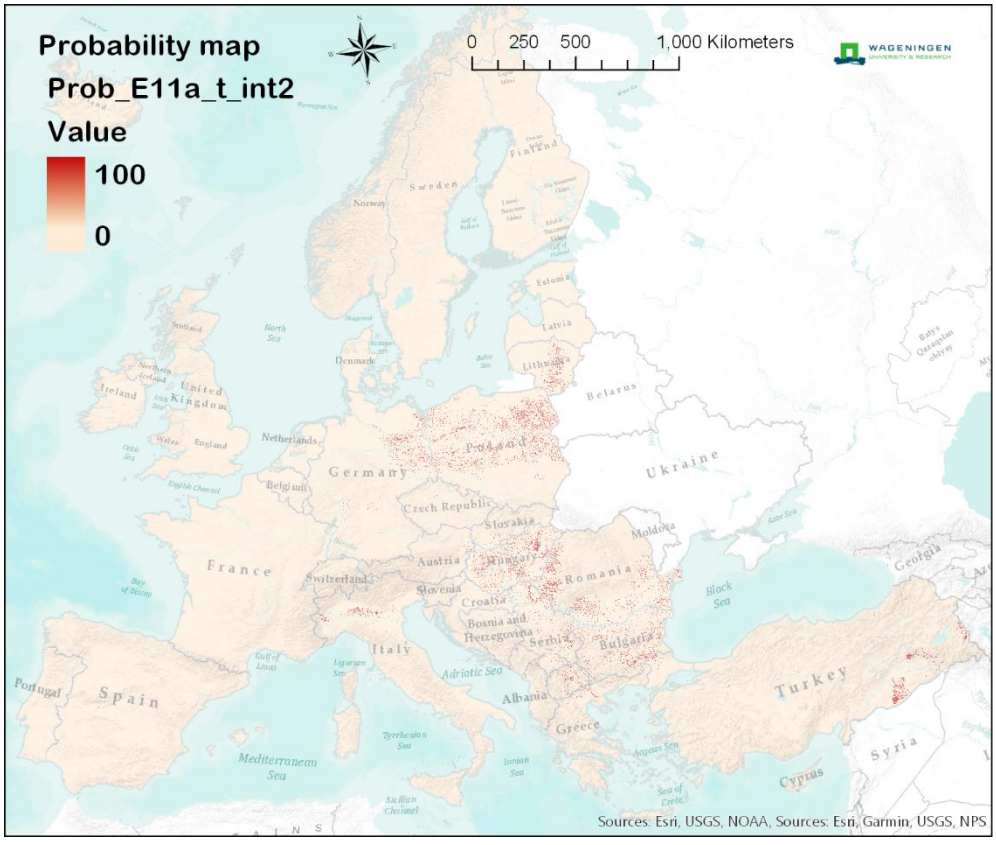


Example detail of the European habitat probability map at 20 m resolution for B1.4c Black Sea coastal dune grassland (grey dune)

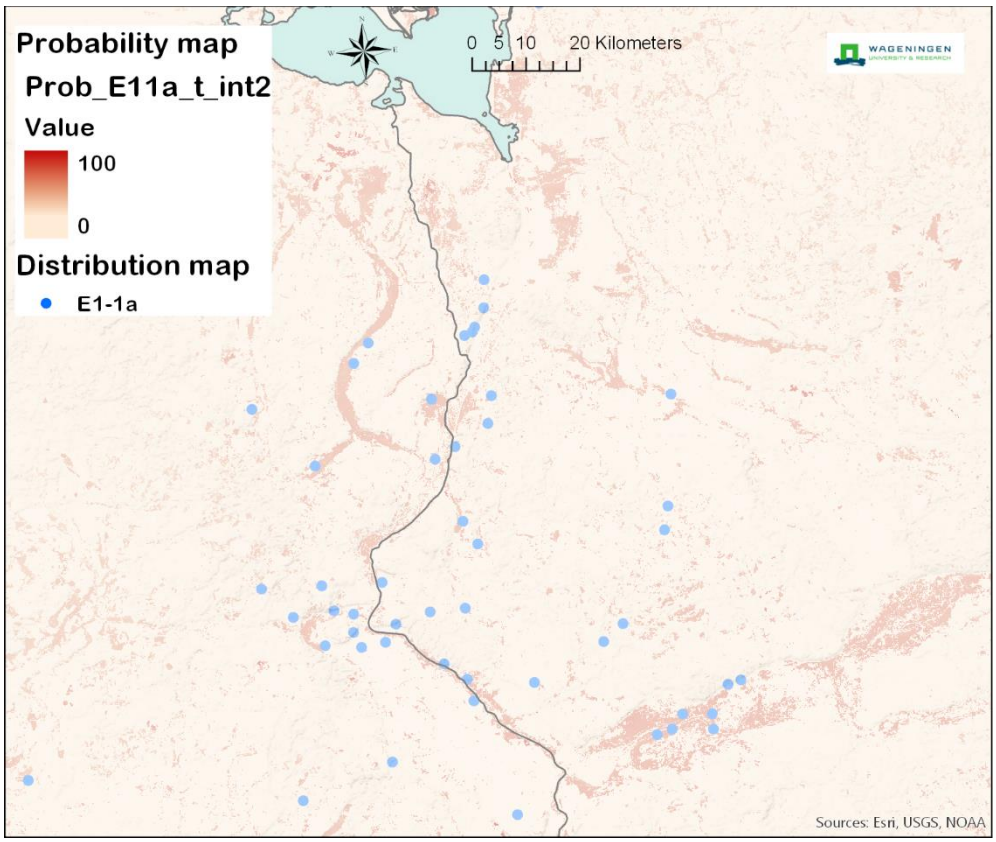


E1.1a Pannonian and Pontic sandy steppe

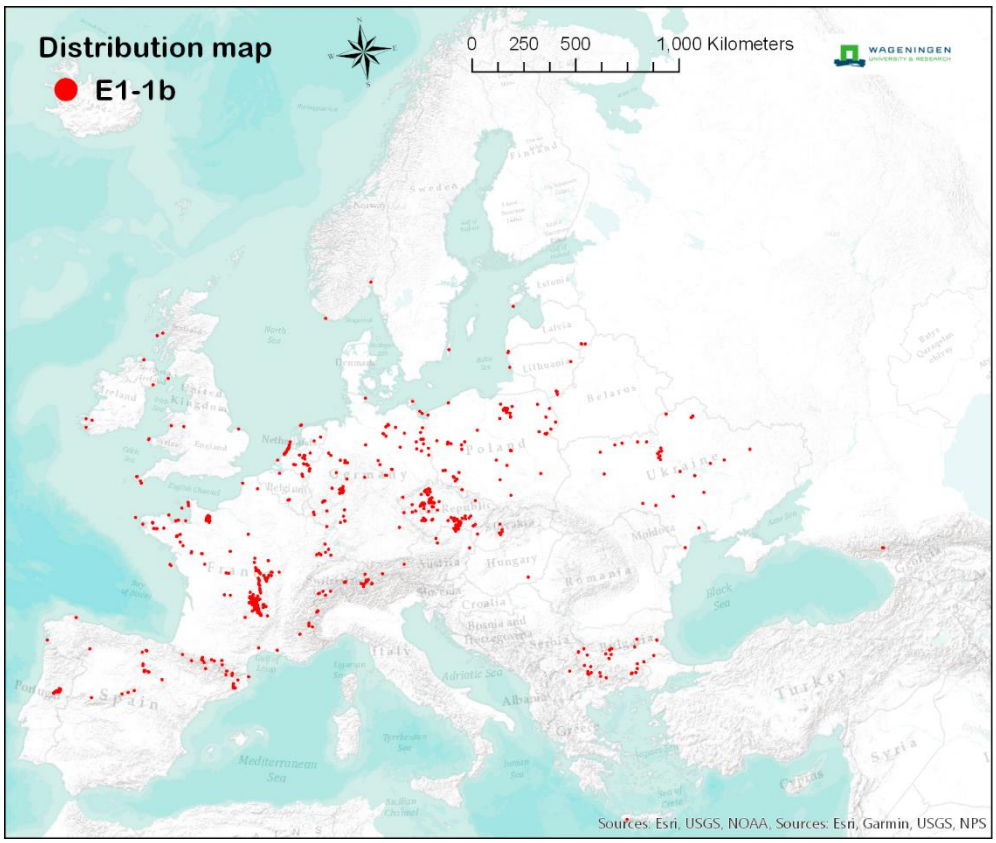


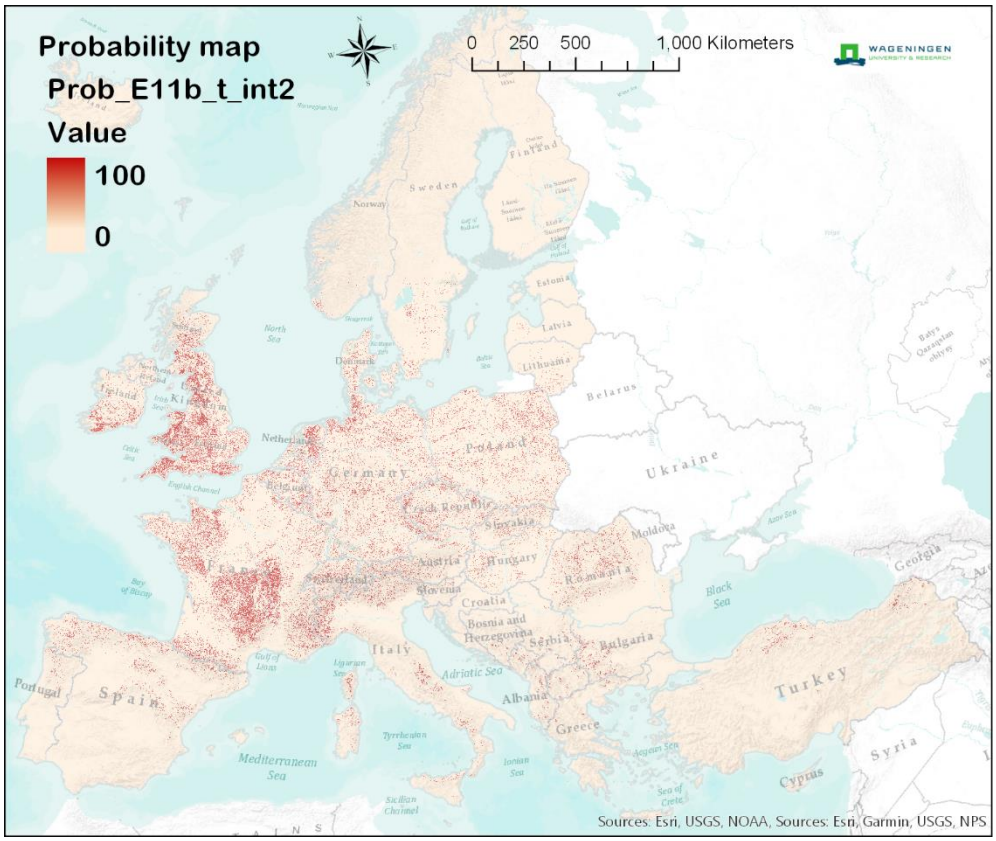


Example detail of the European habitat probability map at 20 m resolution for E1.1ª Pannonian and Pontic sandy steppe

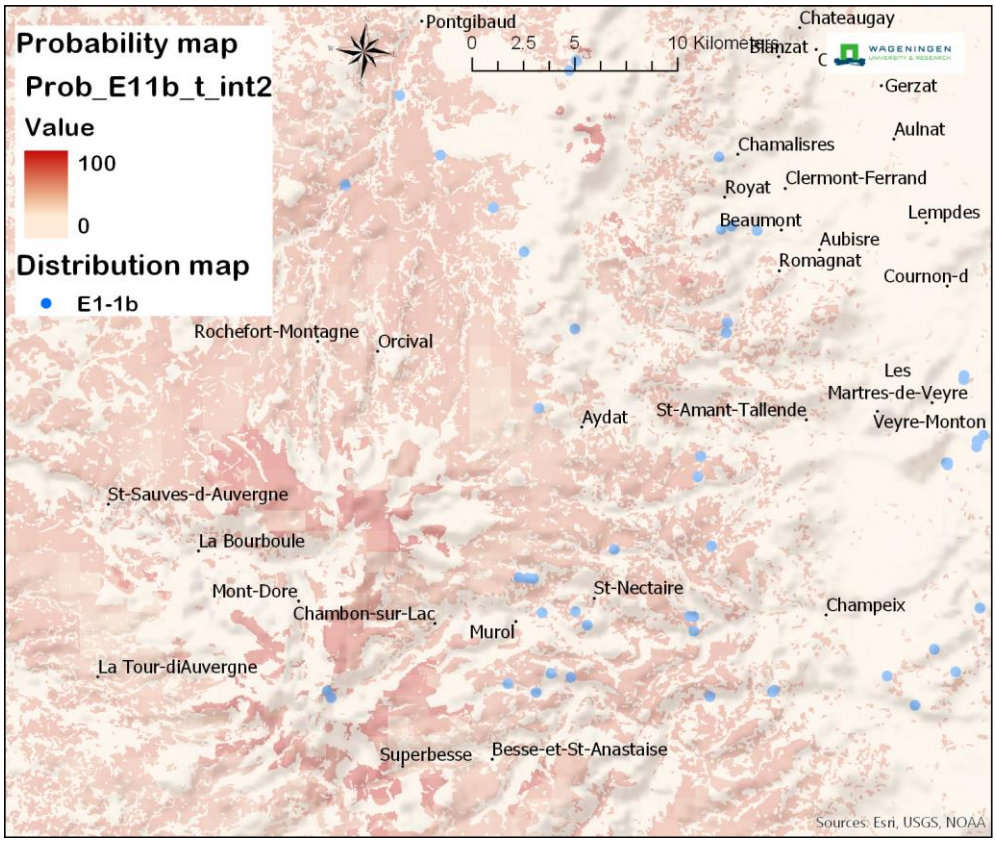


E1.1bCryptogam- and annual-dominated vegetation on siliceous rock outcrops

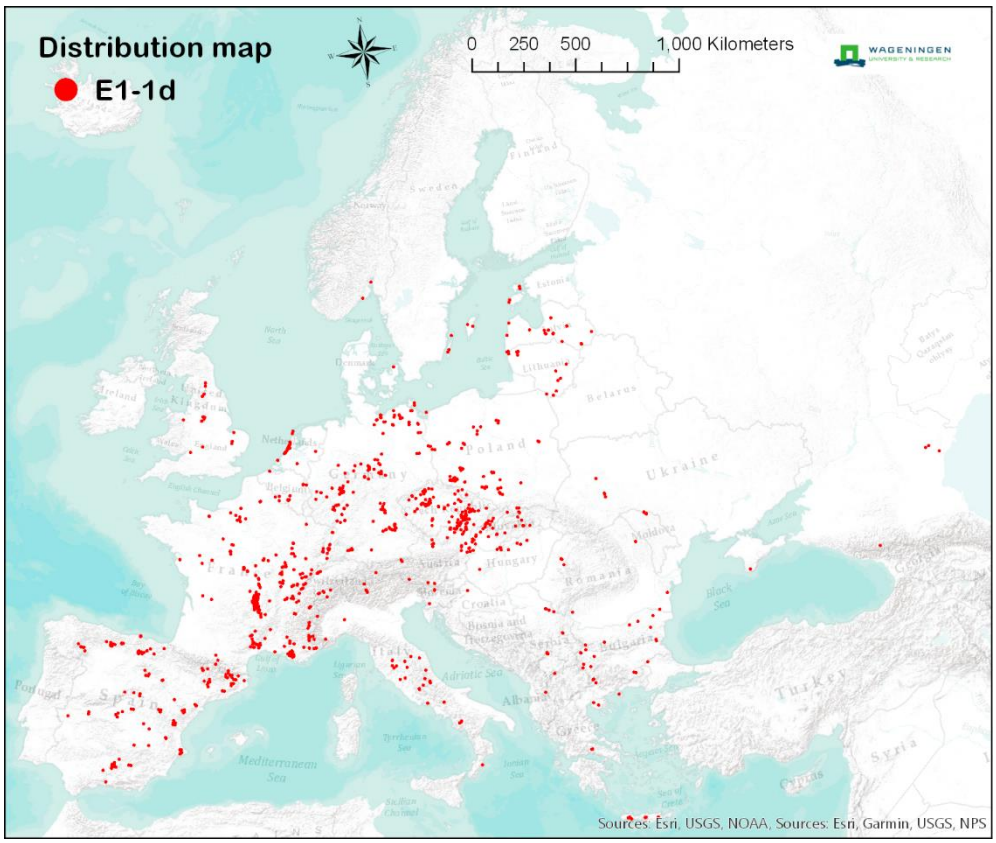


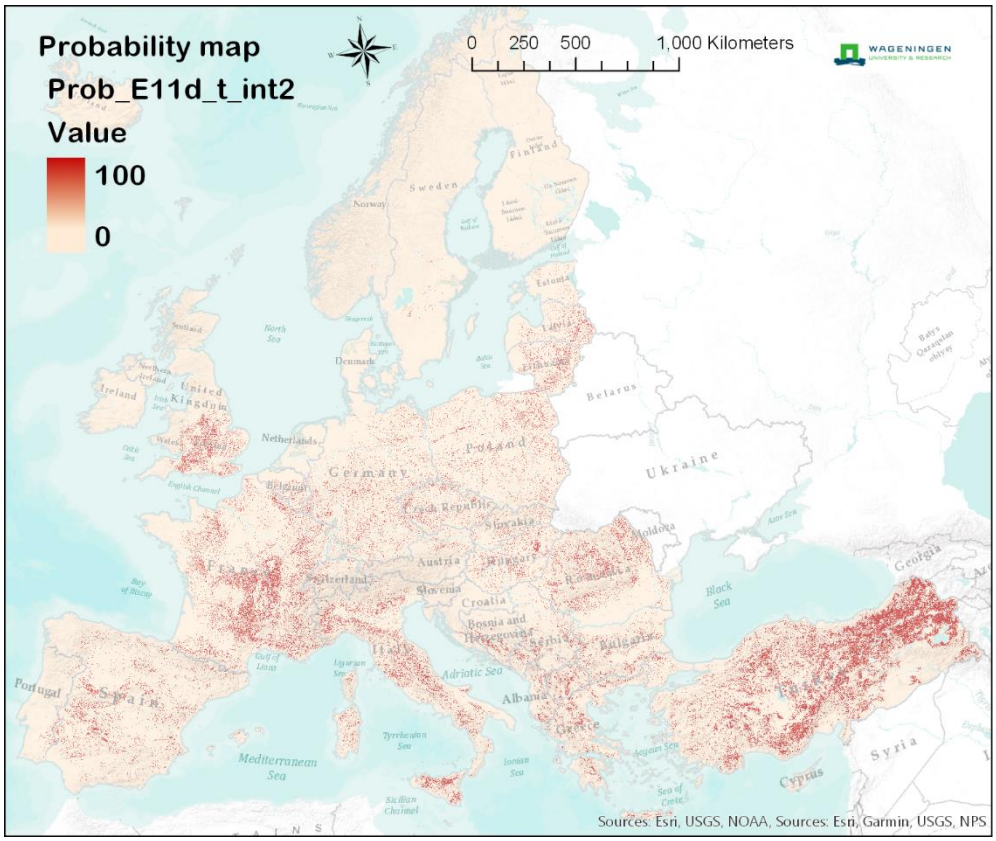


Example detail of the European habitat probability map at 20 m resolution for E1.1b Cryptogam- and annual-dominated vegetation on siliceous rock outcrops

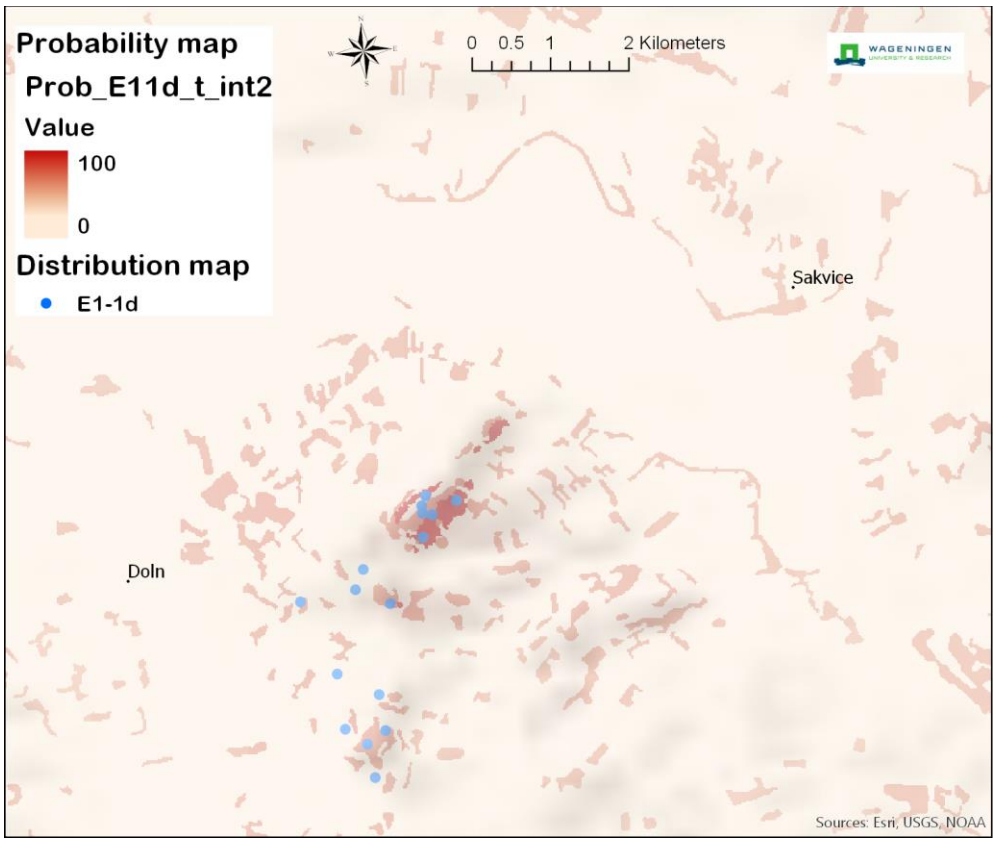


E1.1dCryptogam- and annual-dominated vegetation on calcareous and ultramafic rock outcrops

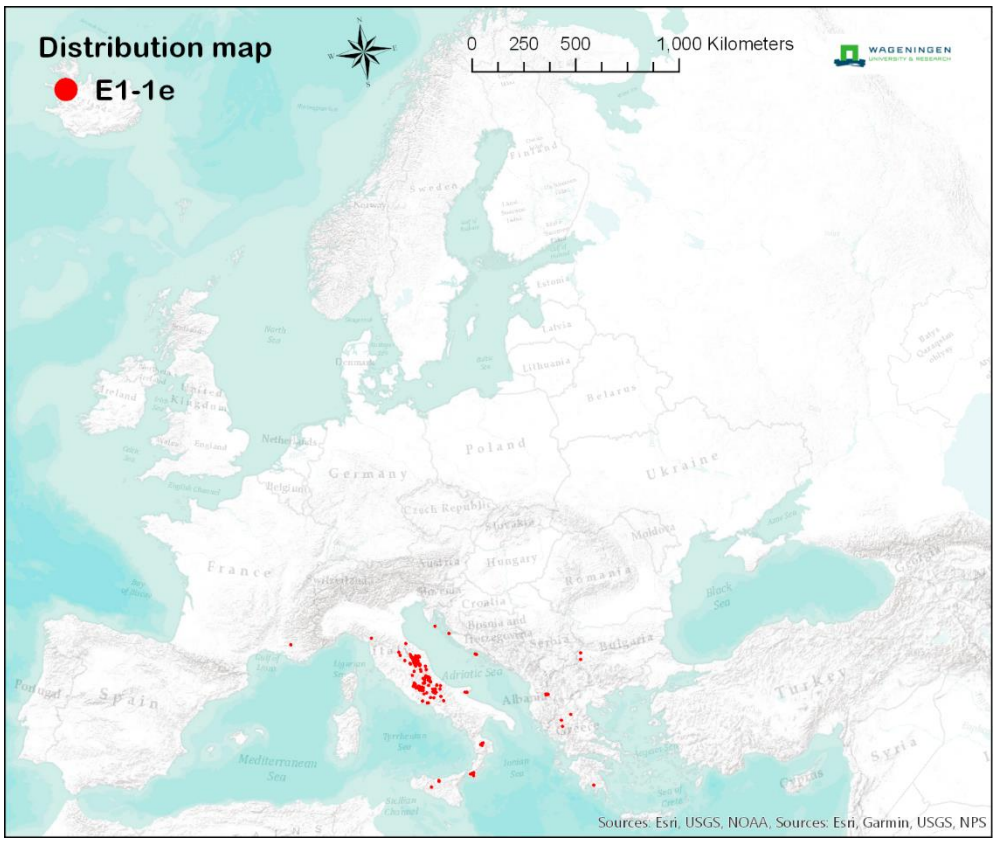


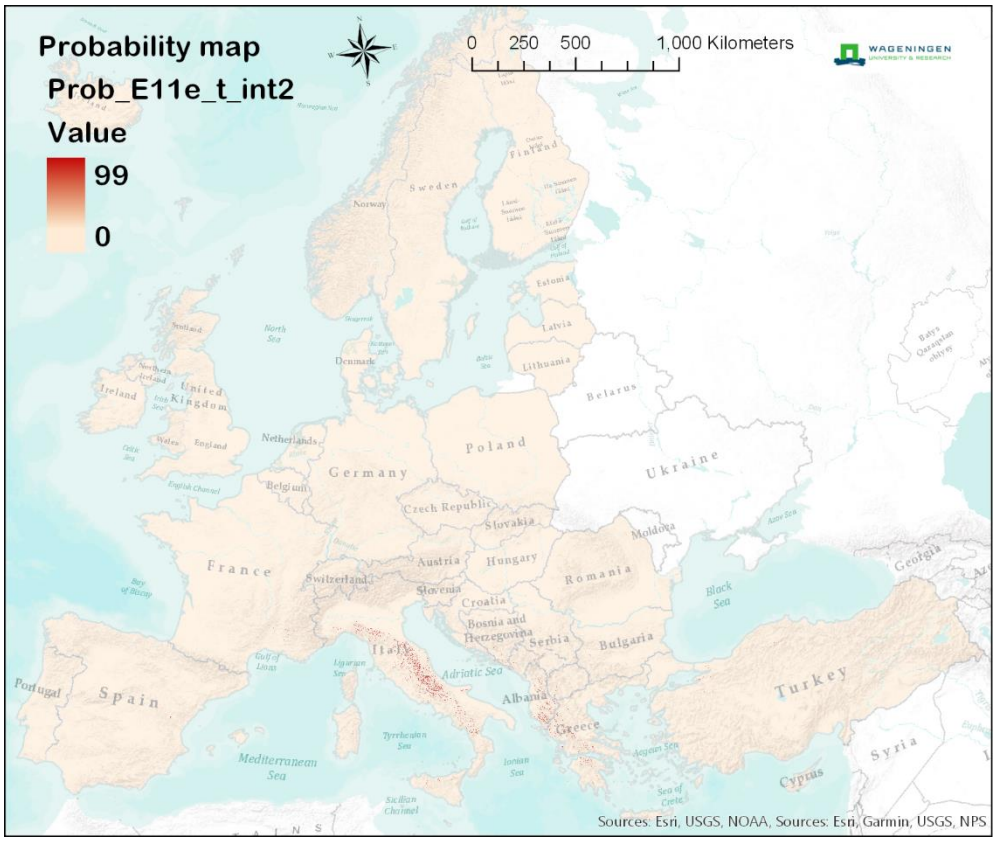


Example detail of the European habitat probability map at 20 m resolution for E1.1d Cryptogam- and annual-dominated vegetation on calcareous and ultramafic rock outcrops

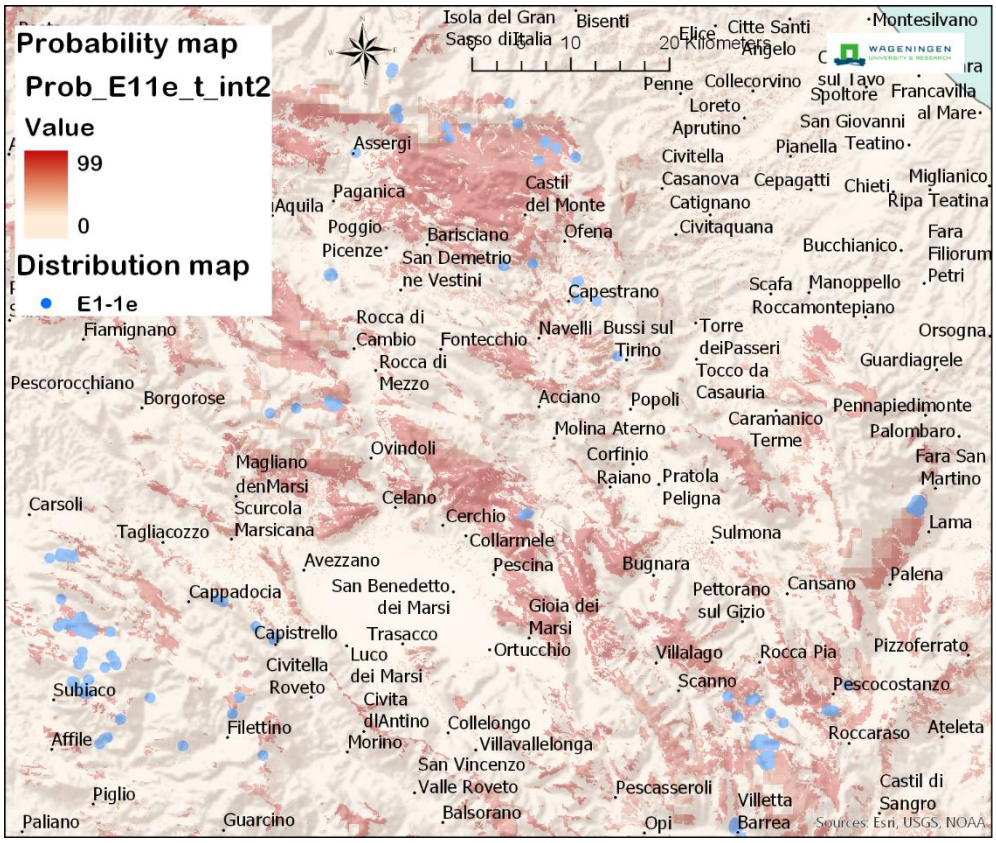


E1.1e Perennial rocky grassland of the Italian Peninsula

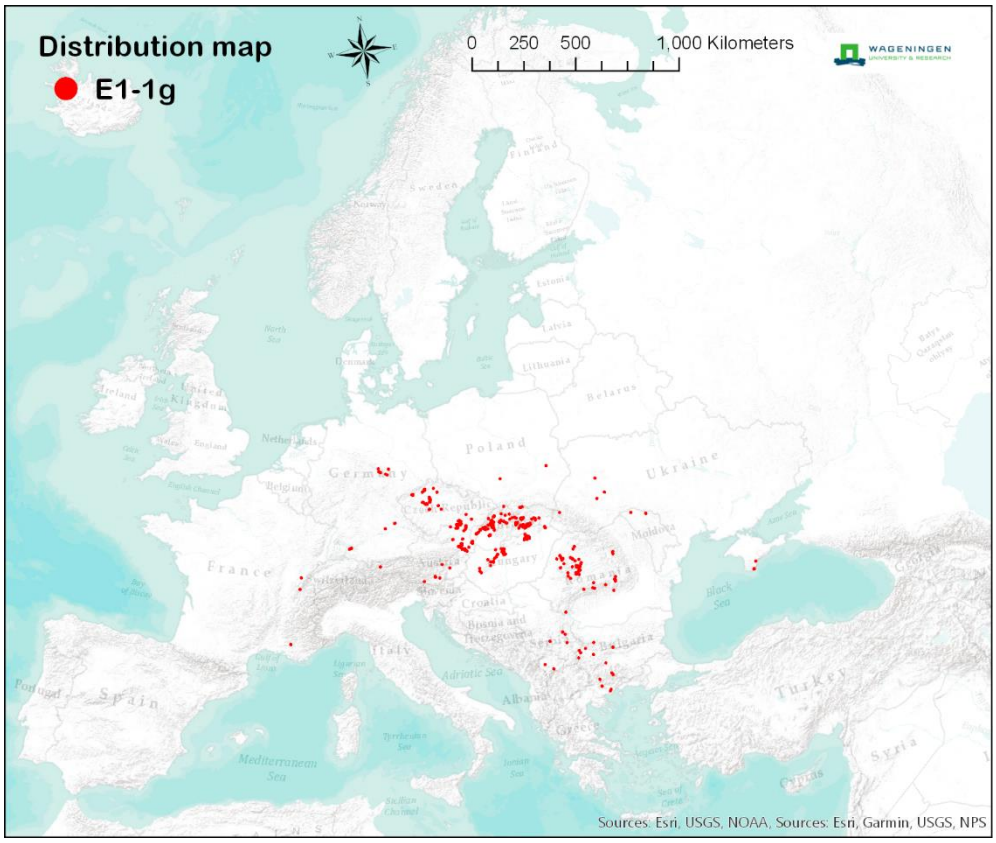


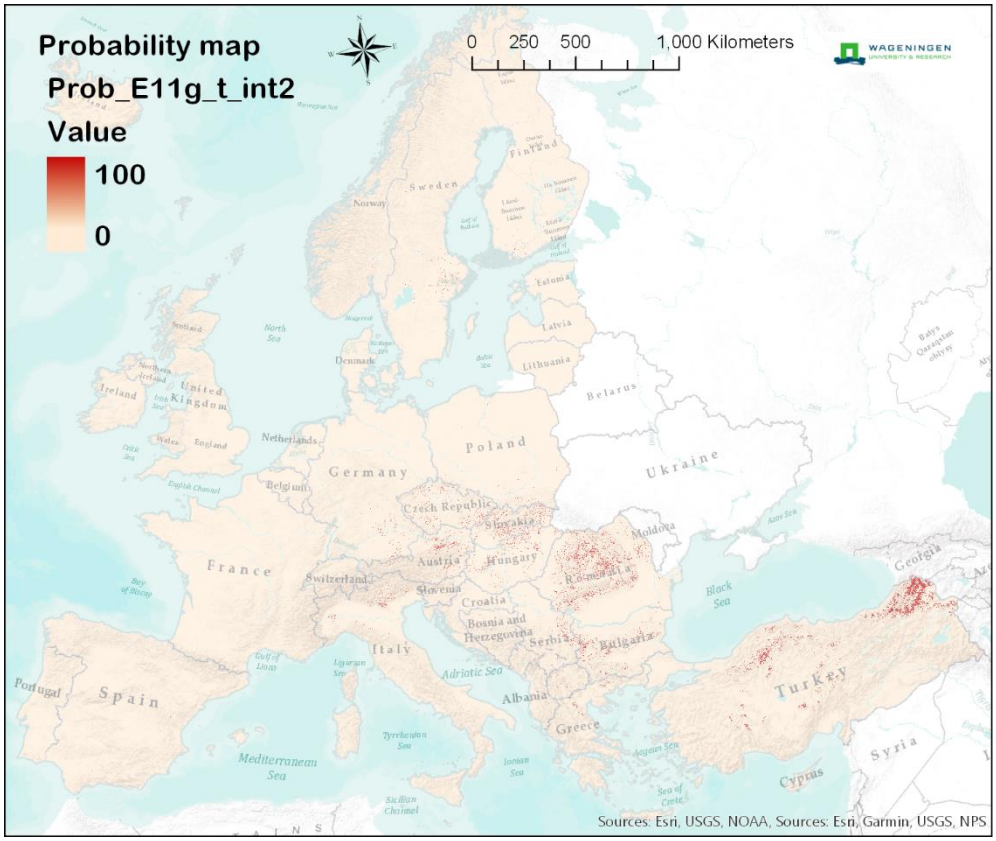


Example detail of the European habitat probability map at 20 m resolution for E1.1e Perennial rocky grassland of the Italian Peninsula

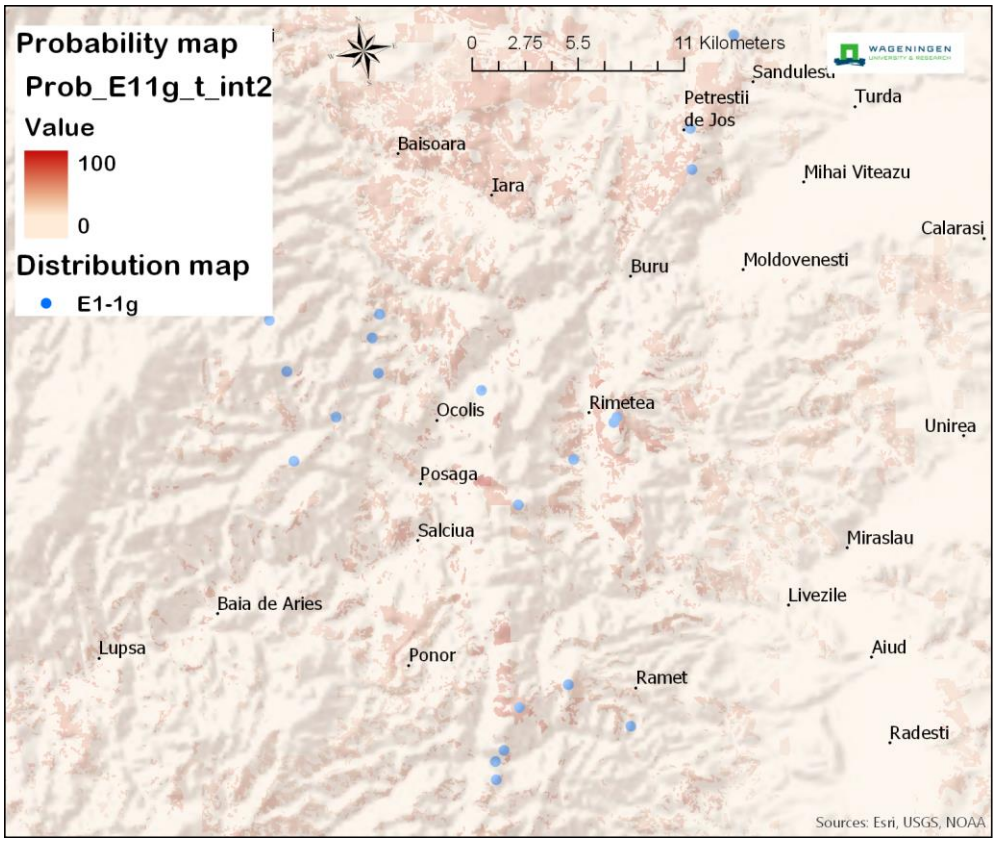


E1.1g Perennial rocky grassland of Central Europe and the Carpathians

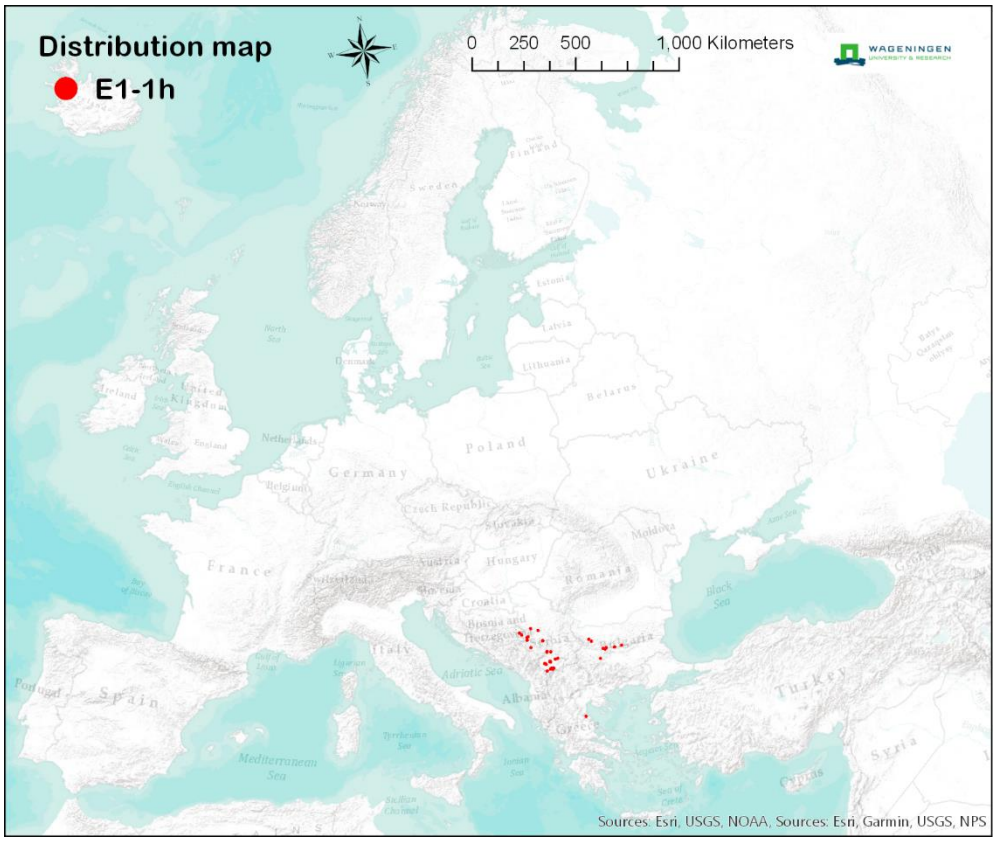


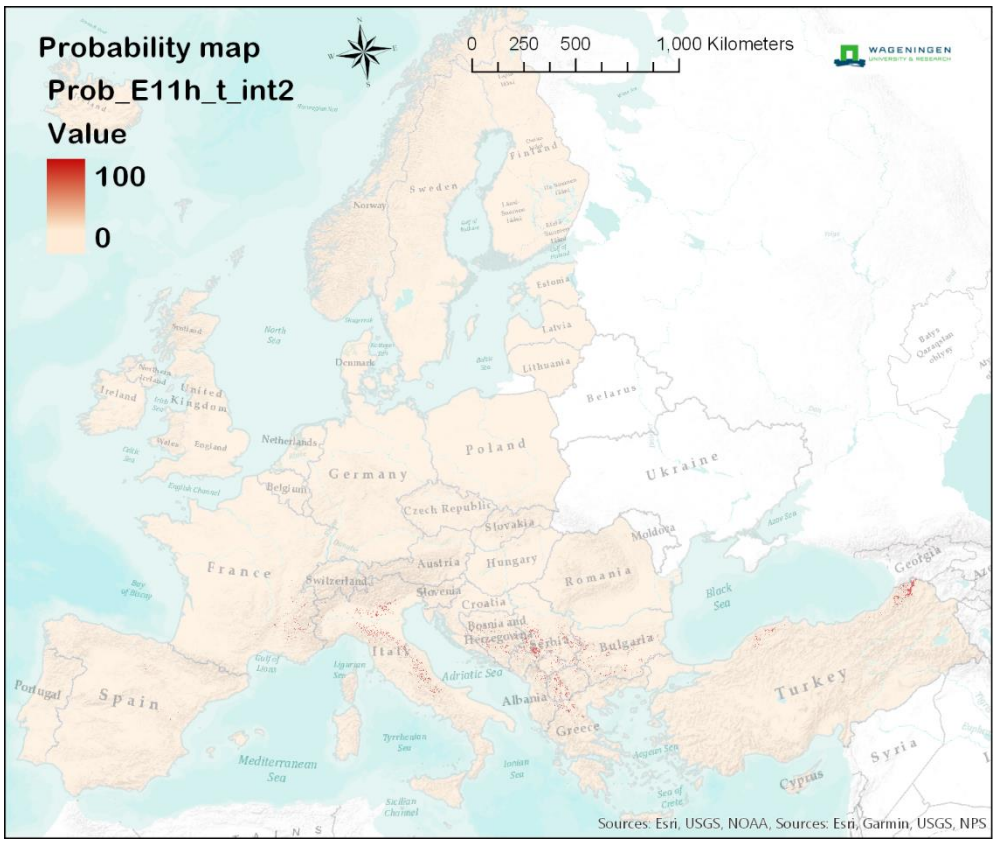


Example detail of the European habitat probability map at 20 m resolution for E1.1g Perennial rocky grassland of Central Europe and the Carpathians

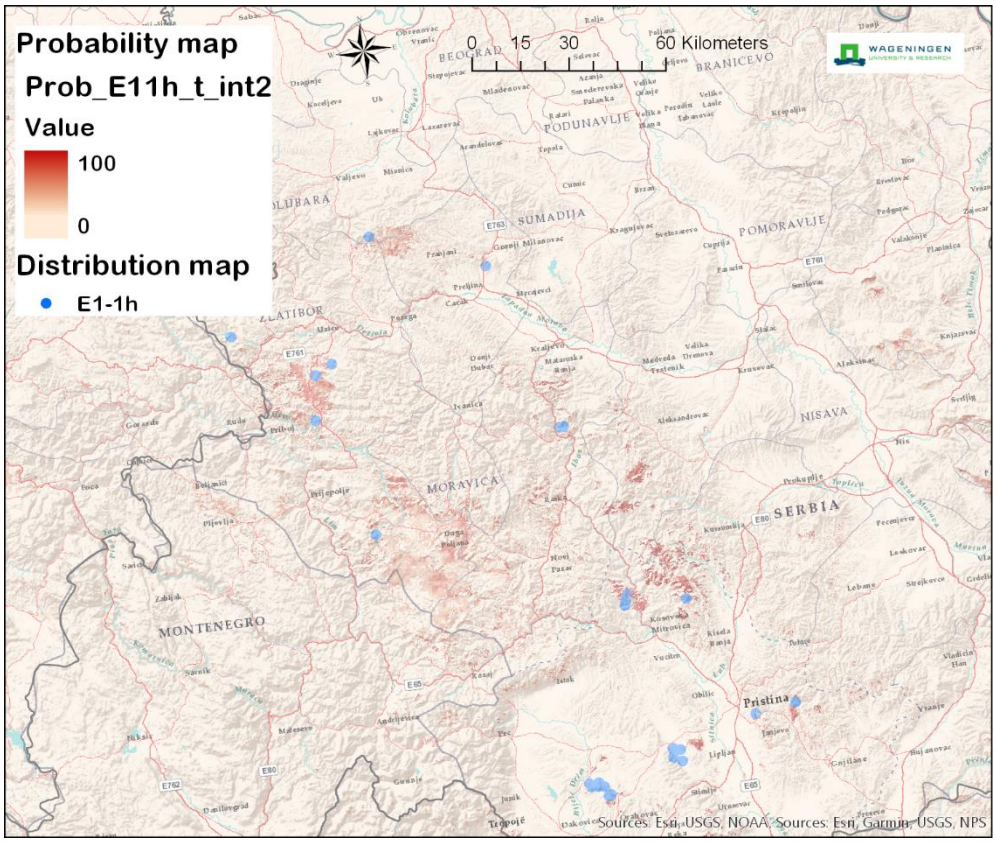


E1.1h Heavy-metal dry grassland of the Balkans

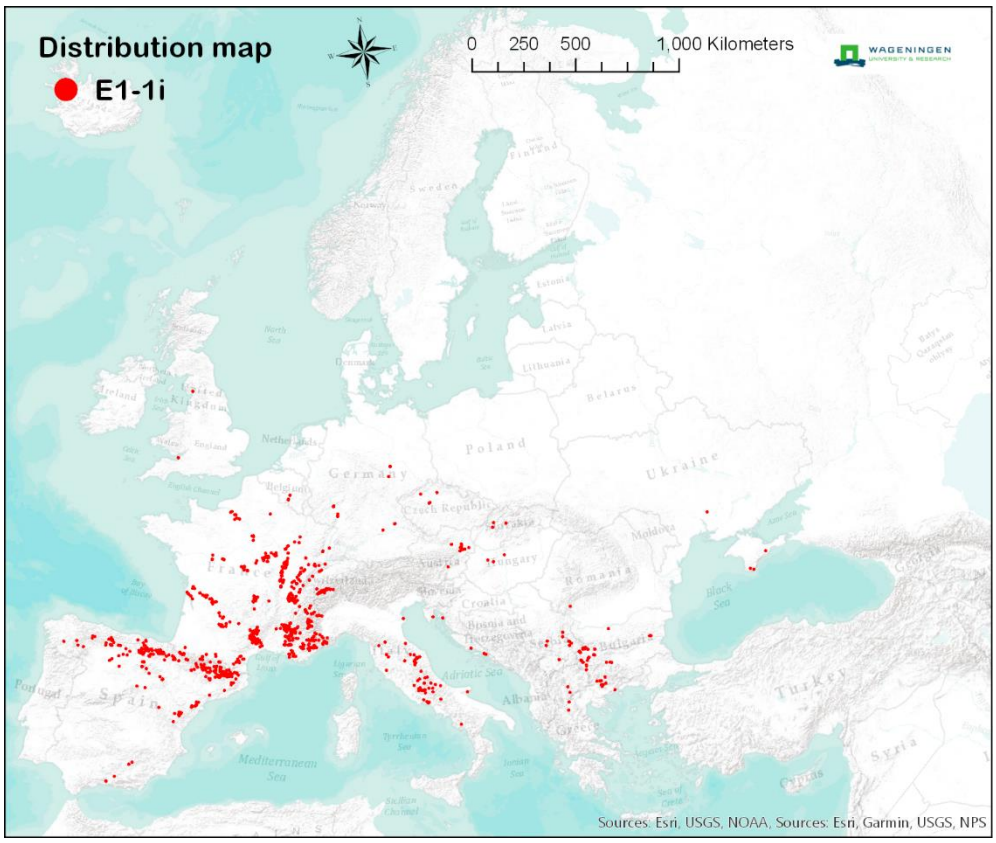


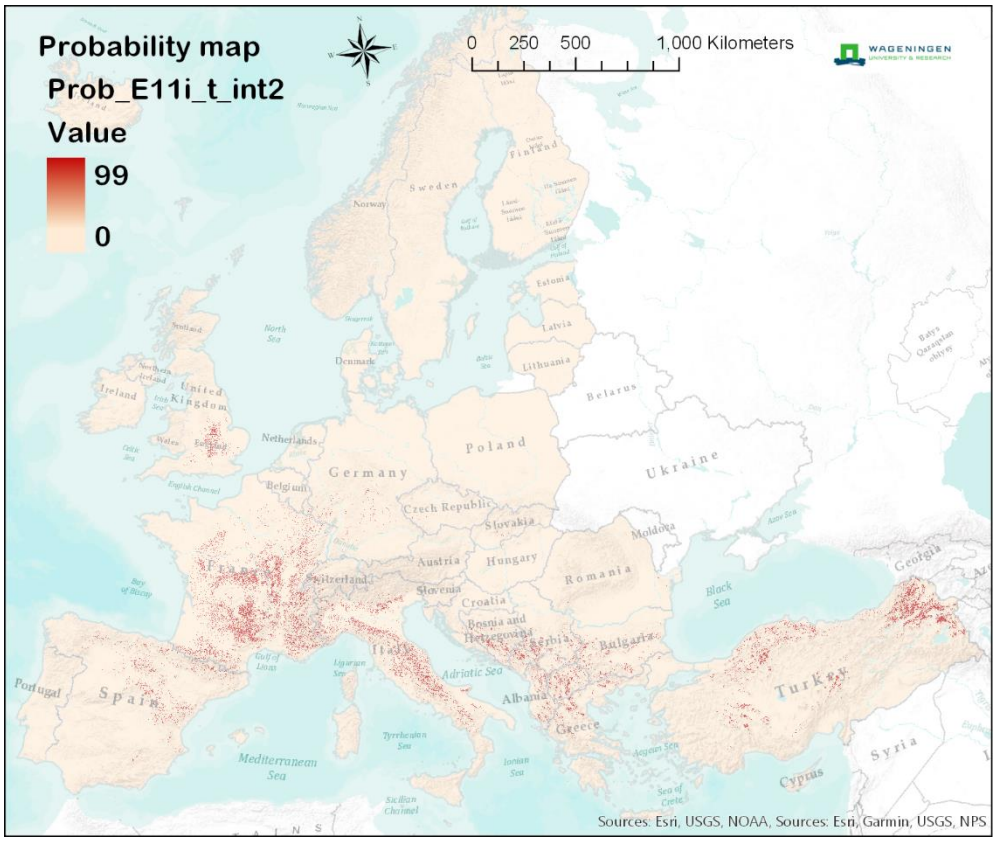


Example detail of the European habitat probability map at 20 m resolution for E1.1h Heavy-metal dry grassland of the Balkans

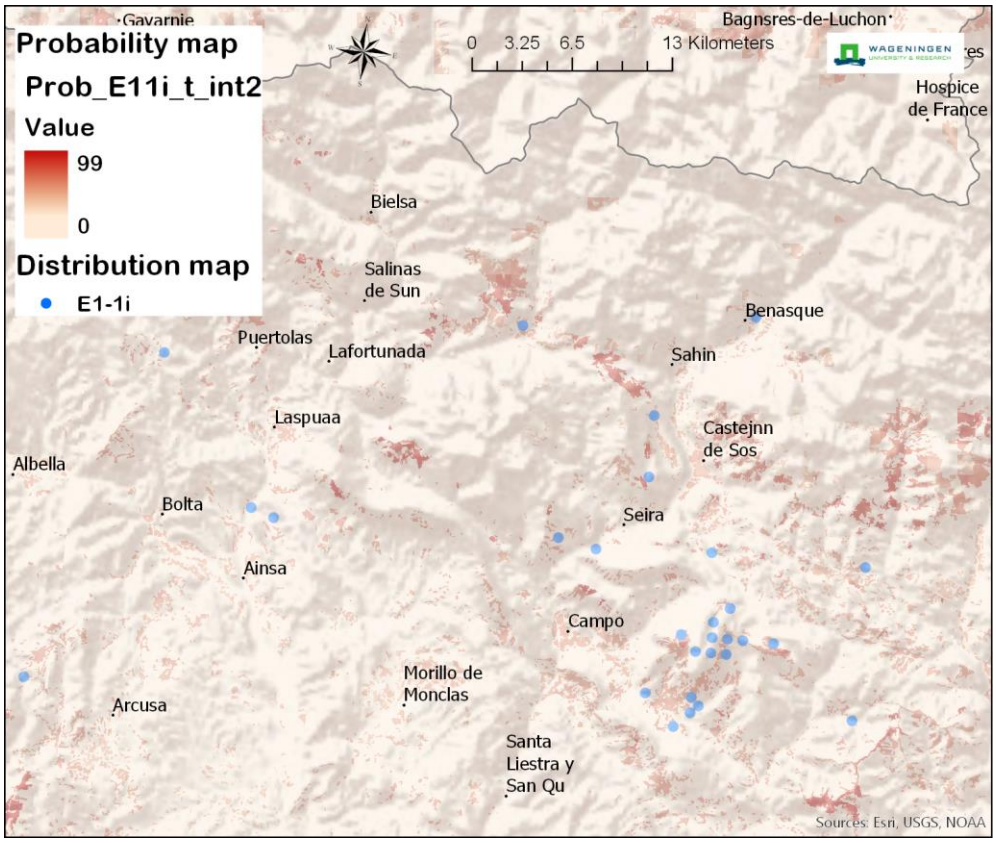


E1.1i Perennial rocky calcareous grassland of subatlantic-submediterranean Europe

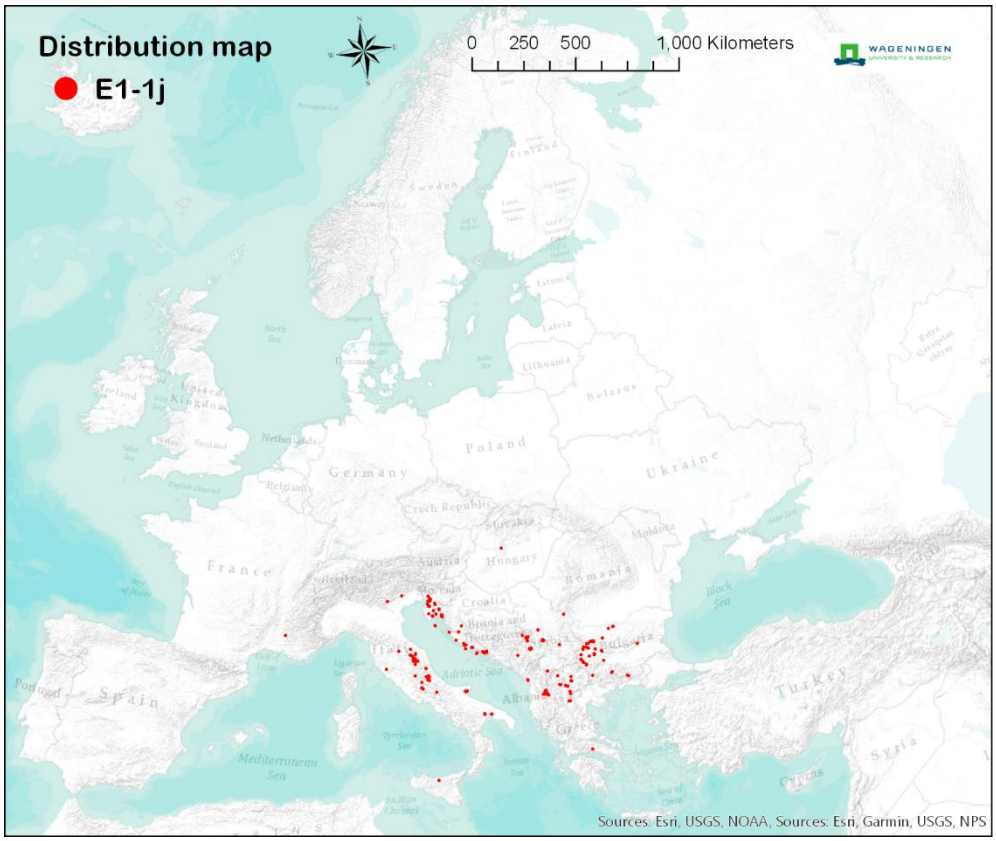


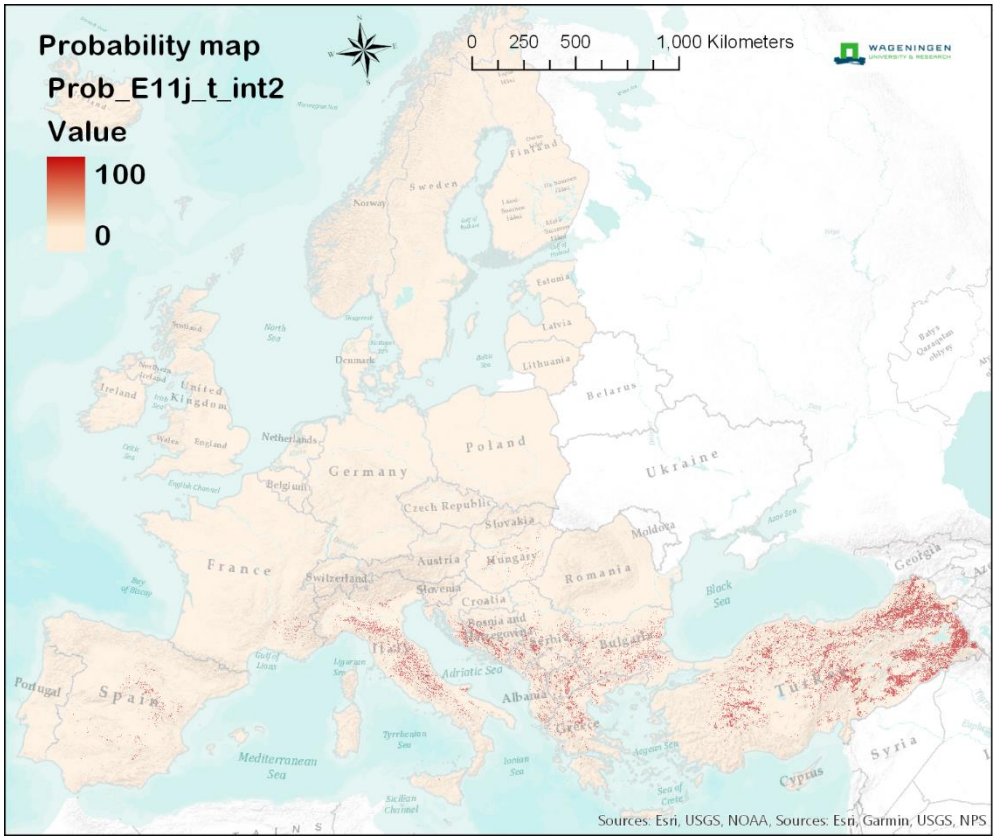


Example detail of the European habitat probability map at 20 m resolution for E1.1i Perennial rocky calcareous grassland of subatlantic-submediterranean Europe

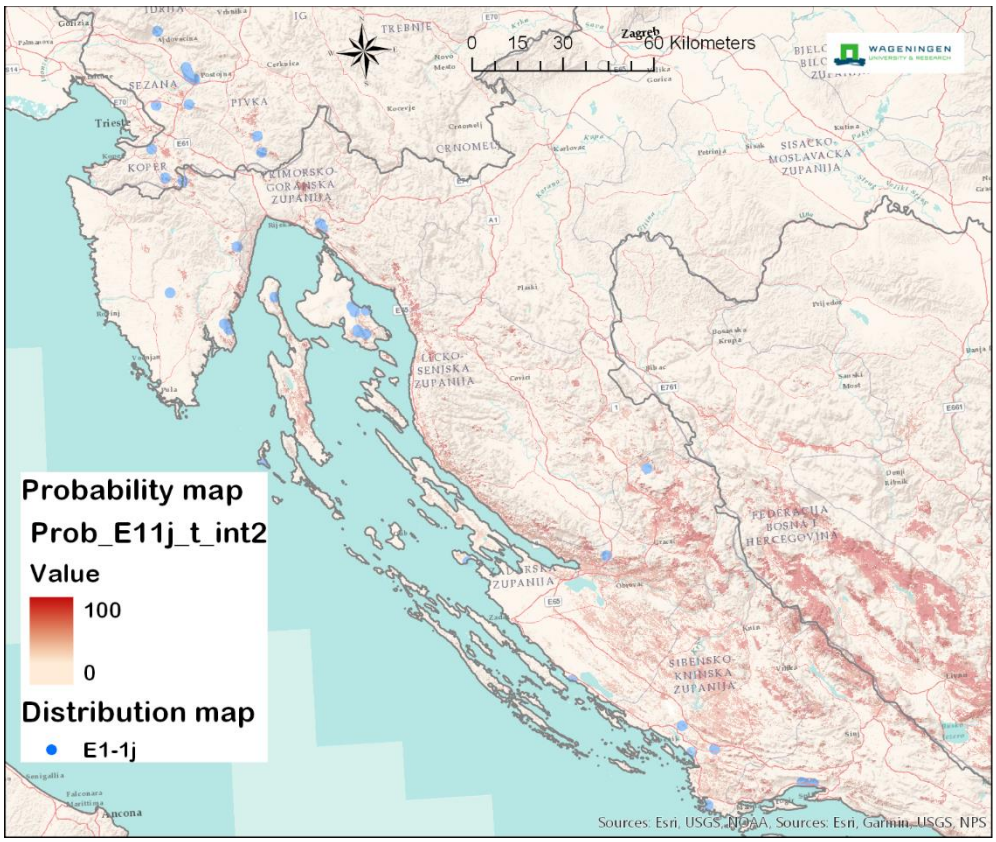


E1.1j Dry steppic, submediterranean pasture of South-Eastern Europe

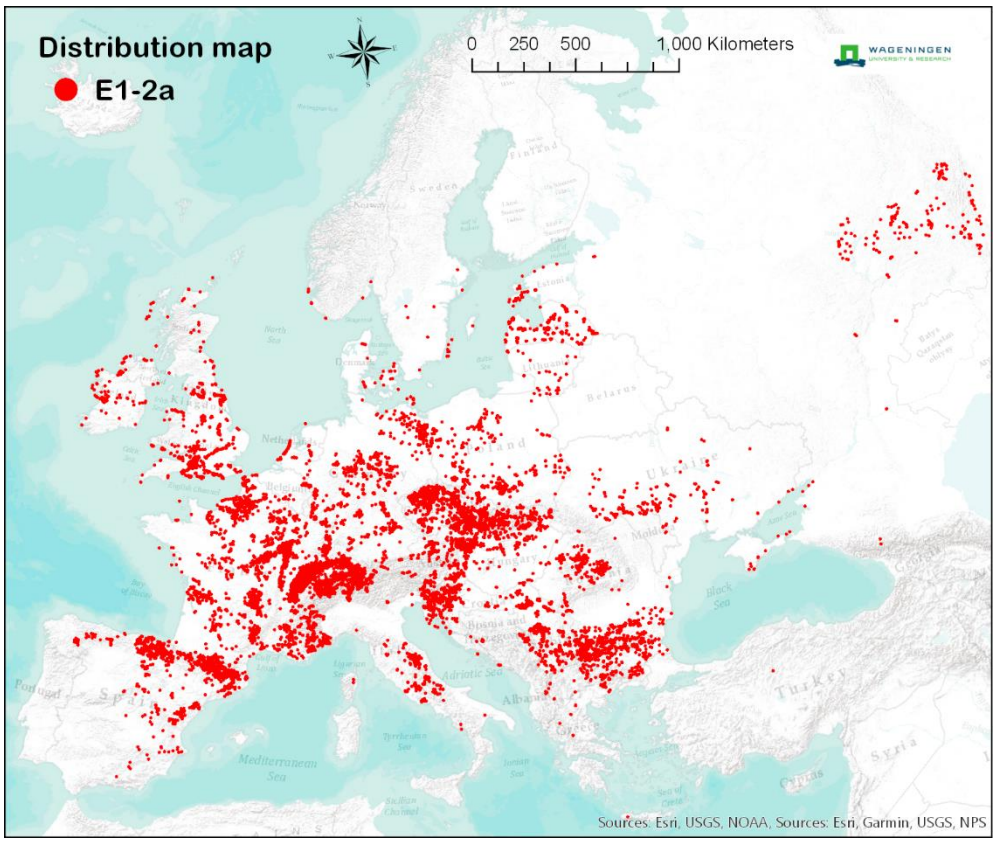


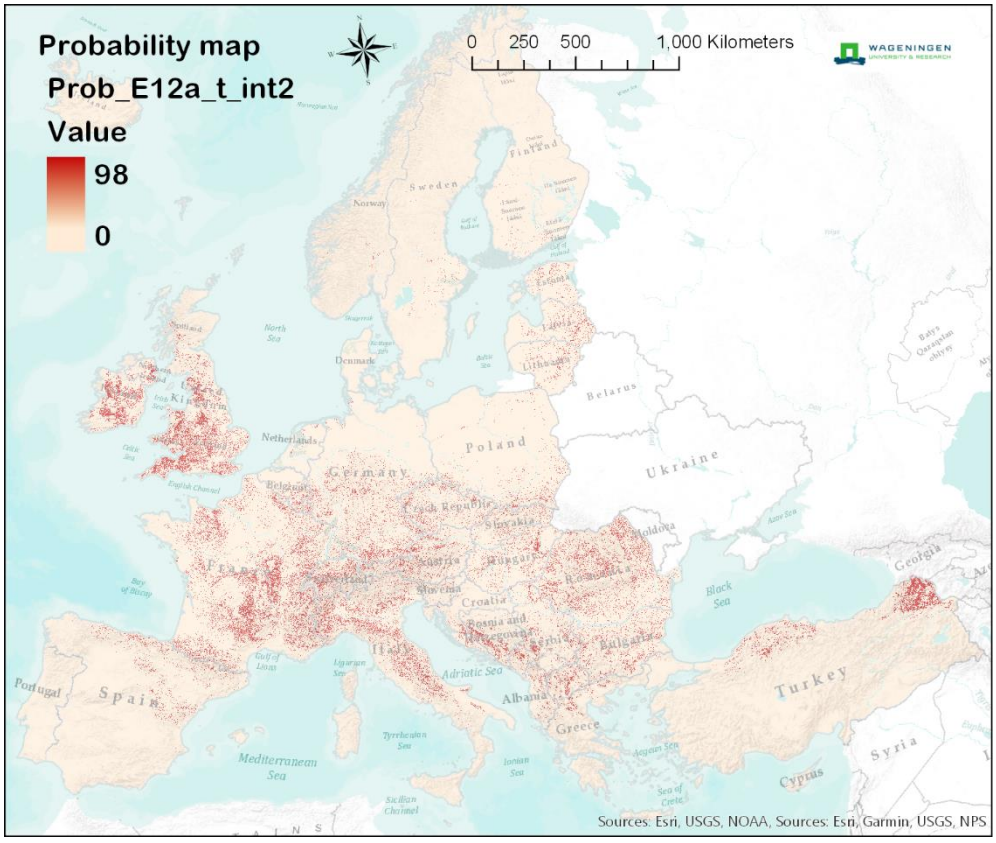


Example detail of the European habitat probability map at 20 m resolution for E1.1j Dry steppic, submediterranean pasture of South-Eastern Europe

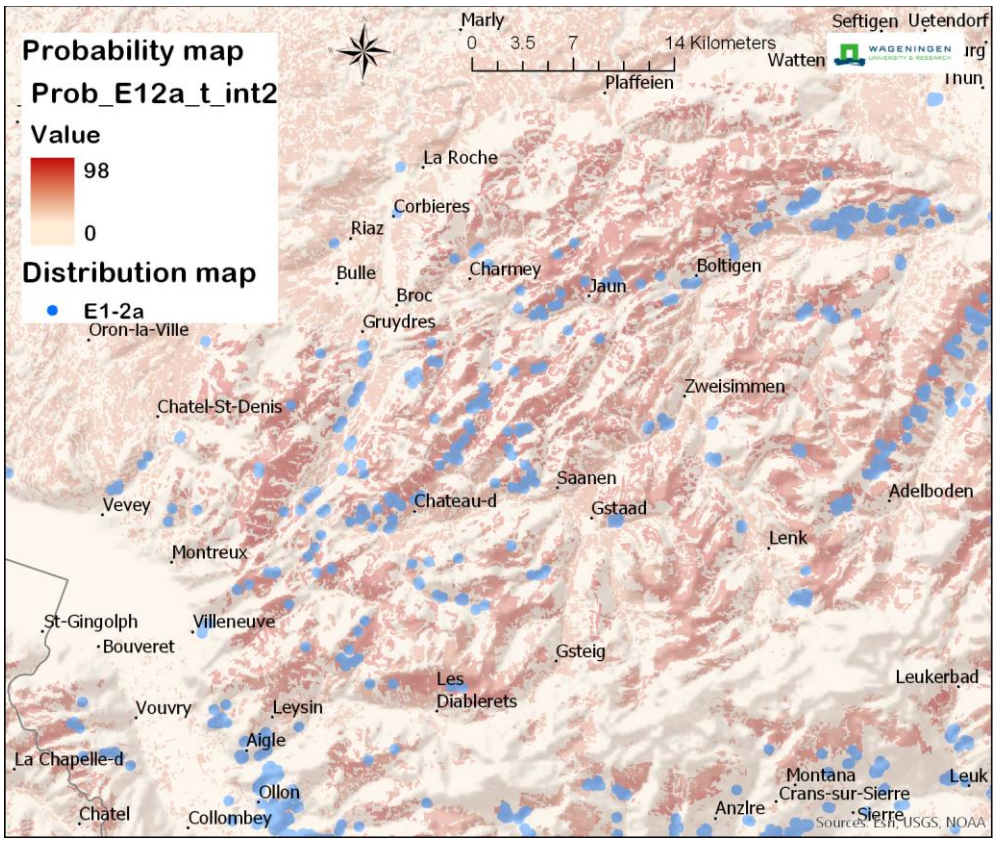


E1.2a Semi-dry perennial calcareous grassland

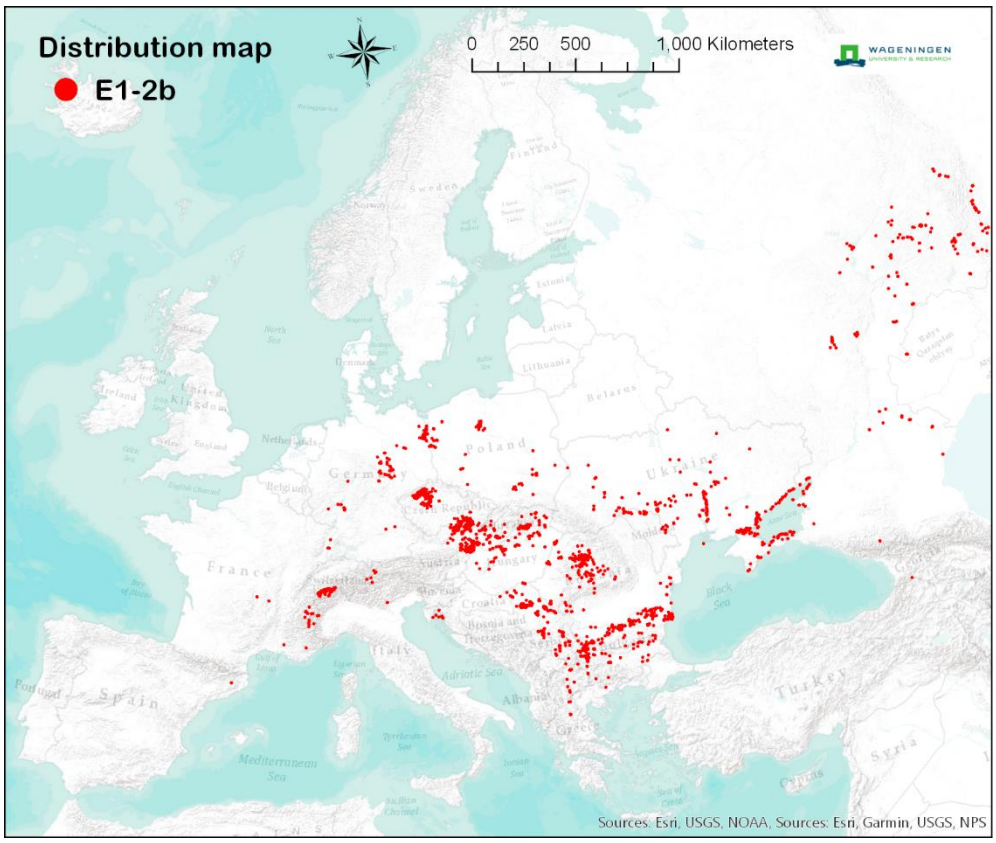


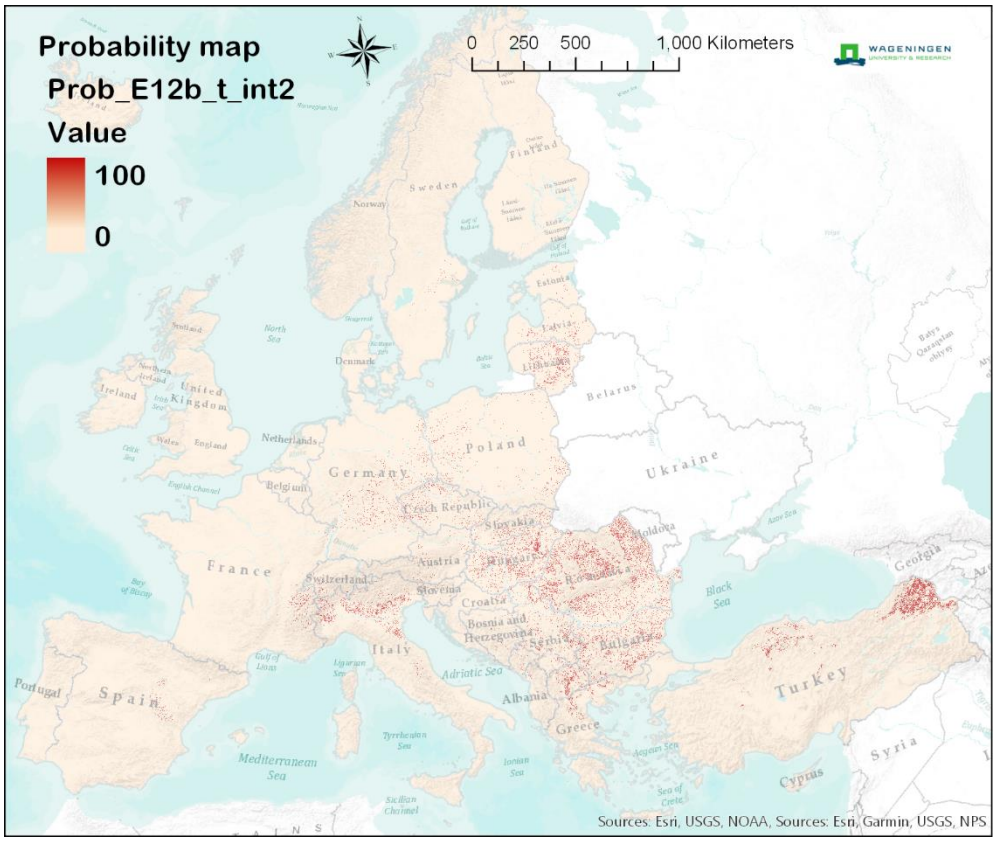


Example detail of the European habitat probability map at 20 m resolution for E1.2ª Semi-dry perennial calcareous grassland

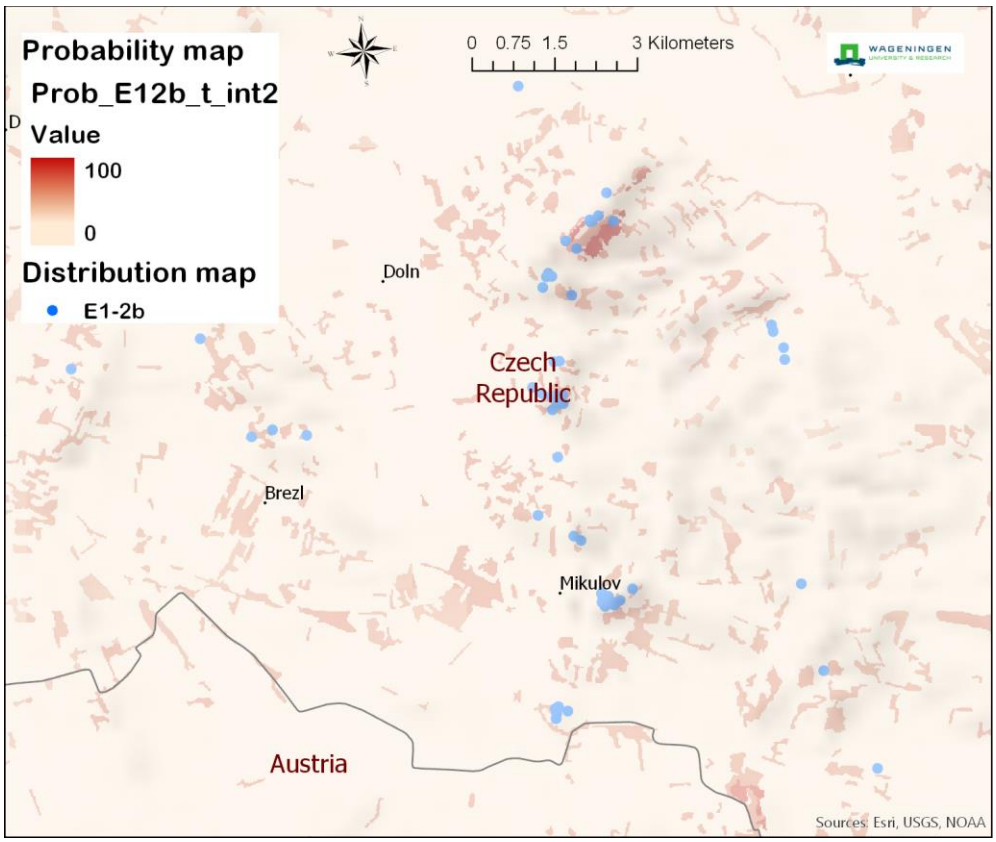


E1.2bContinental dry steppe

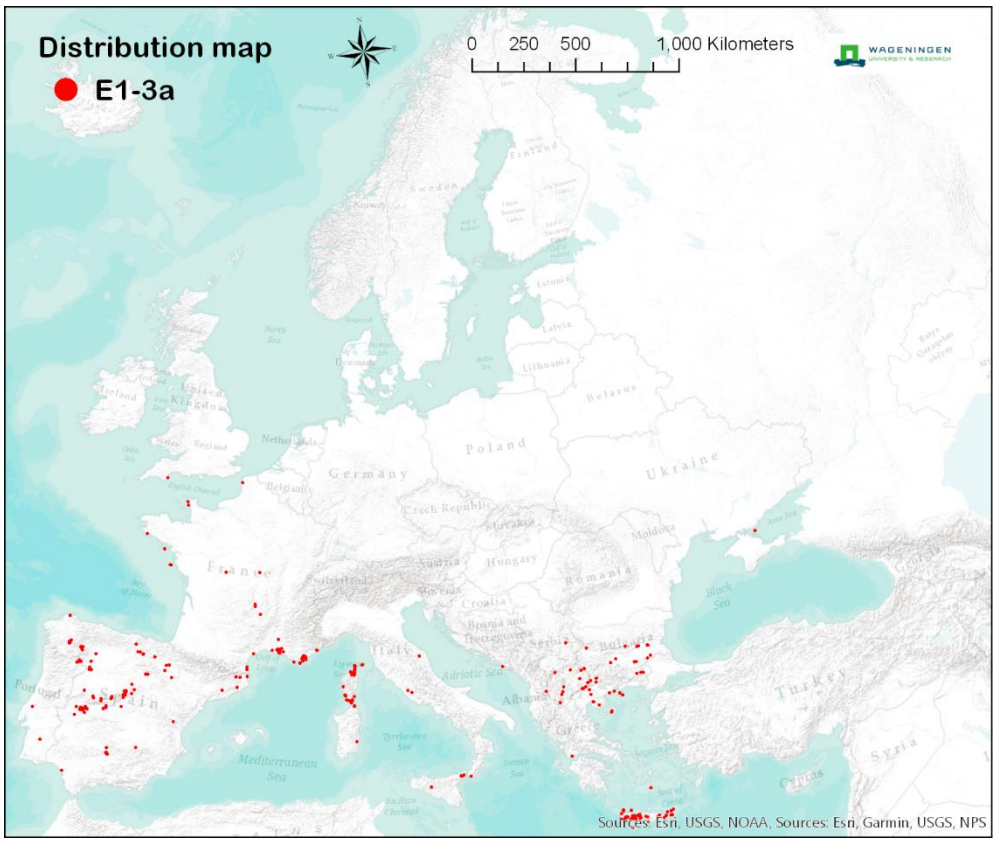


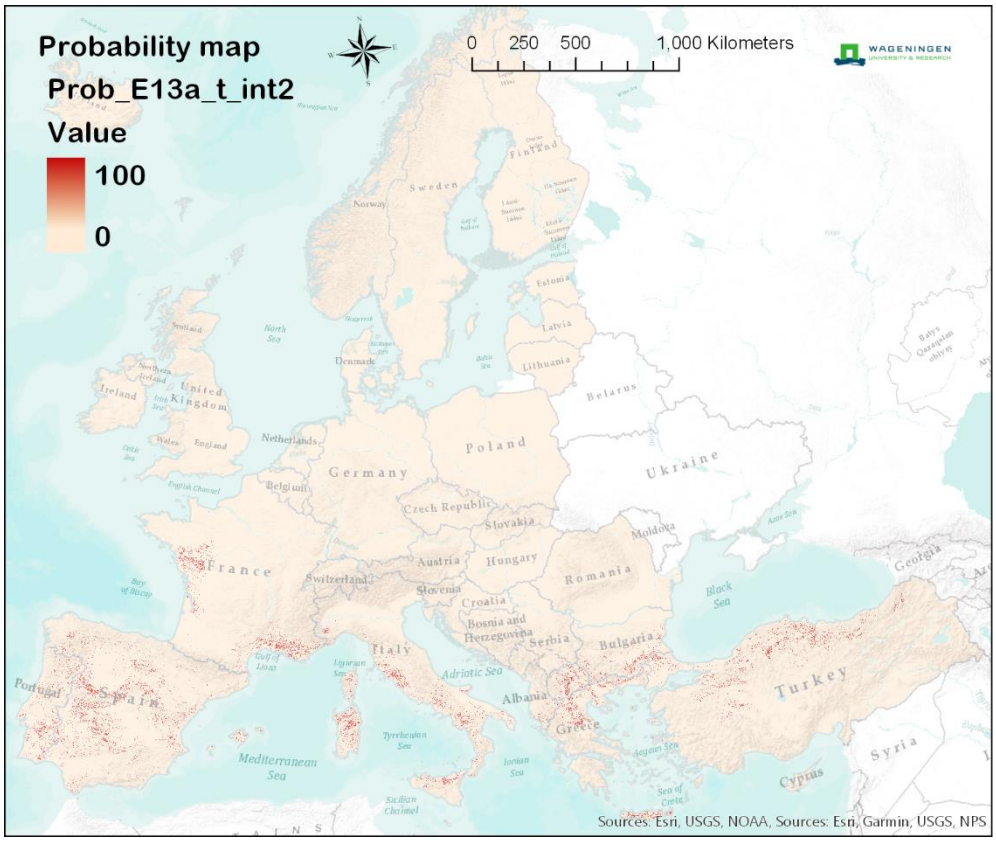


Example detail of the European habitat probability map at 20 m resolution for E1.2b Continental dry steppe

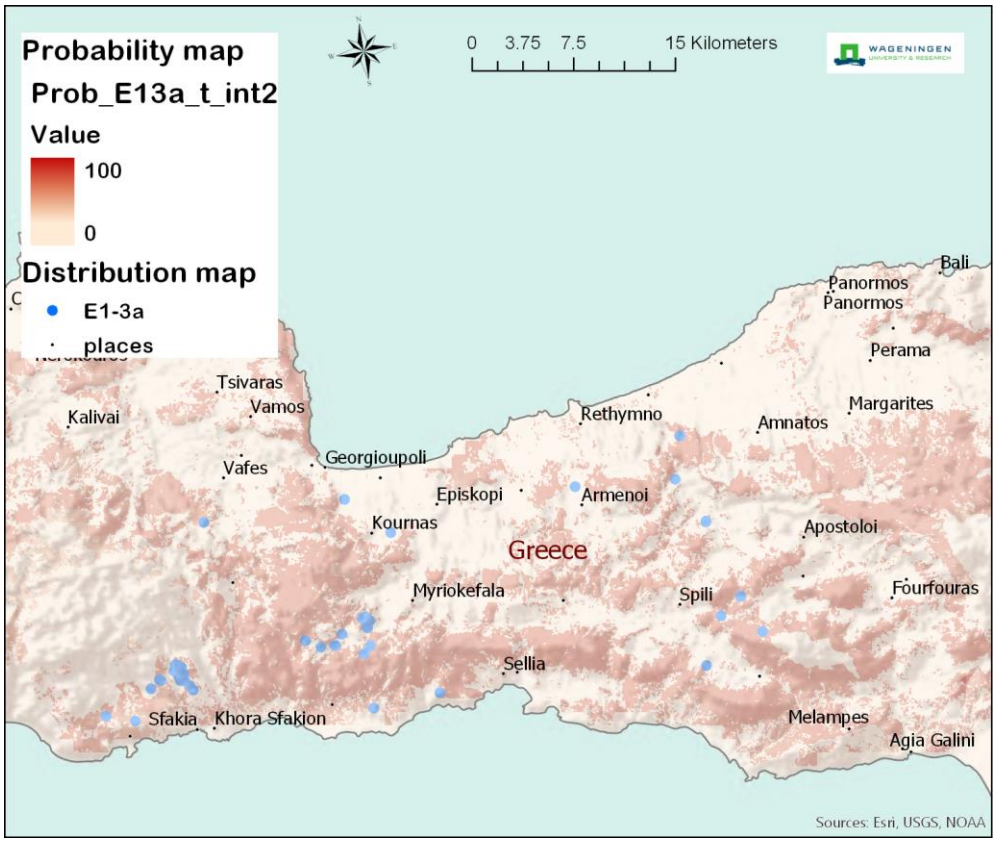


E1.3a Mediterranean closely grazed dry grassland

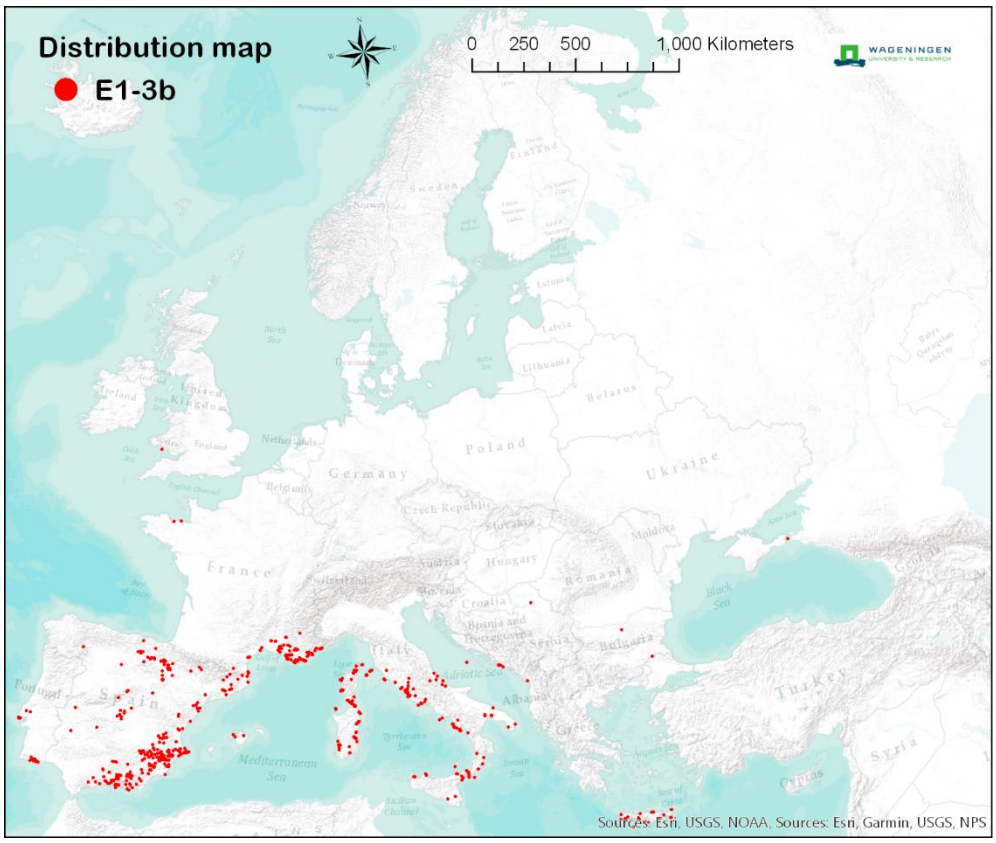


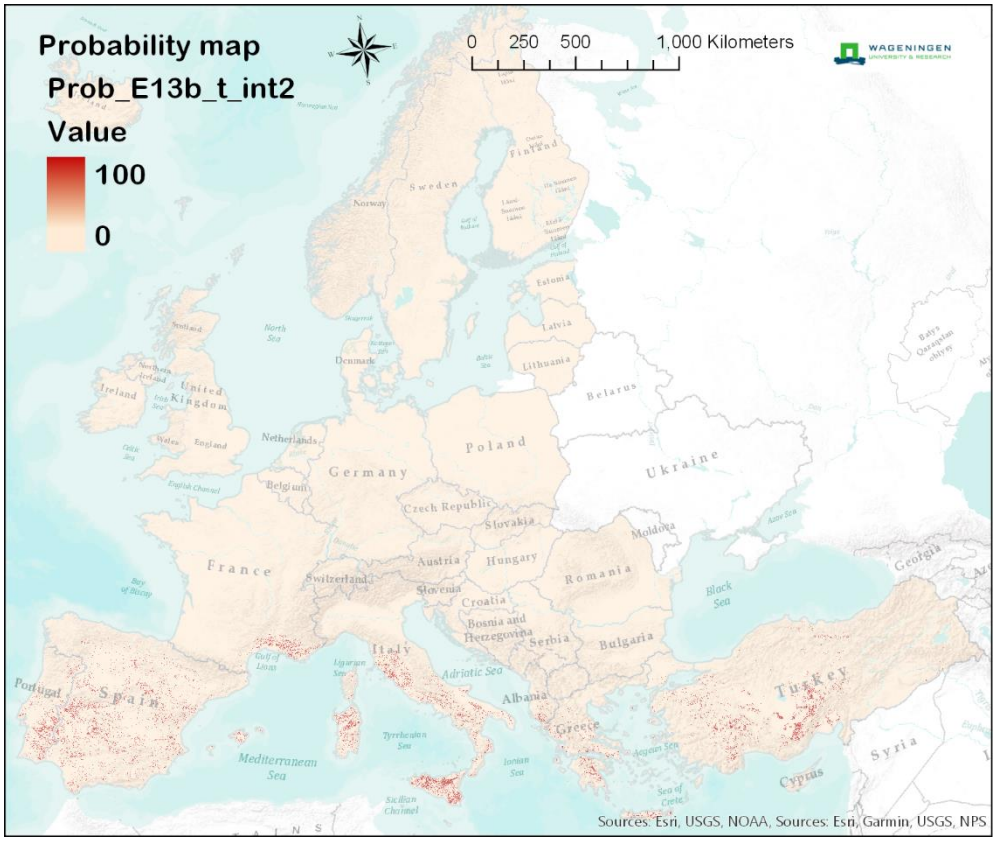


Example detail of the European habitat probability map at 20 m resolution for E1.3a Mediterranean closely grazed dry grassland

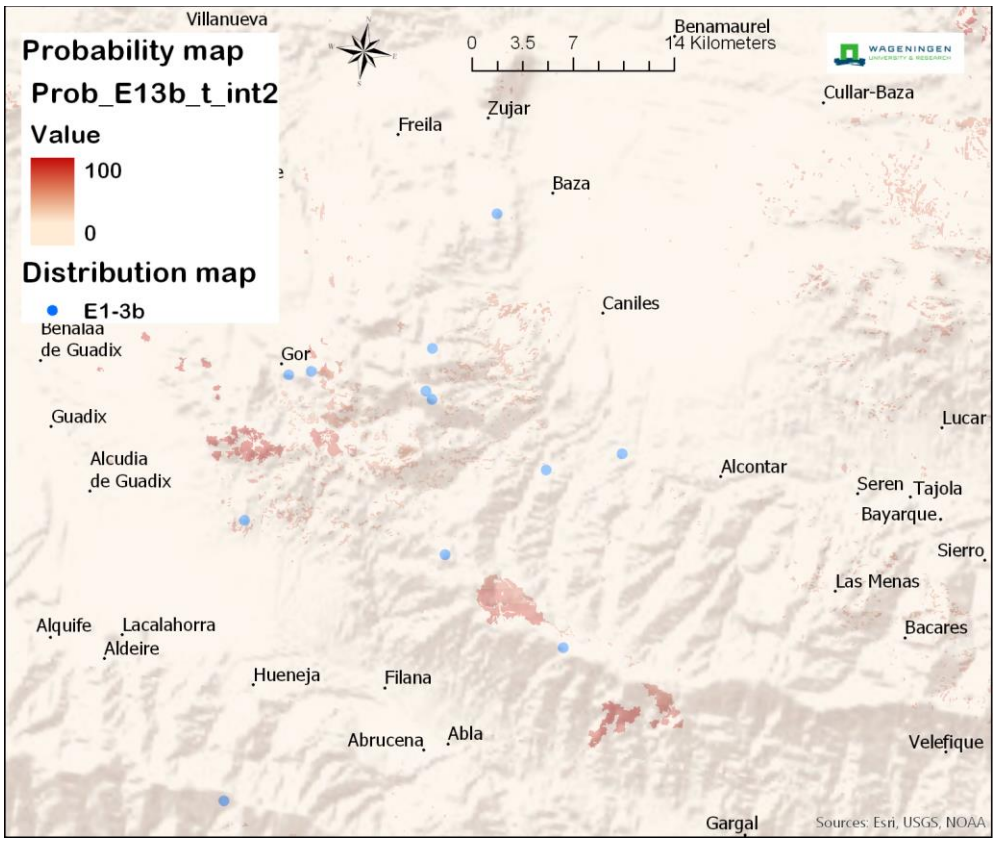


E1.3b Mediterranean tall perennial dry grassland

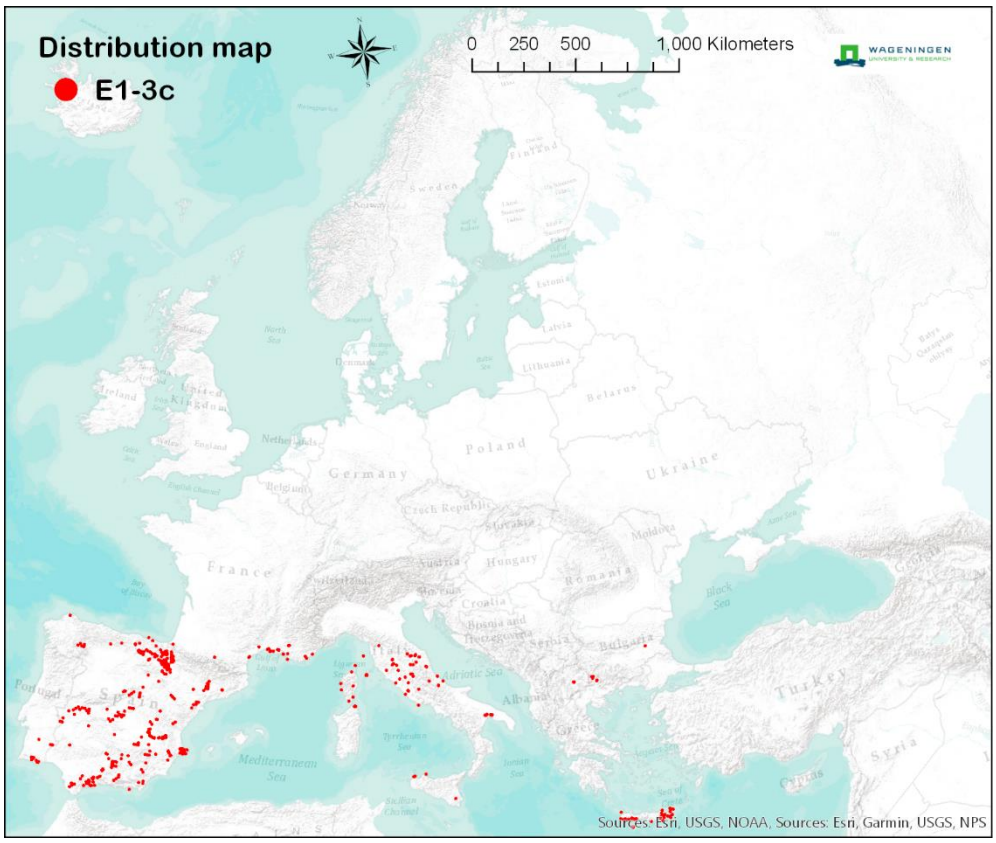


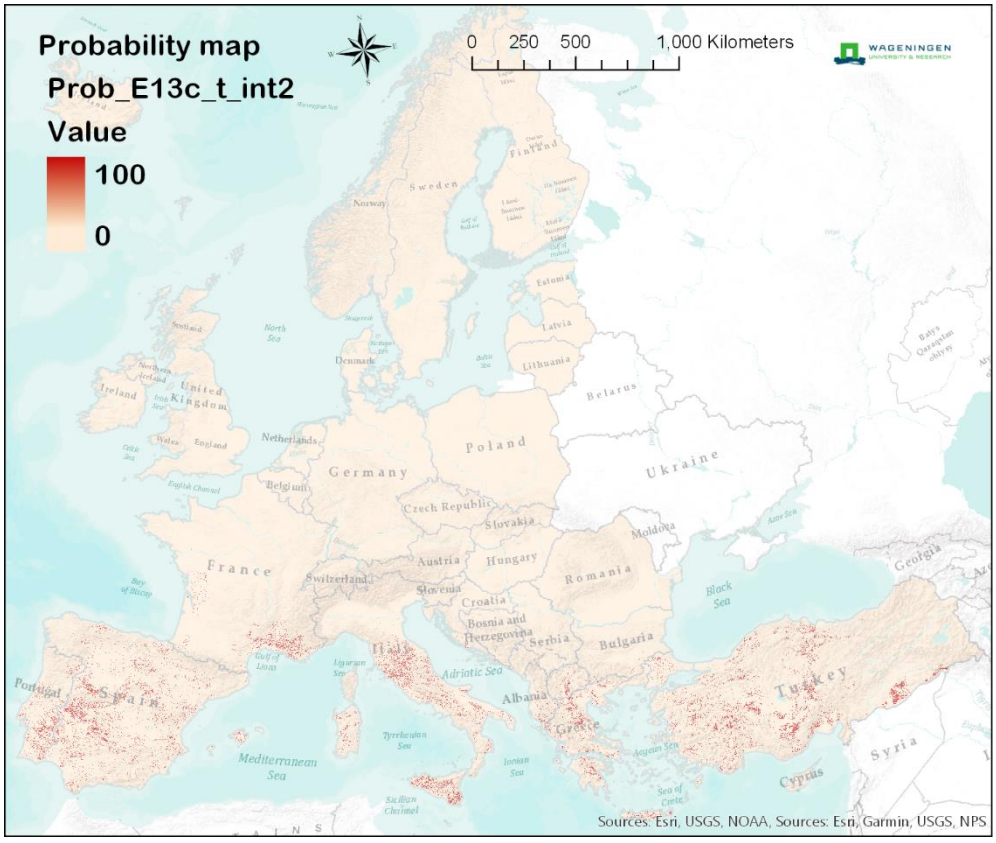


Example detail of the European habitat probability map at 20 m resolution for E1.3b Mediterranean tall perennial dry grassland

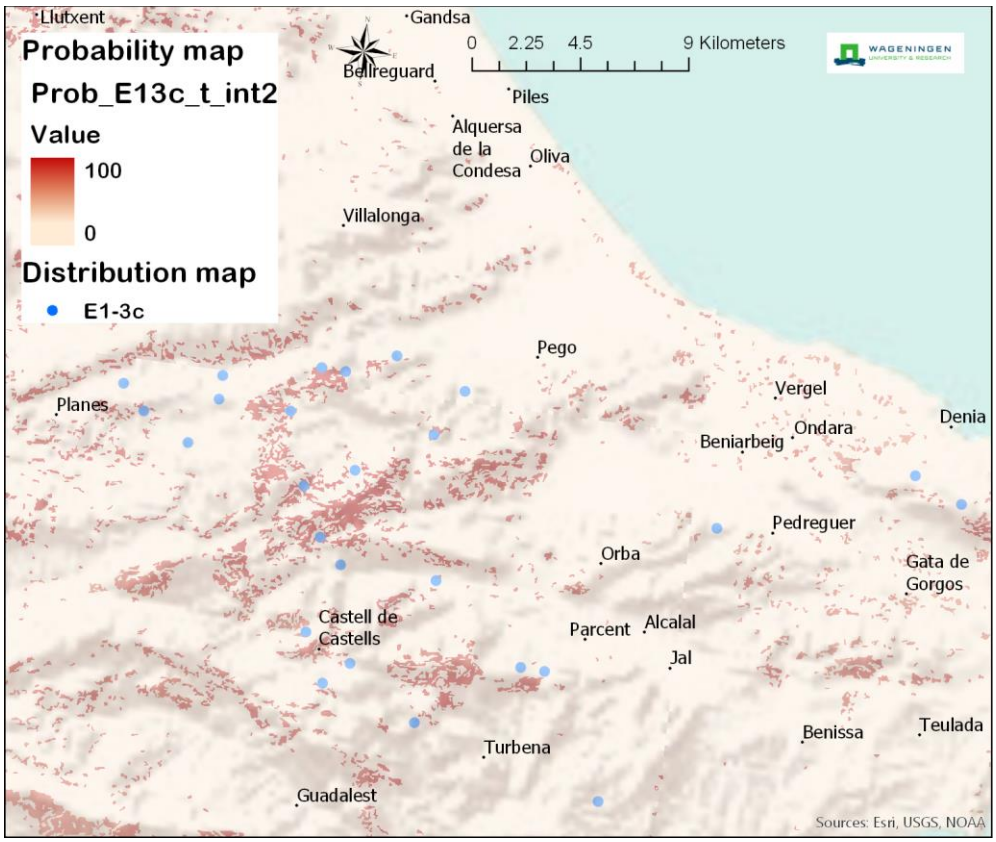


E1.3c Mediterranean annual-rich dry grassland

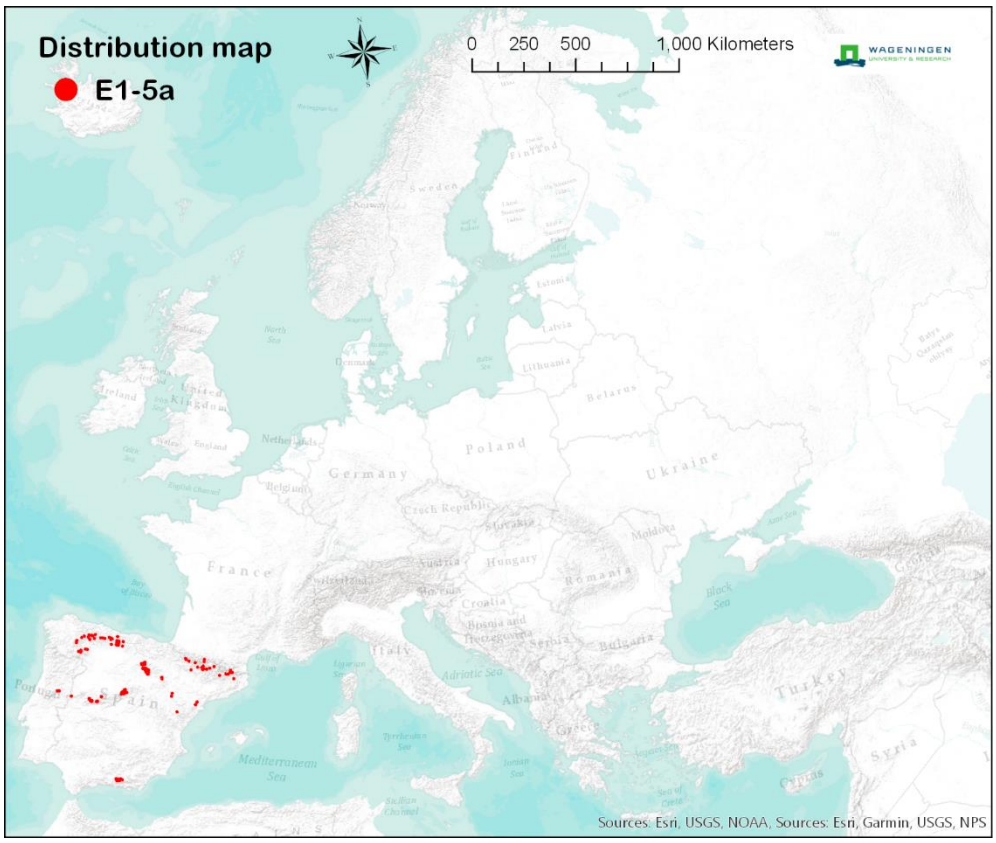


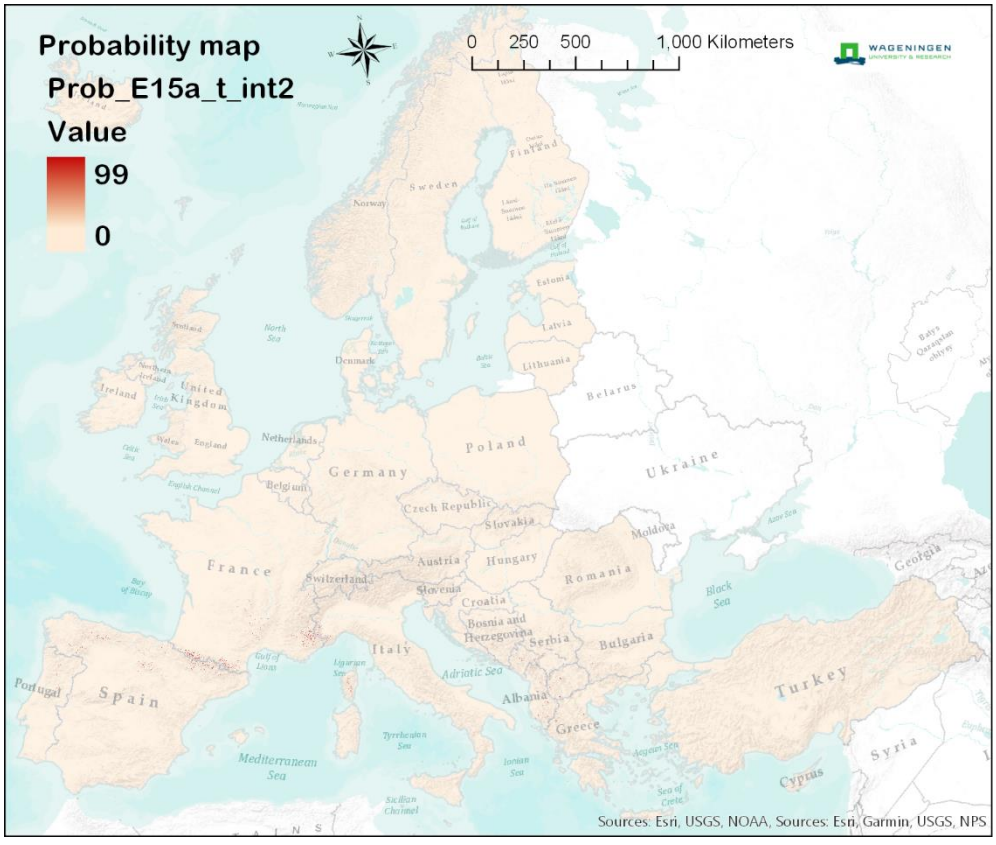


Example detail of the European habitat probability map at 20 m resolution for E1.3c Mediterranean annual-rich dry grassland

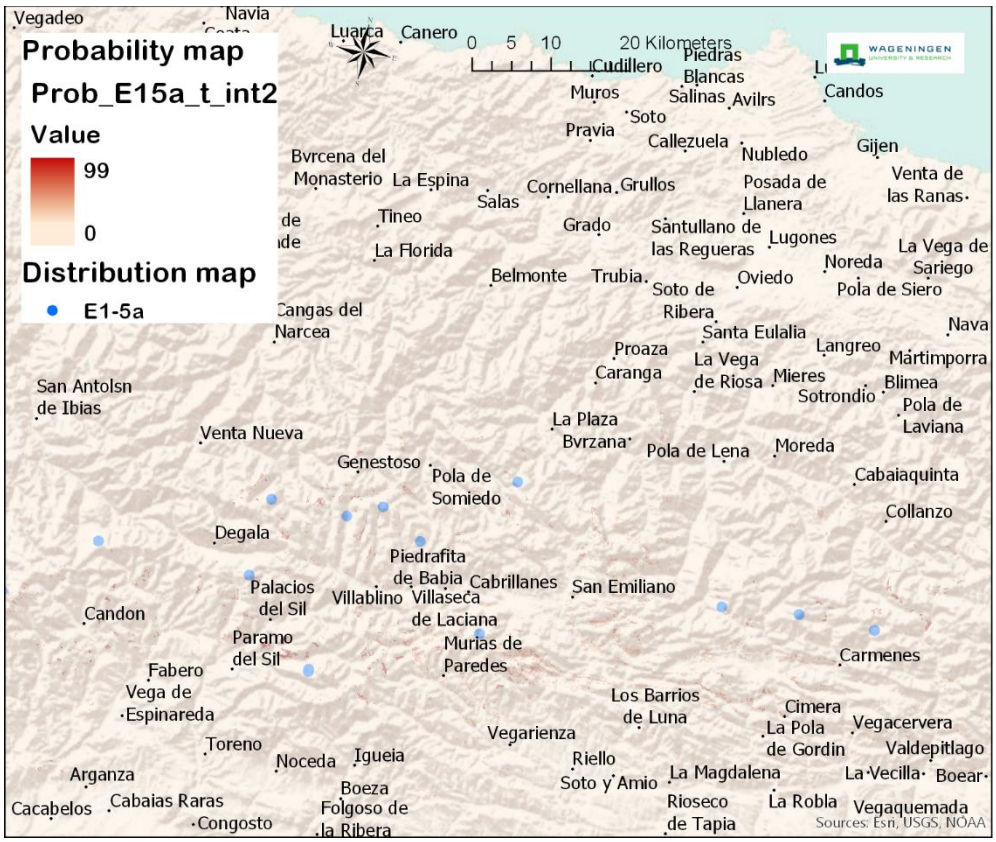


E1.5a Iberian oromediterranean siliceous dry grassland

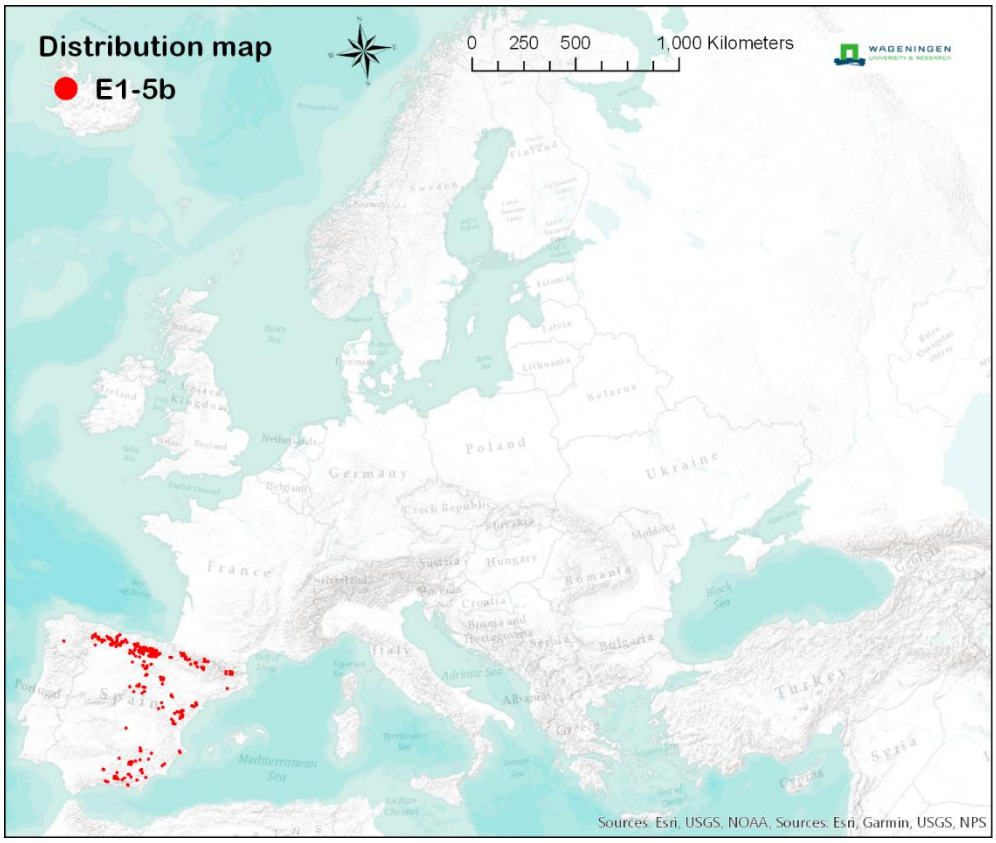


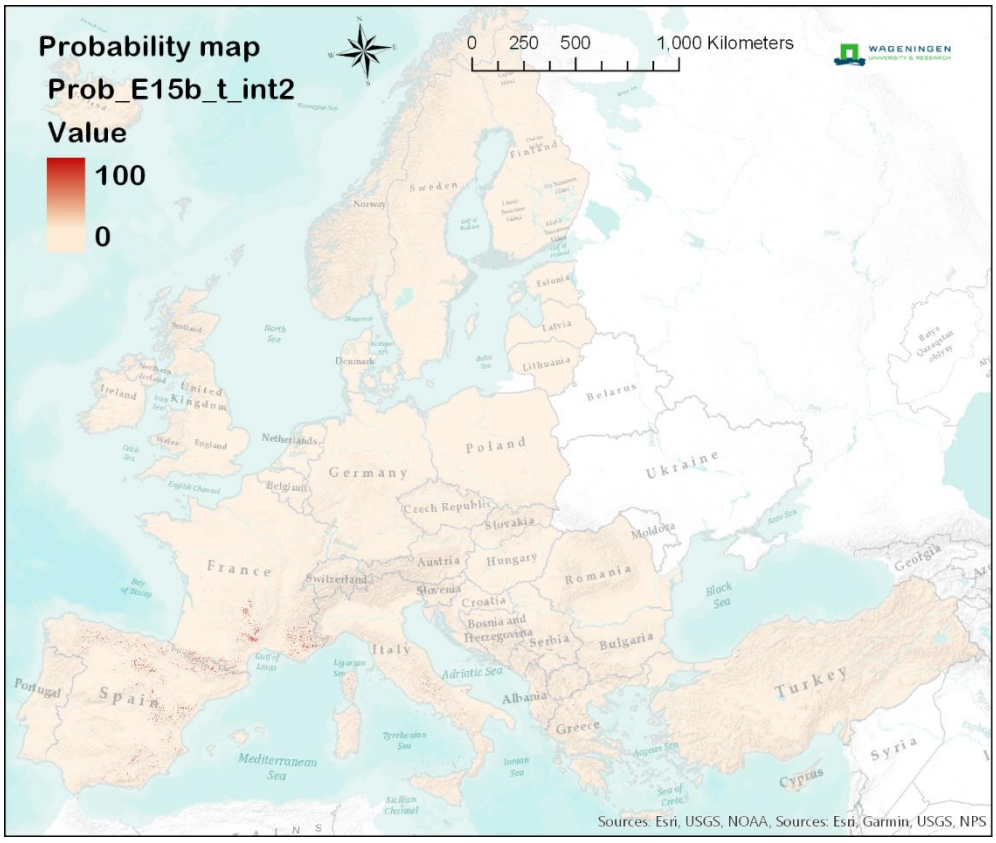


Example detail of the European habitat probability map at 20 m resolution for E1.5aIberian oromediterranean siliceous dry grassland

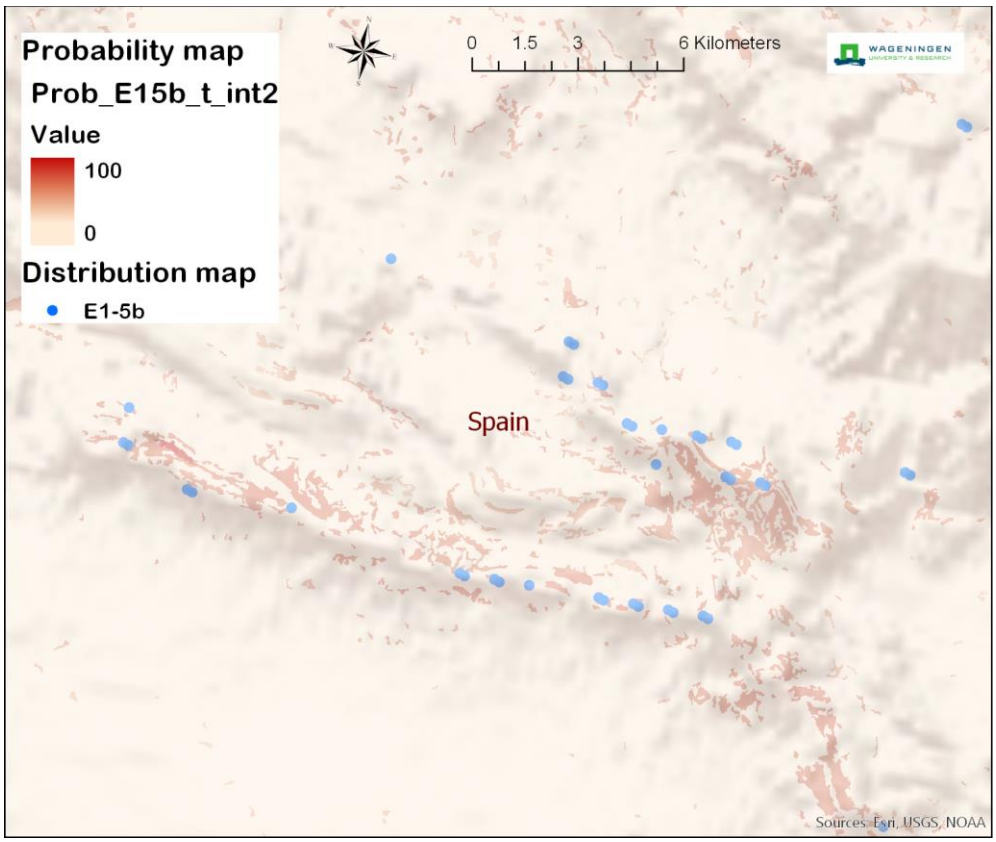


E1.5b Iberian oromediterranean basiphilous dry grassland

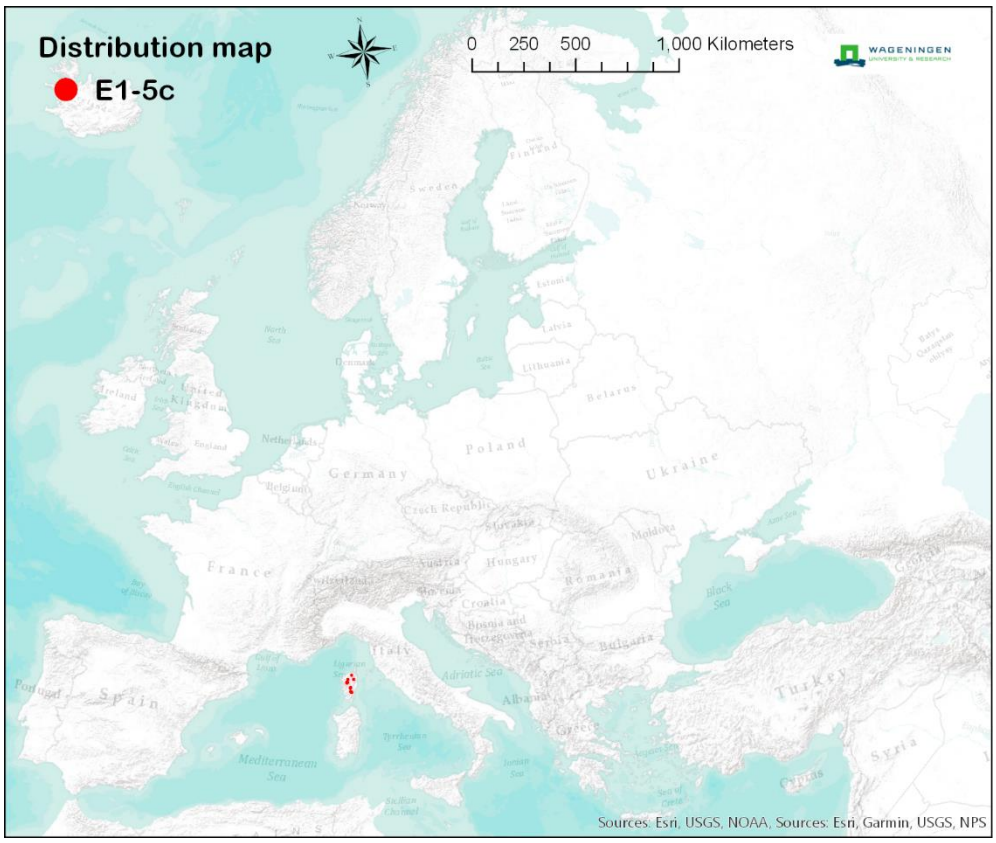


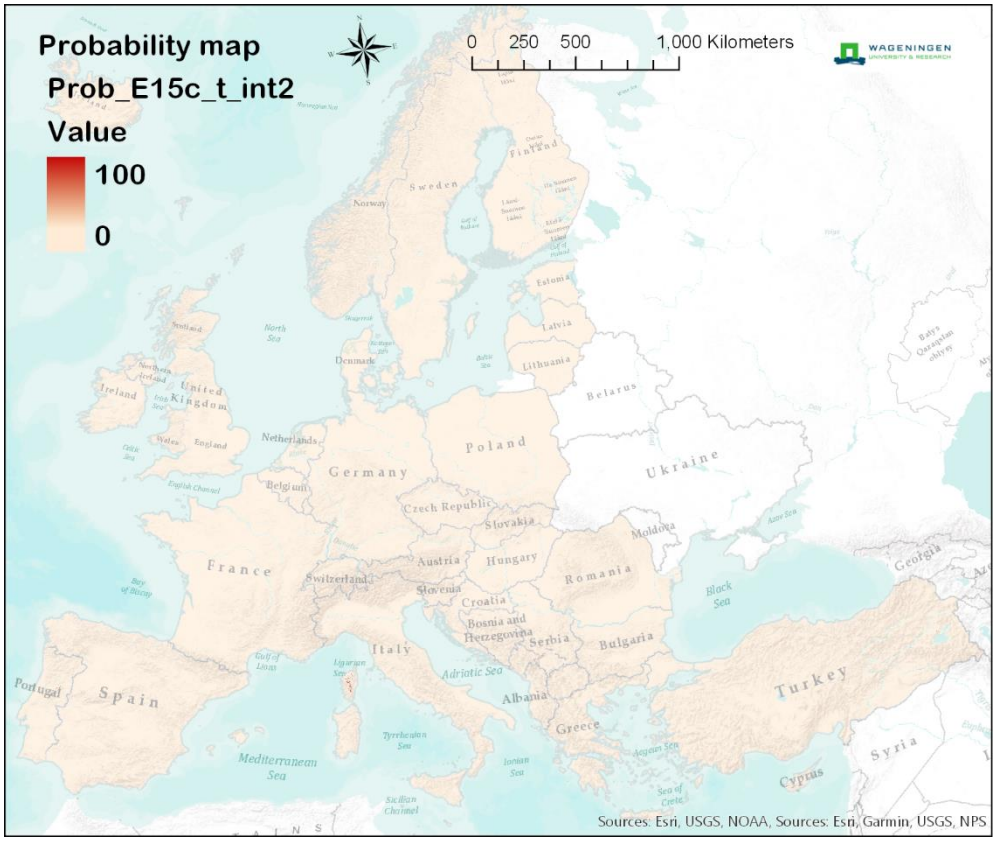


Example detail of the European habitat probability map at 20 m resolution for E1.5b Iberian oromediterranean basiphilous dry grassland

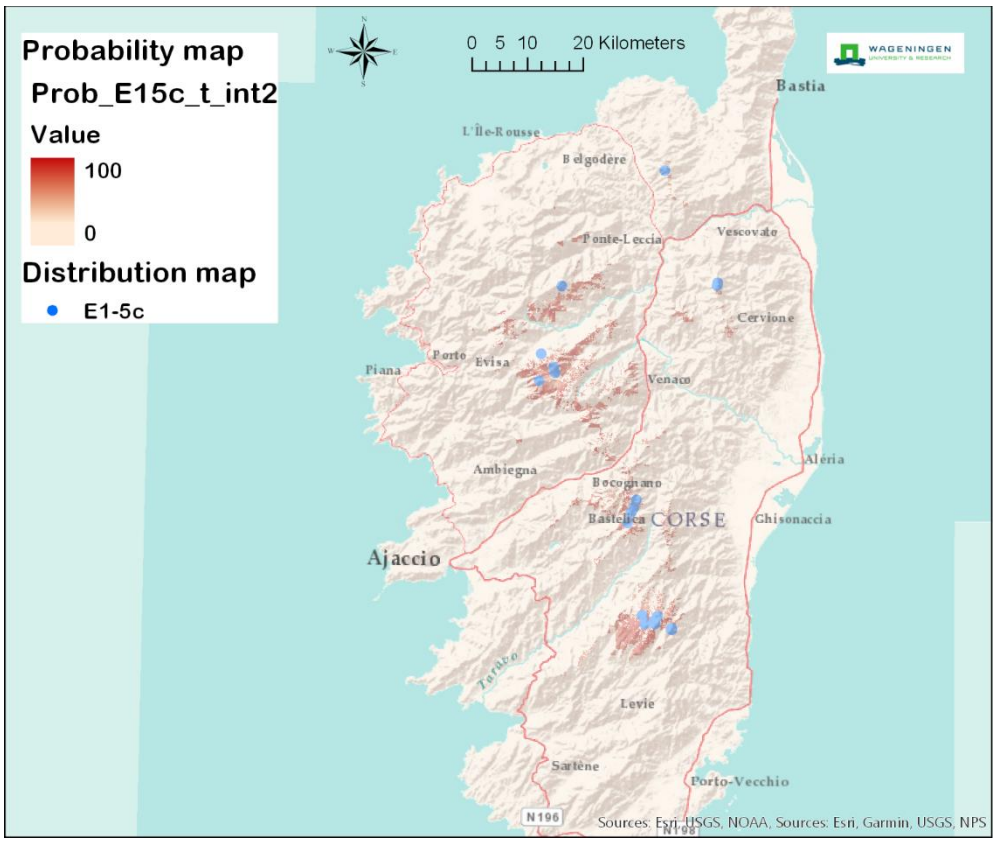


E1.5c Cyrno-Sardean-oromediterranean siliceous dry grassland

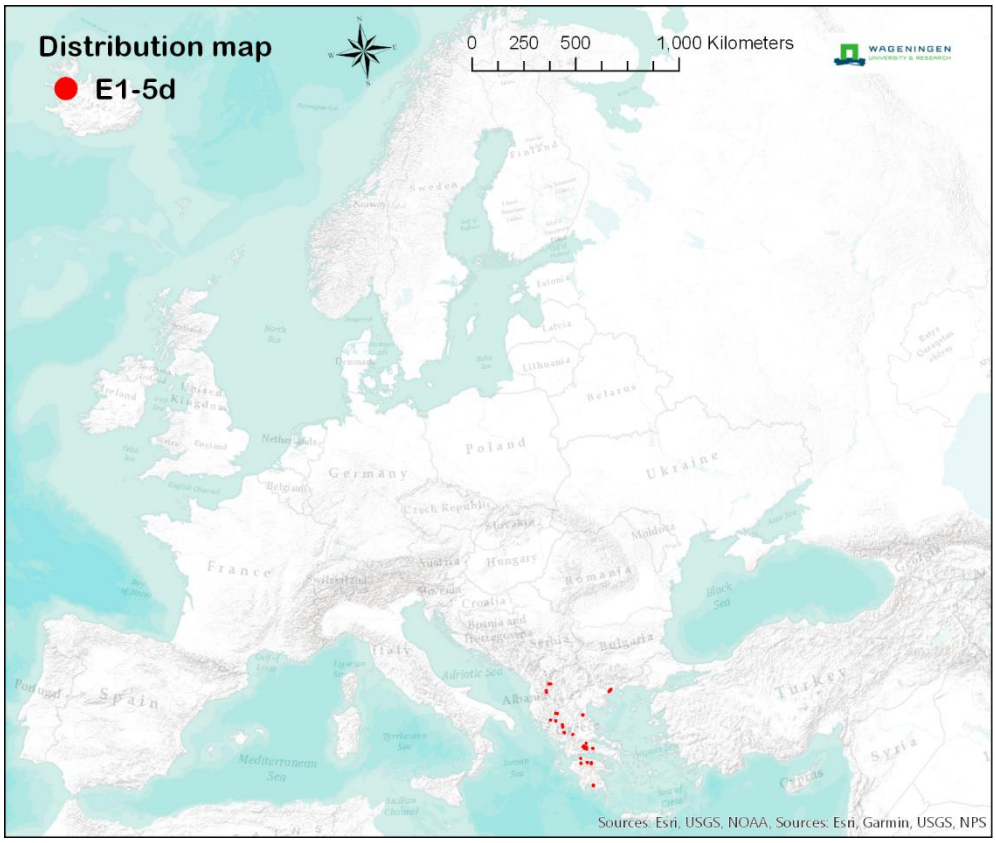


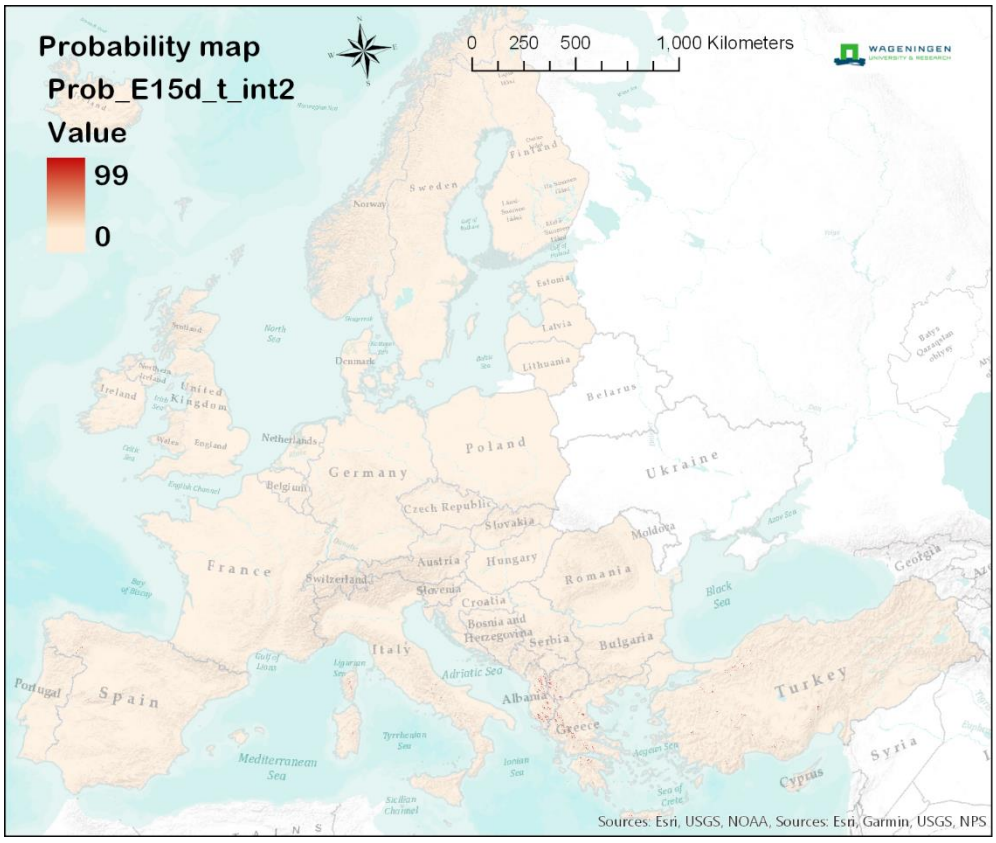


Example detail of the European habitat probability map at 20 m resolution for E1.5c Cyrno-Sardean-oromediterranean siliceous dry grassland

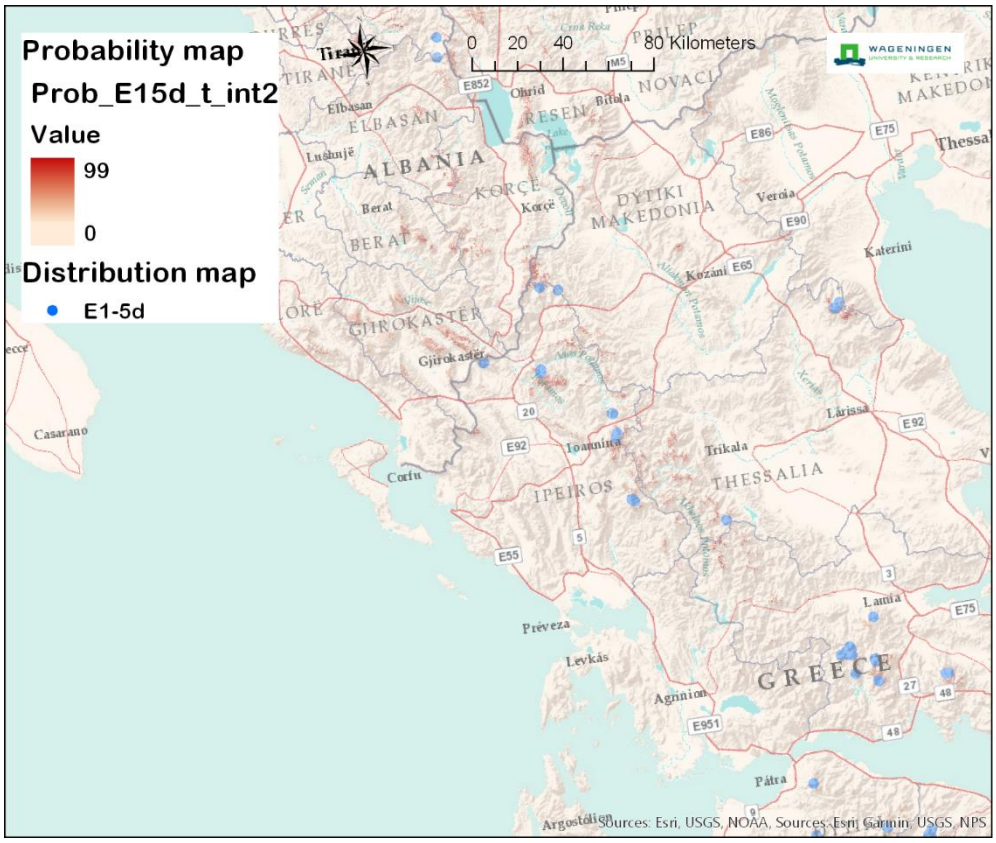


E1.5dGreek and Anatolian oromediterranean siliceous dry grassland

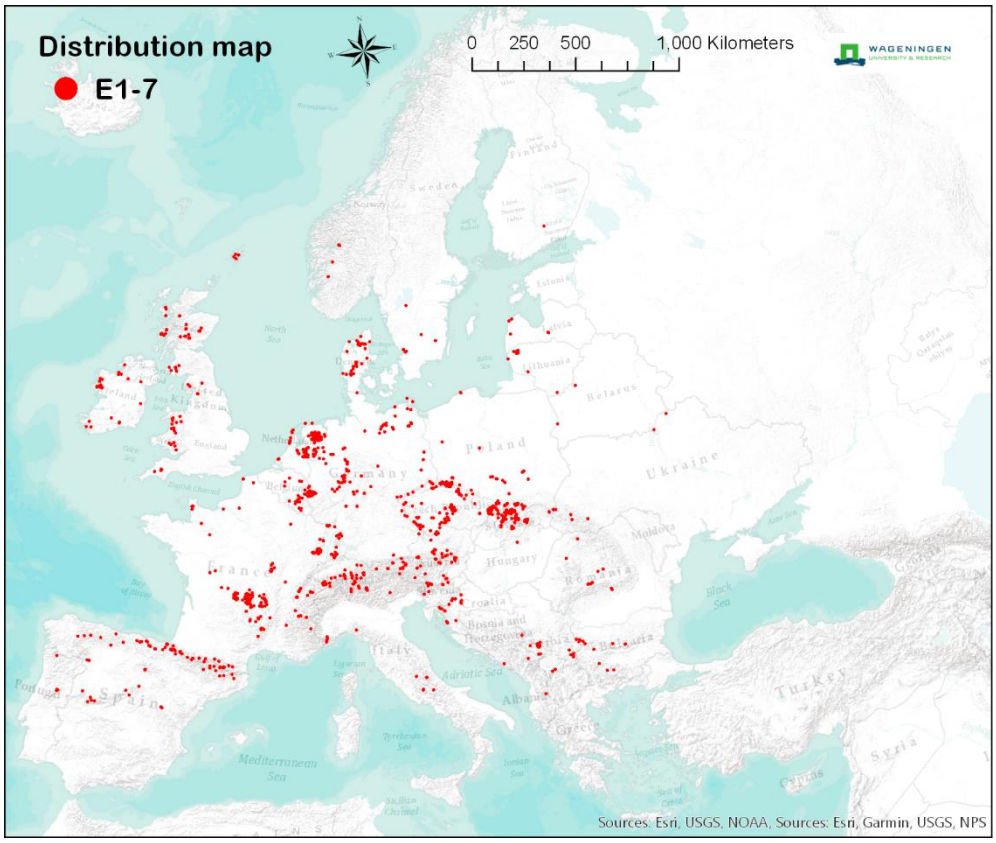


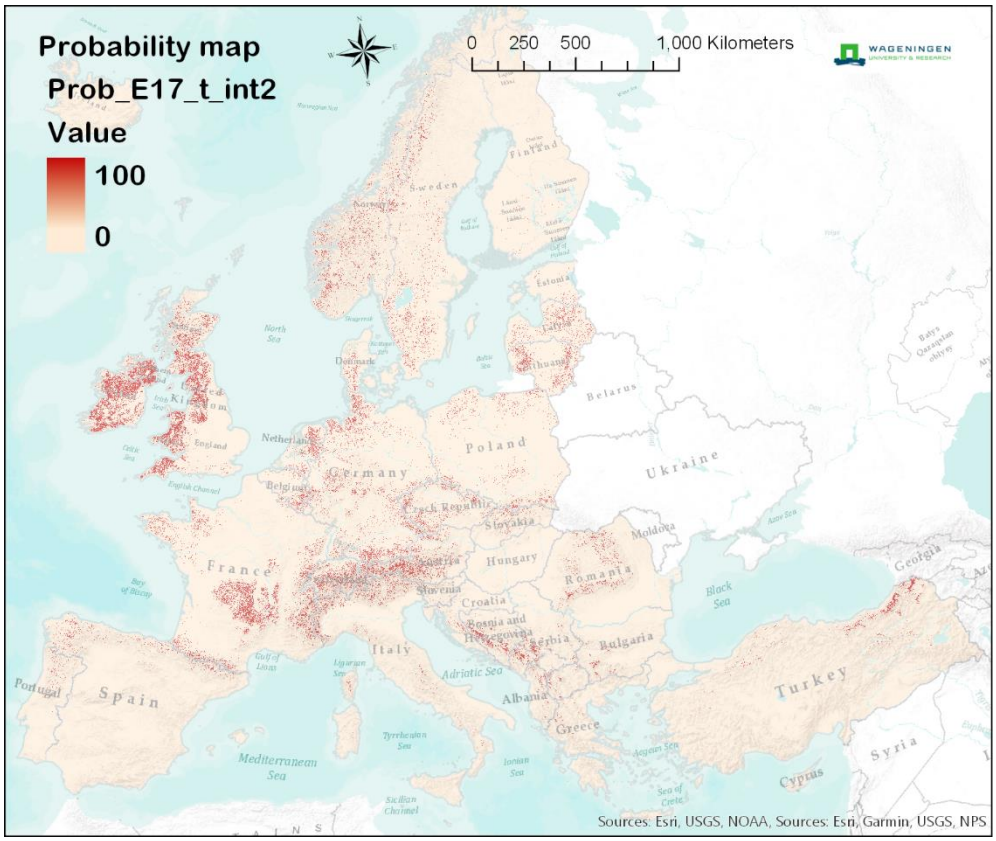


Example detail of the European habitat probability map at 20 m resolution for E1.5d Greek and Anatolian oromediterranean siliceous dry grassland

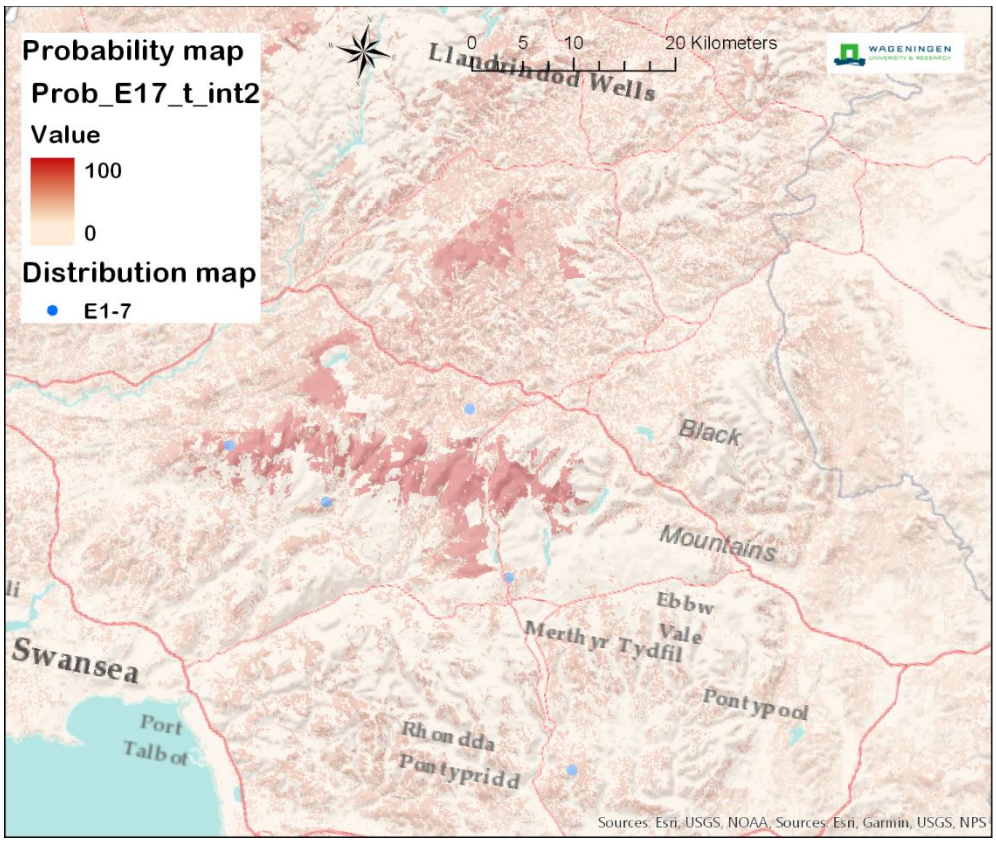


E1.7 Lowland to submontane, dry to mesic Nardus grassland

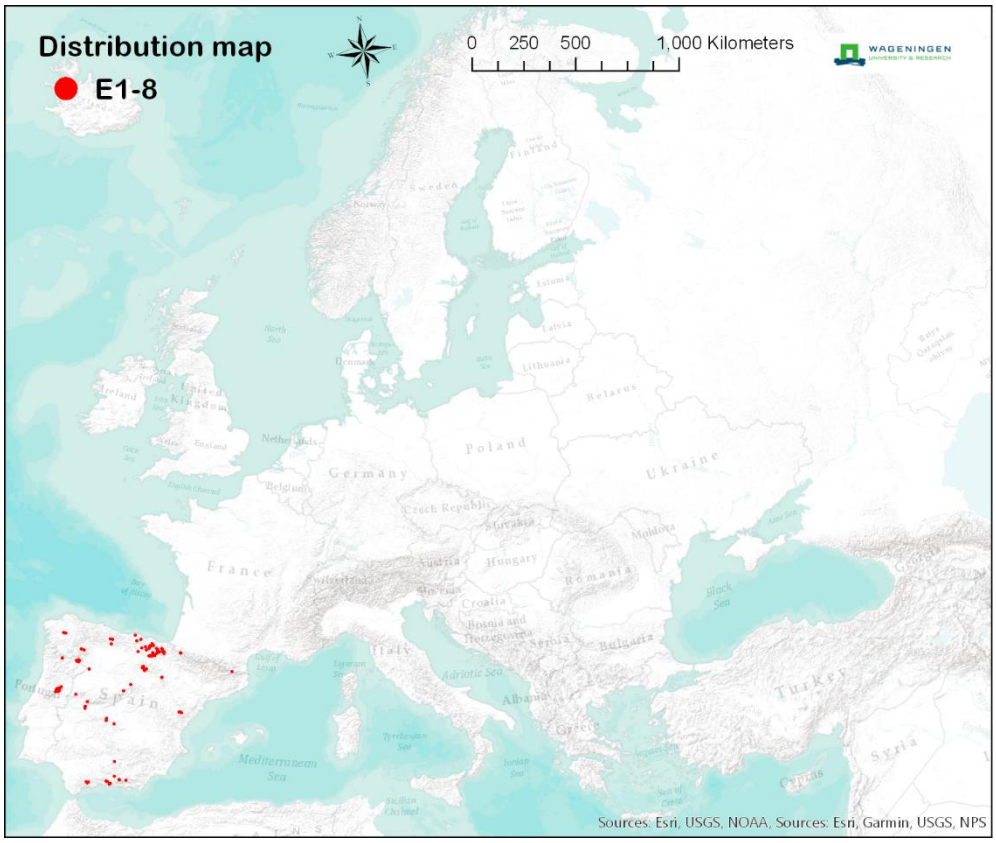


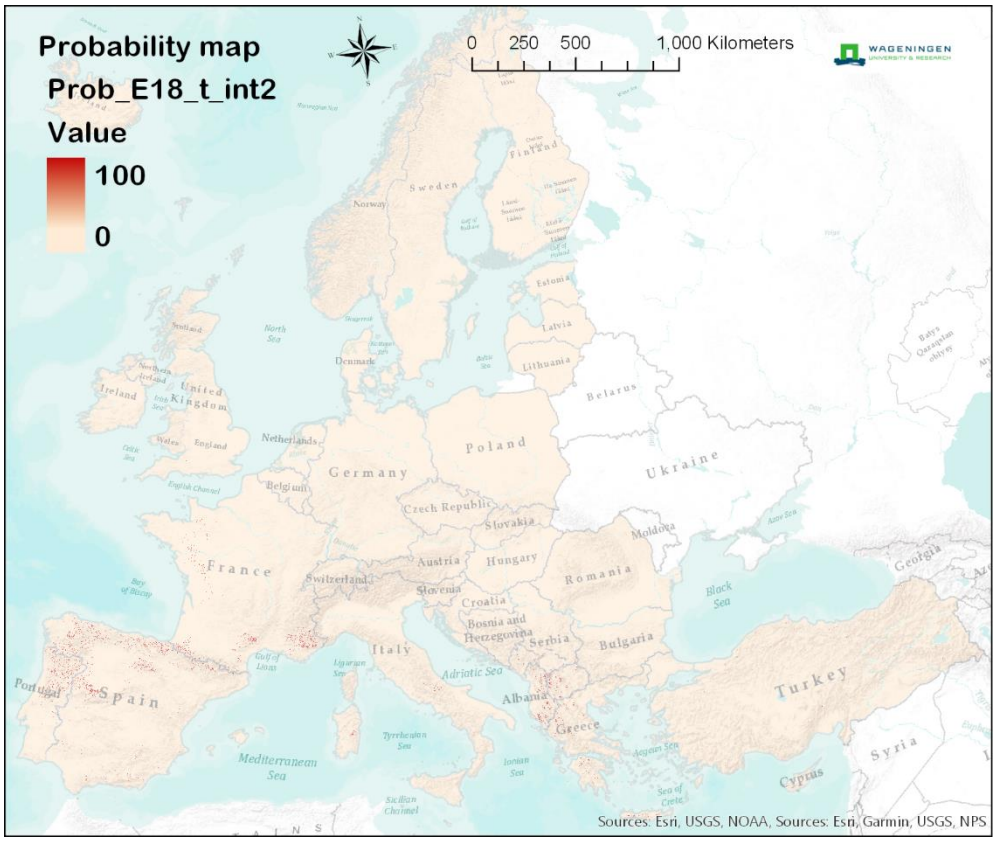


Example detail of the European habitat probability map at 20 m resolution for E1.7 Lowland to submontane, dry to mesic Nardus grassland

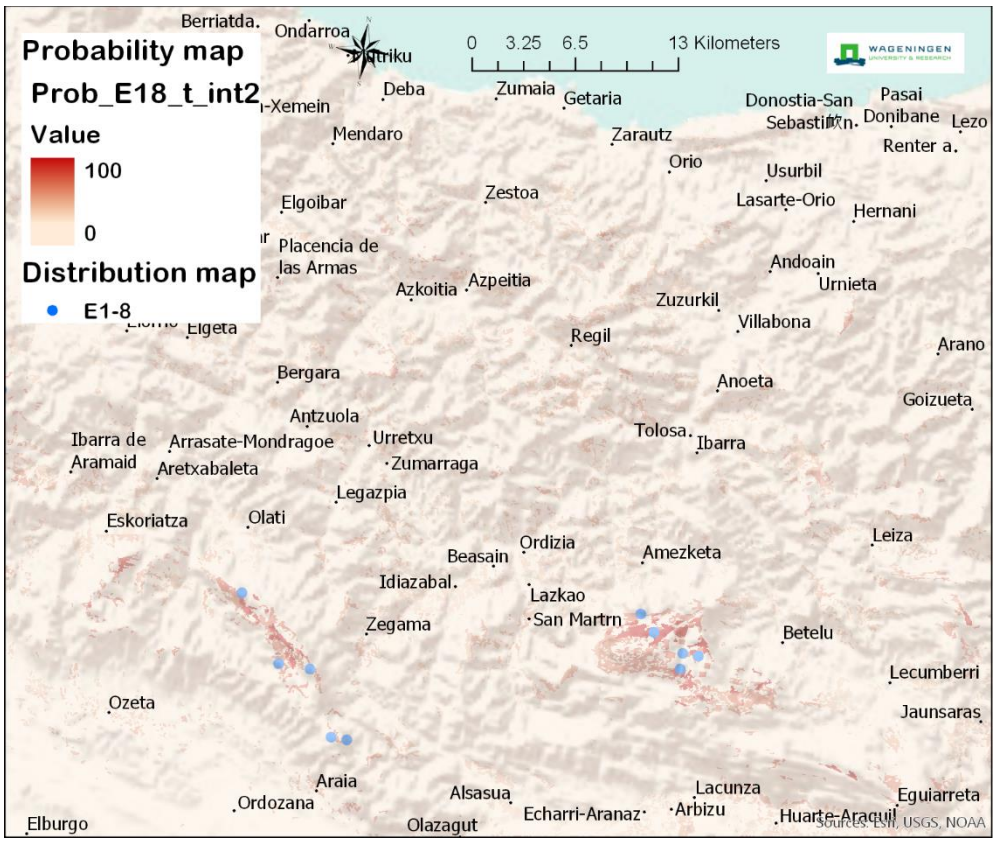


E1.8 Open Iberian supra-mediterranean dry acid and neutral grassland

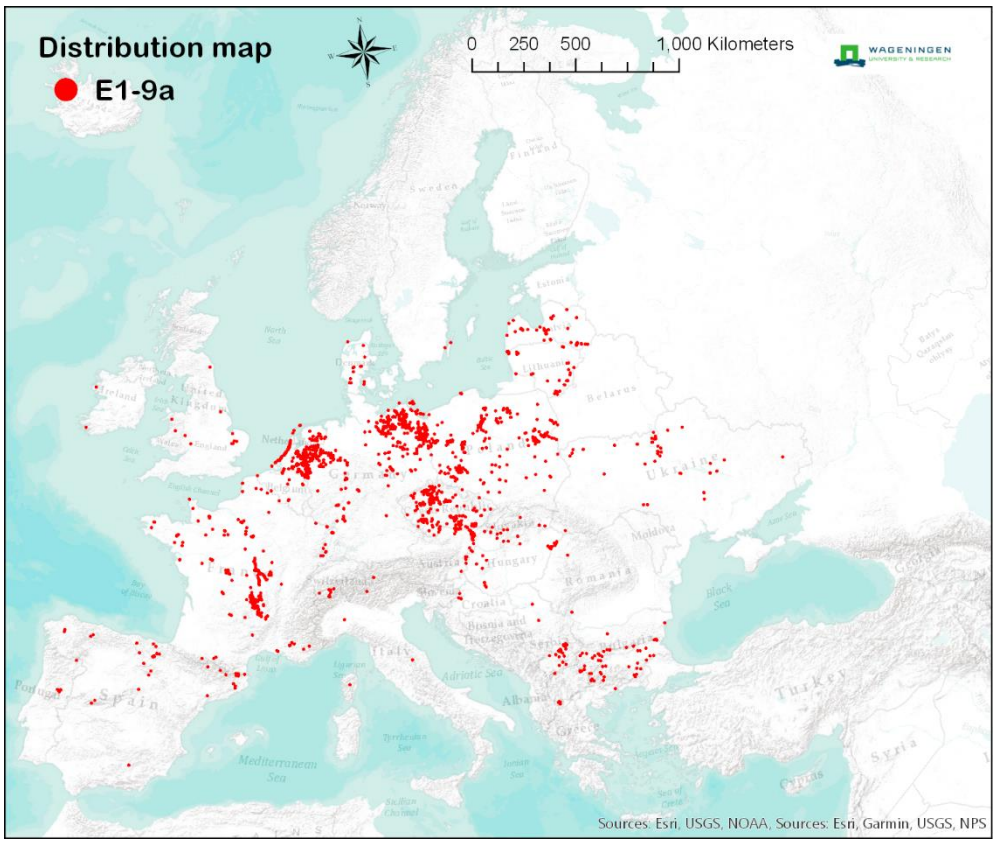


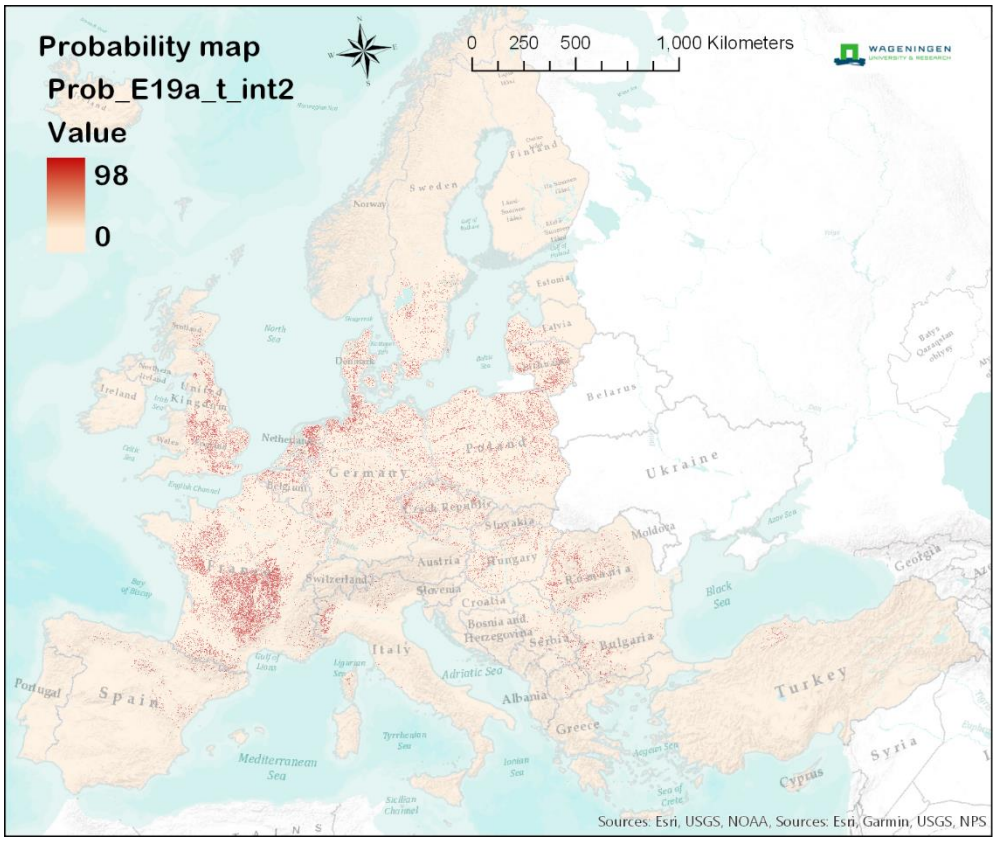


Example detail of the European habitat probability map at 20 m resolution for E1.8 Open Iberian supra-mediterranean dry acid and neutral grassland

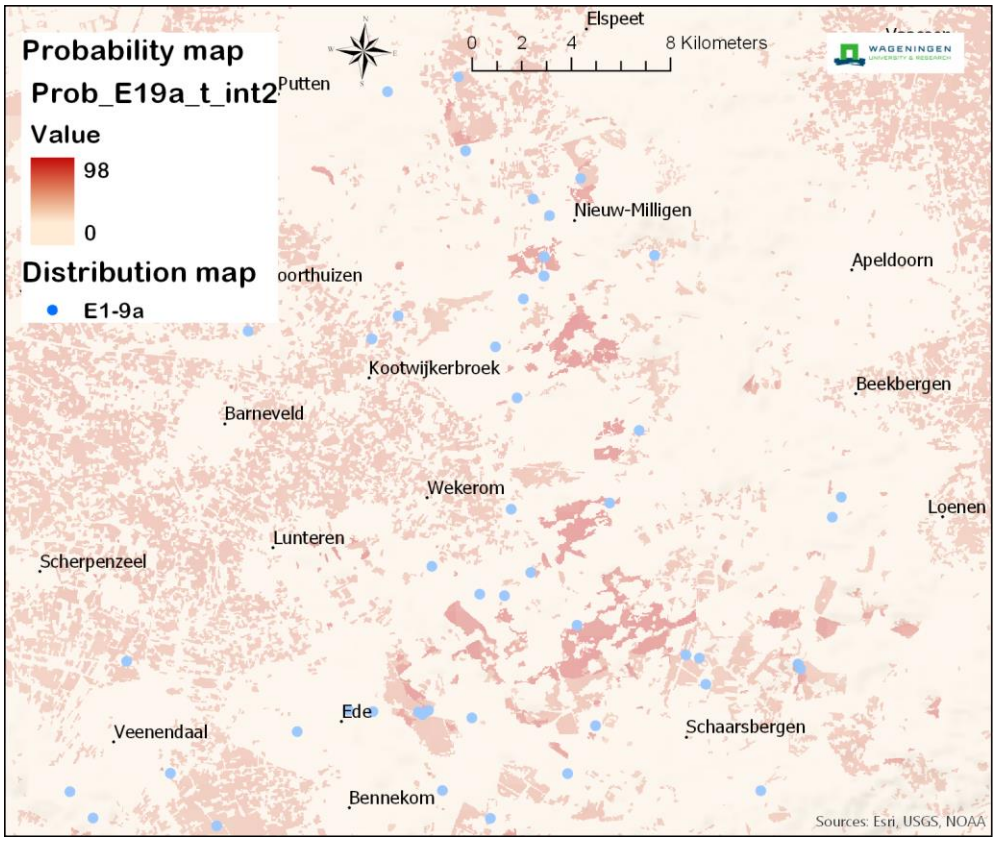


E1.9a Oceanic to subcontinental inland sand grassland on dry acid and neutral soils

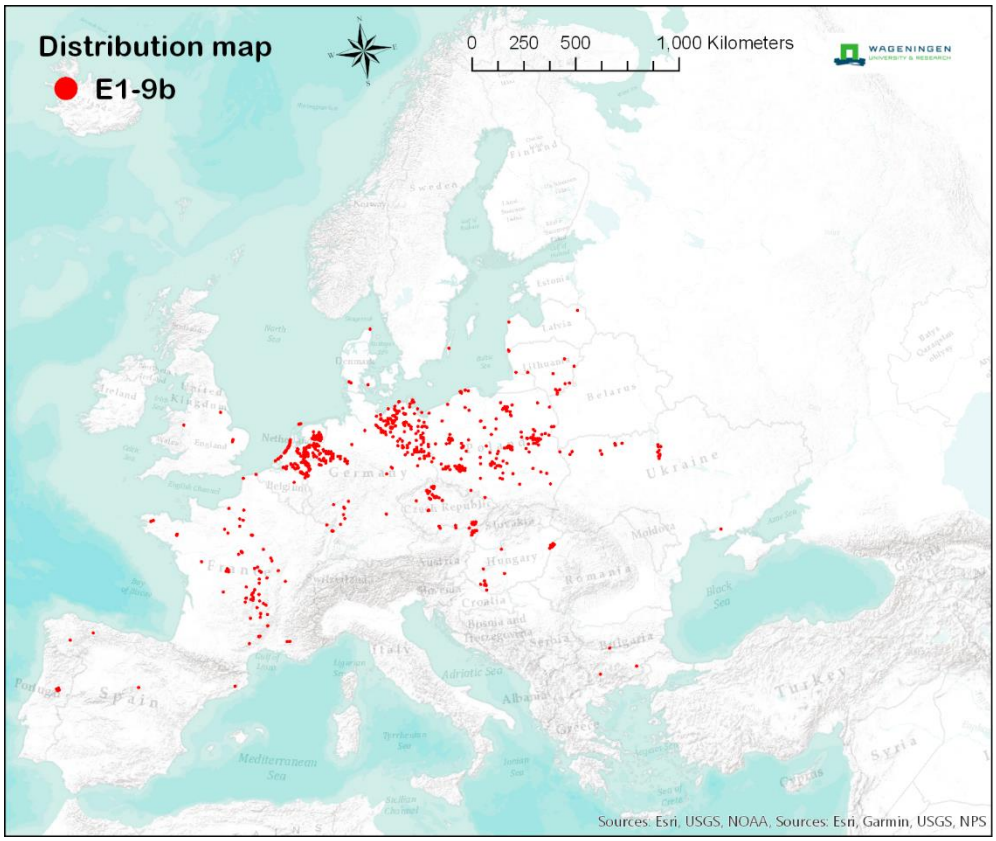


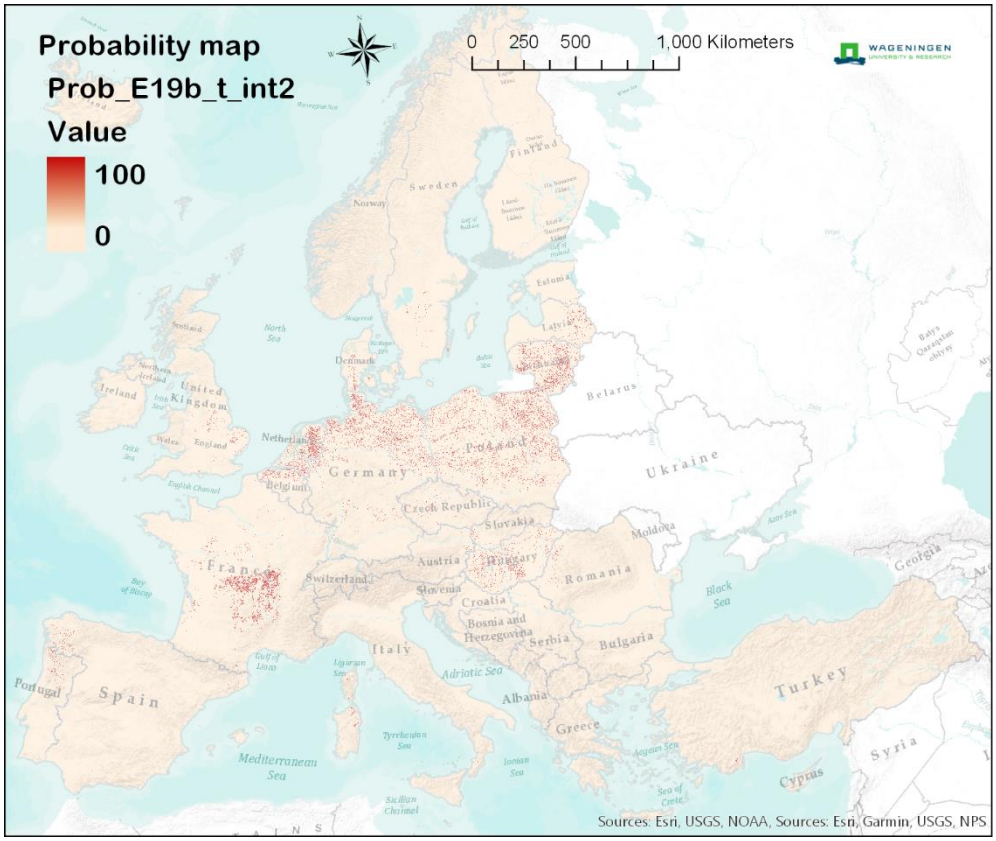


Example detail of the European habitat probability map at 20 m resolution for E1.9ª Oceanic to subcontinental inland sand grassland on dry acid and neutral soils

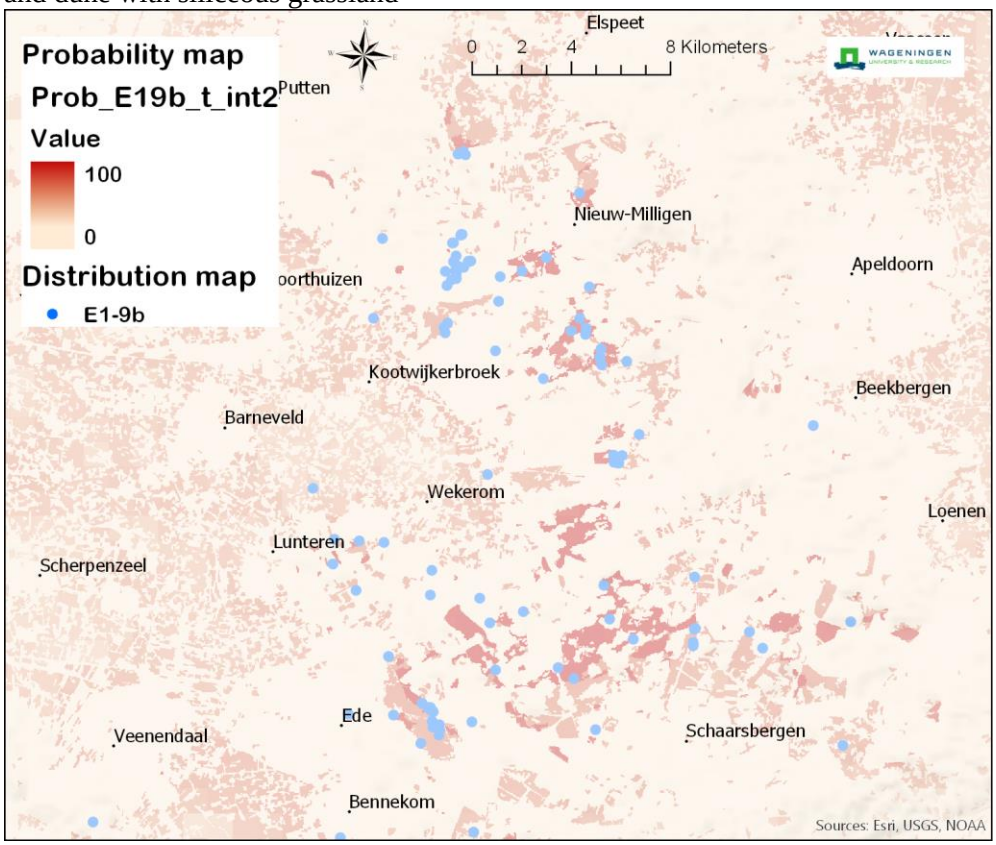


E1.9b Inland sanddrift and dune with siliceous grassland

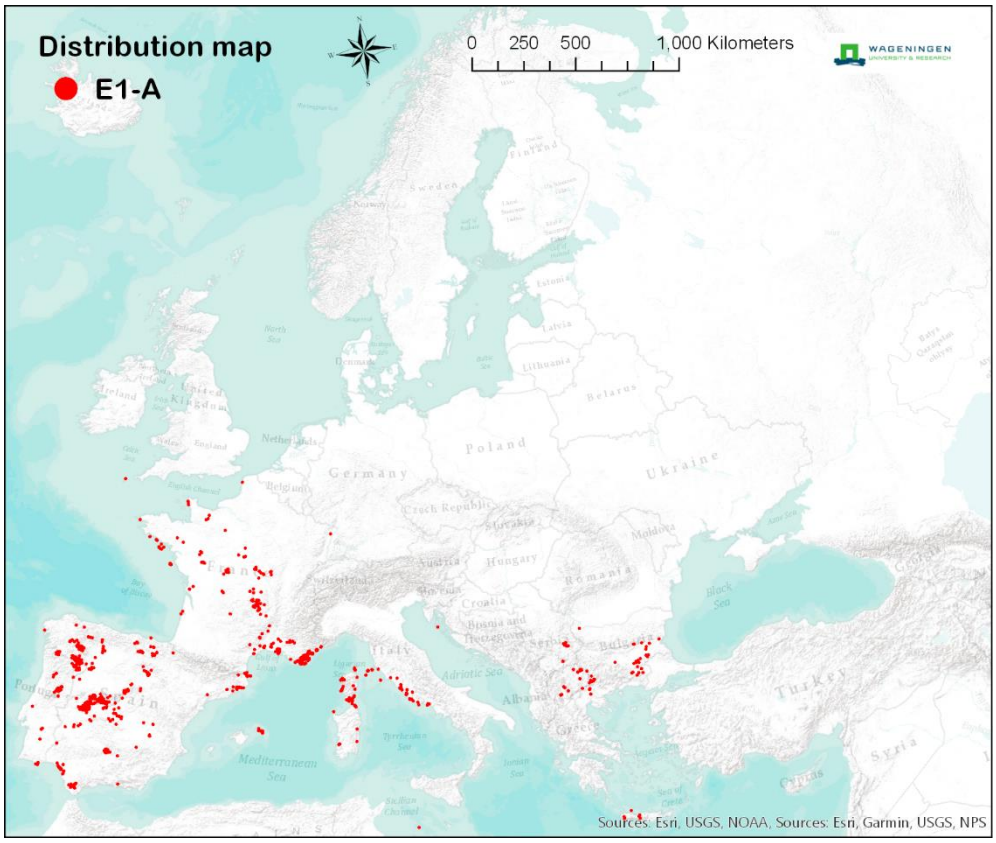


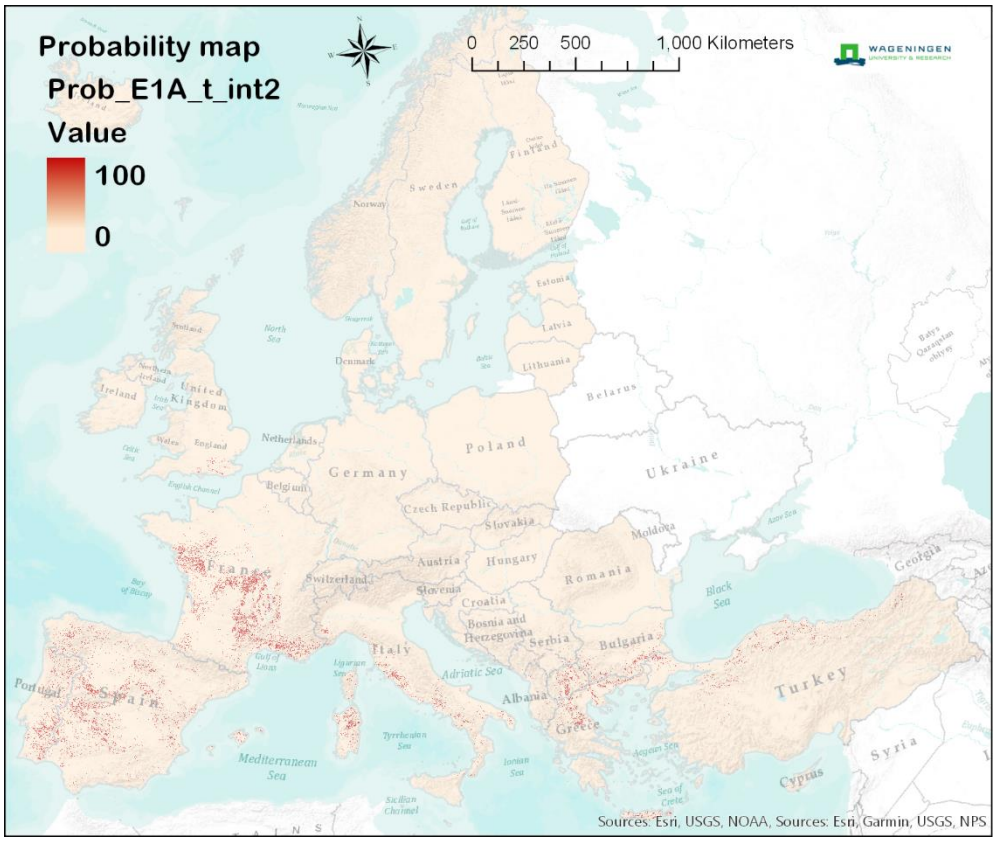


Example detail of the European habitat probability map at 20 m resolution for E1.9b Inland sanddrift and dune with siliceous grassland

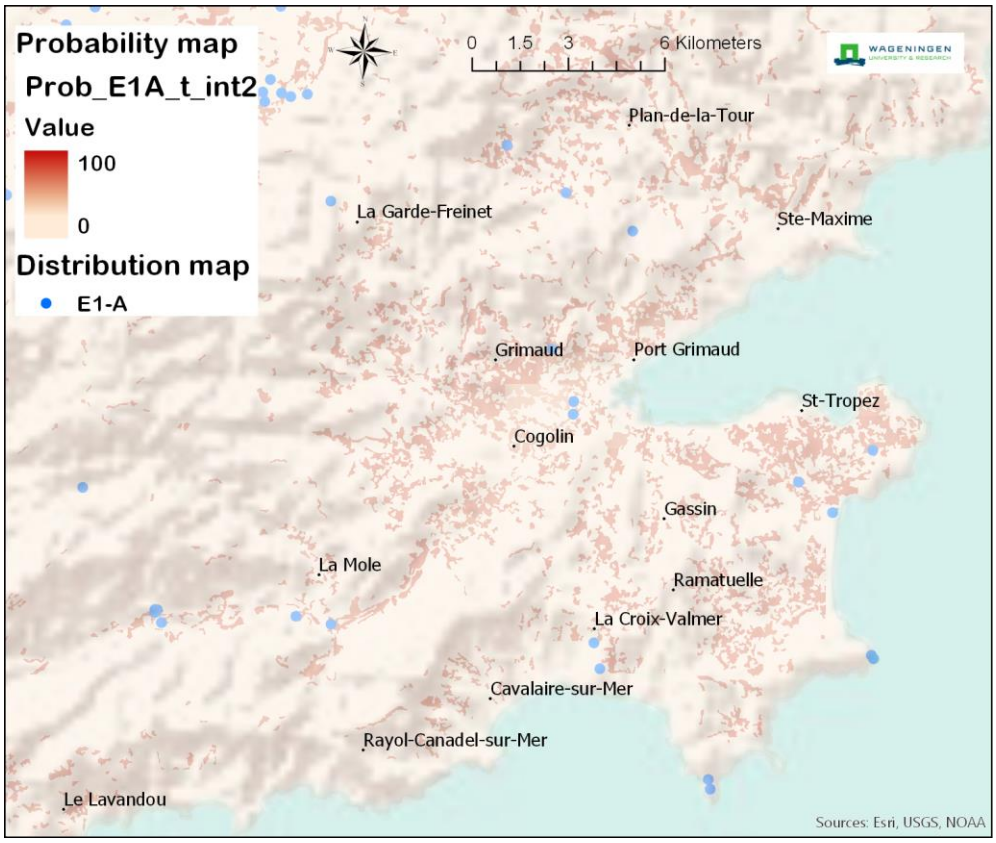


E1.A Mediterranean to Atlantic open, dry, acid and neutral grassland

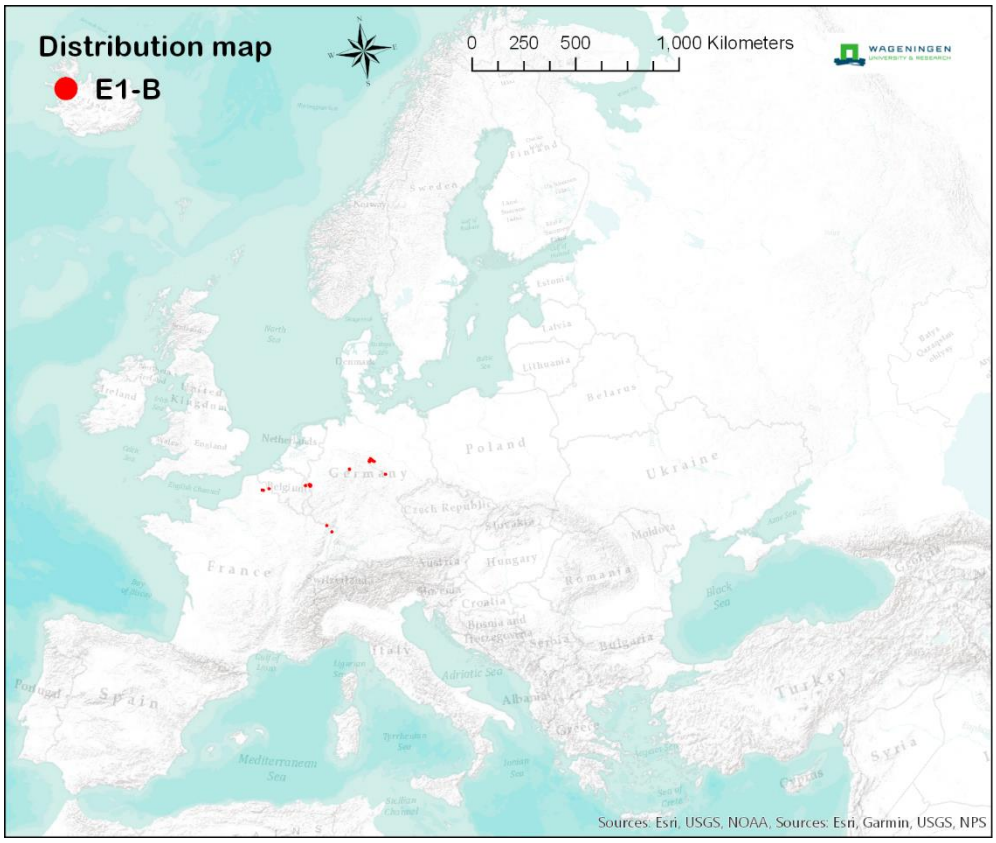


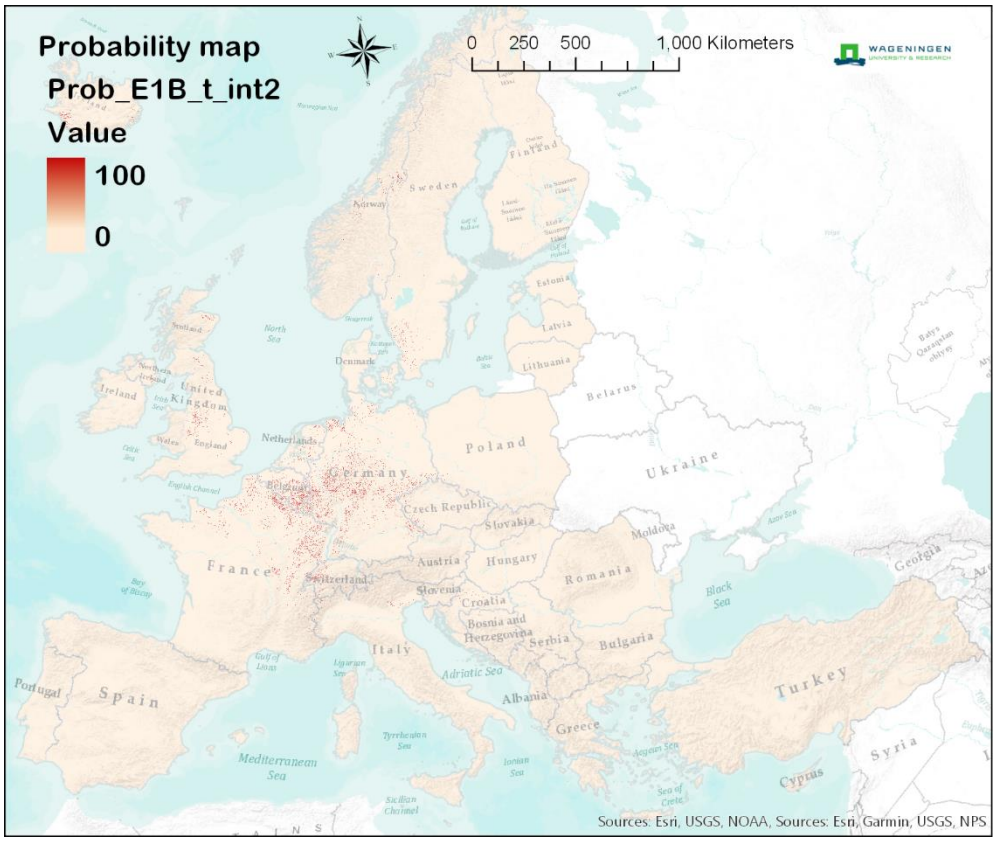


Example detail of the European habitat probability map at 20 m resolution for E1.A Mediterranean to Atlantic open, dry, acid and neutral grassland

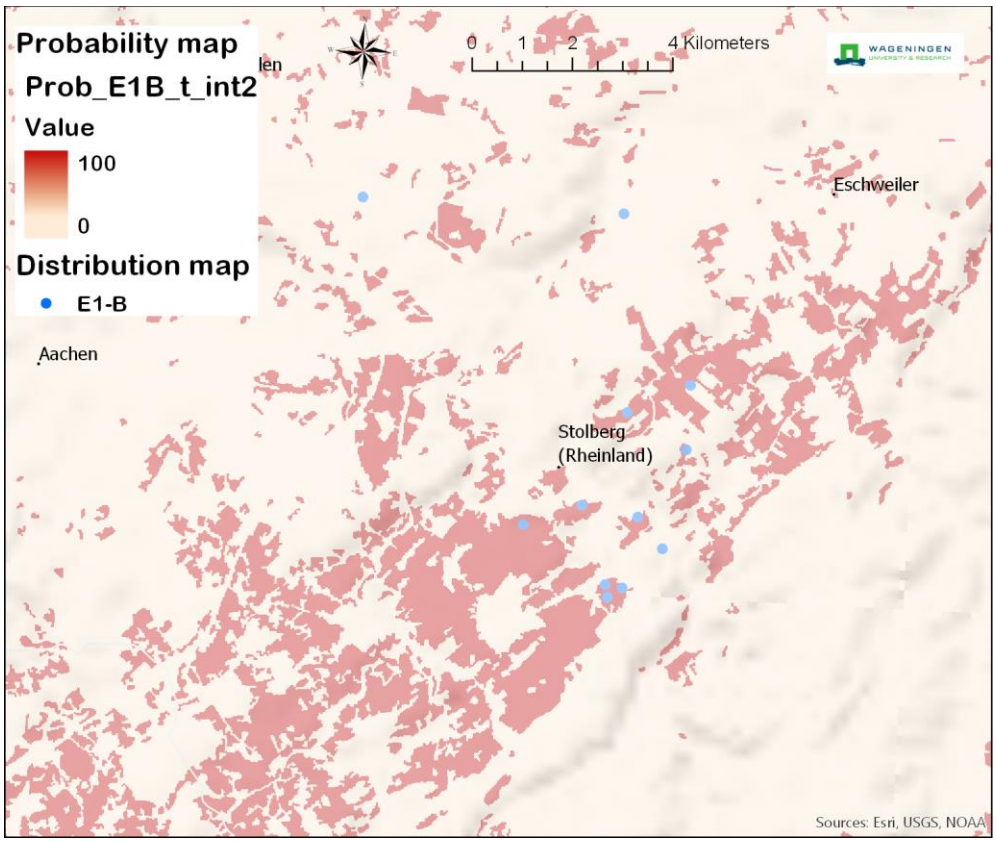


E1.B Heavy-metal grassland in Western and Central Europe

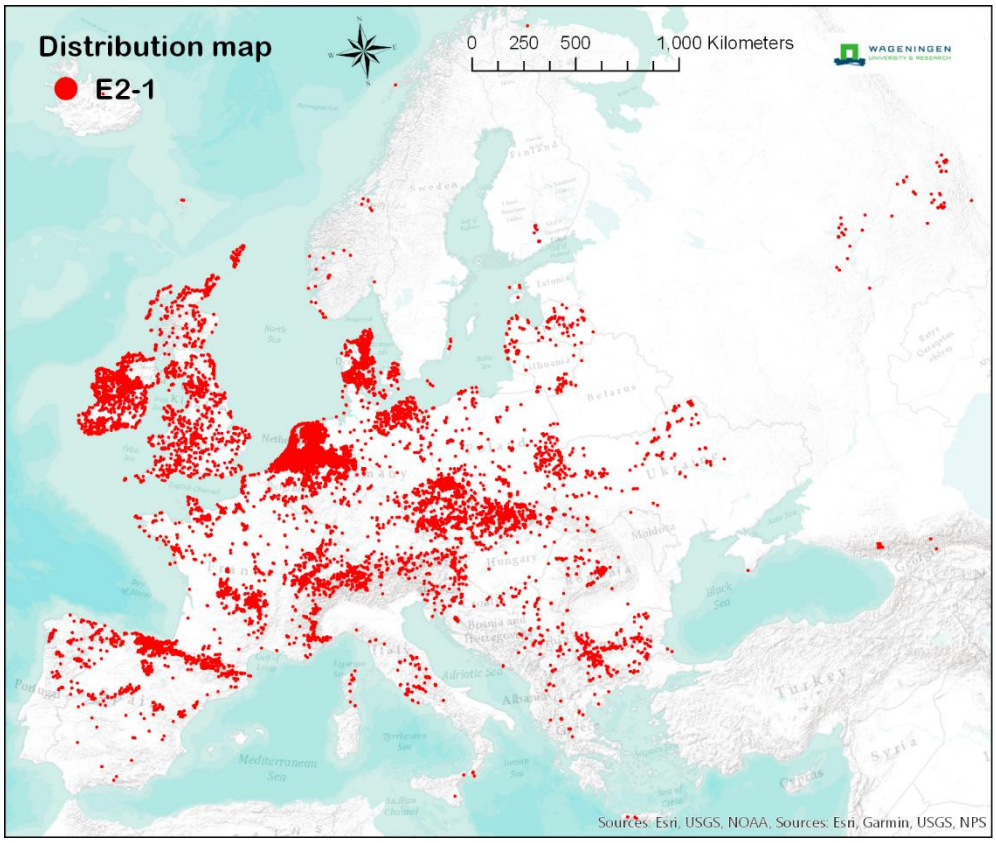


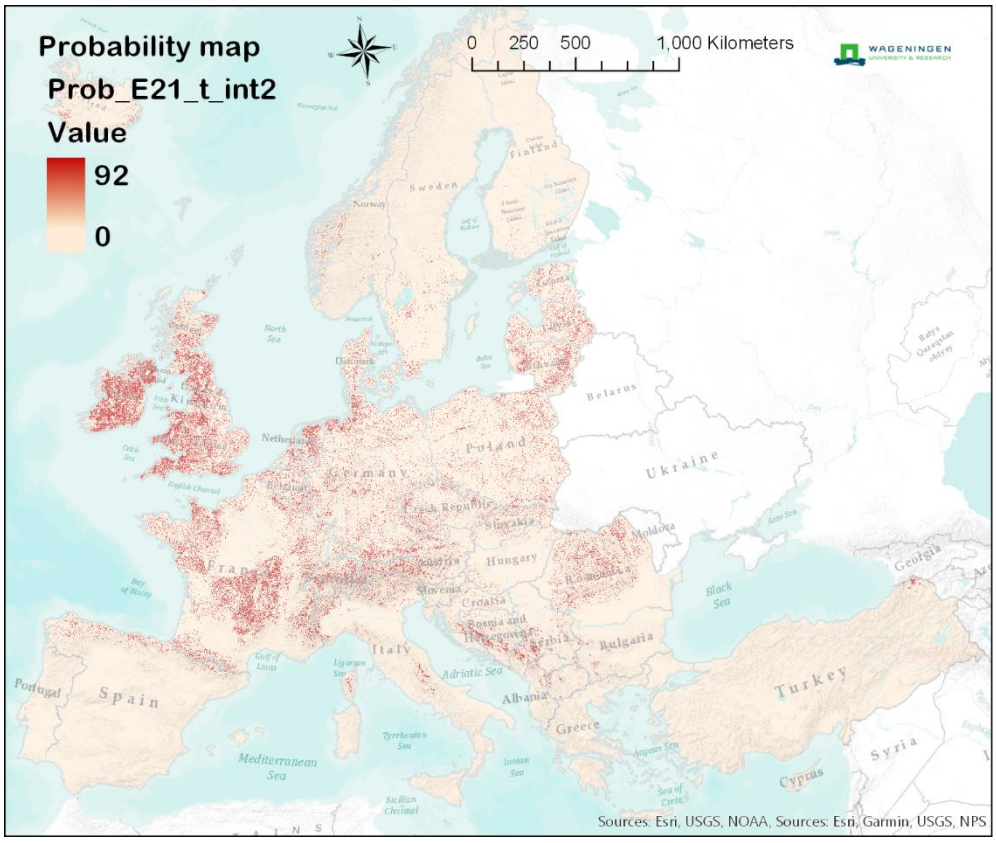


Example detail of the European habitat probability map at 20 m resolution for E1.B Heavy-metal grassland in Western and Central Europe

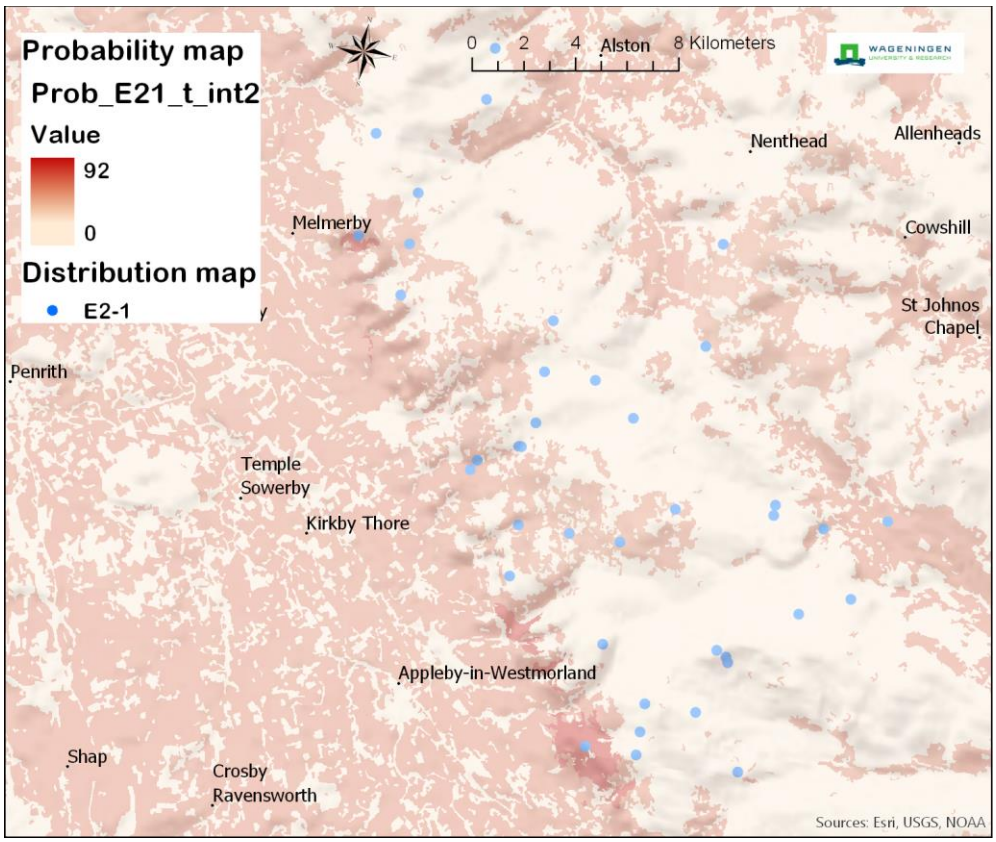


E2.1 Mesic permanent pasture of lowlands and mountains

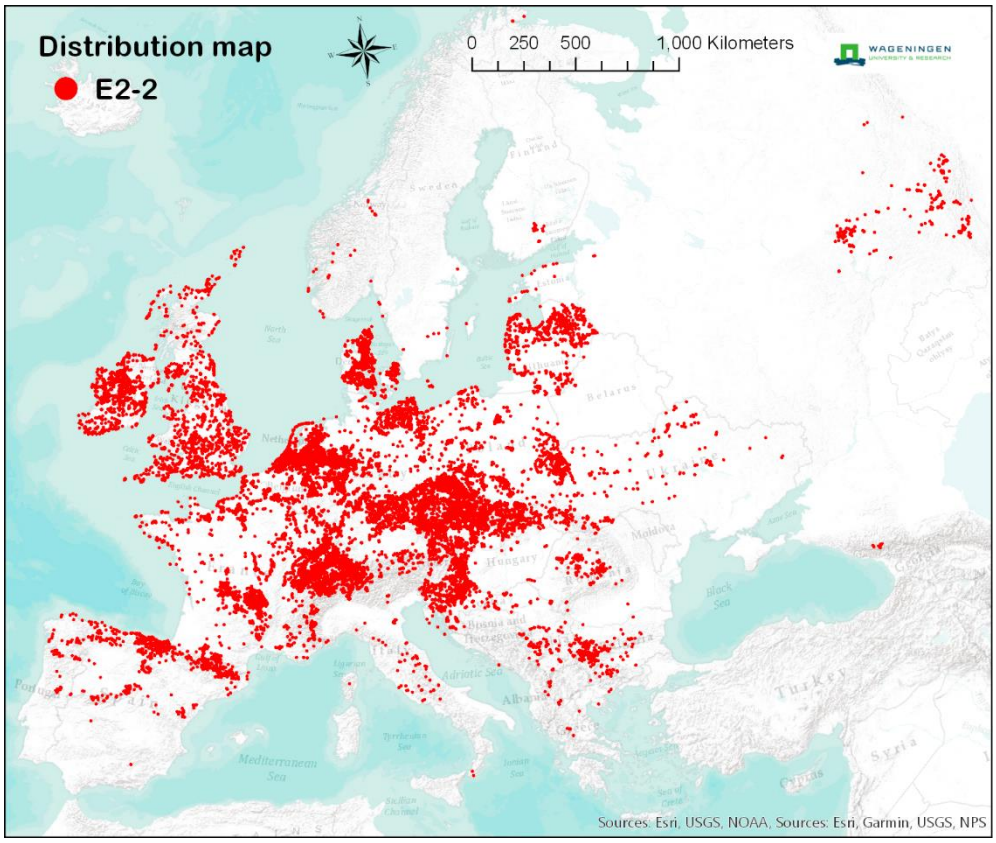


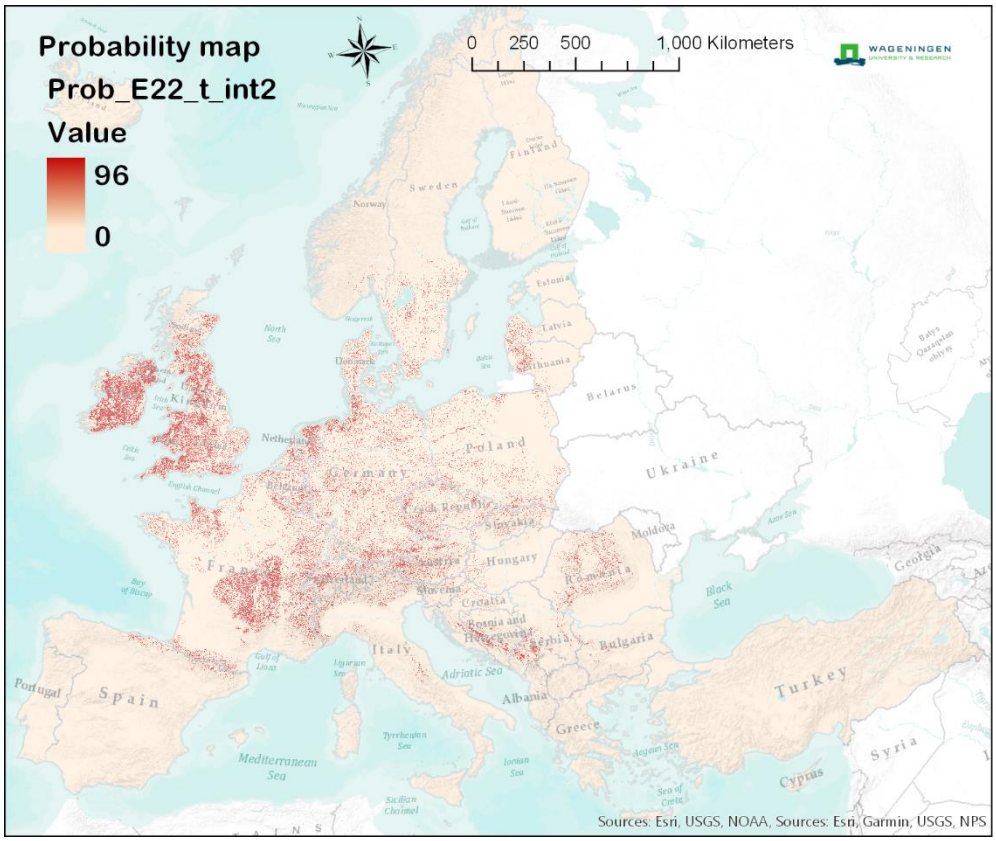


Example detail of the European habitat probability map at 20 m resolution for E2.1 Mesic permanent pasture of lowlands and mountains

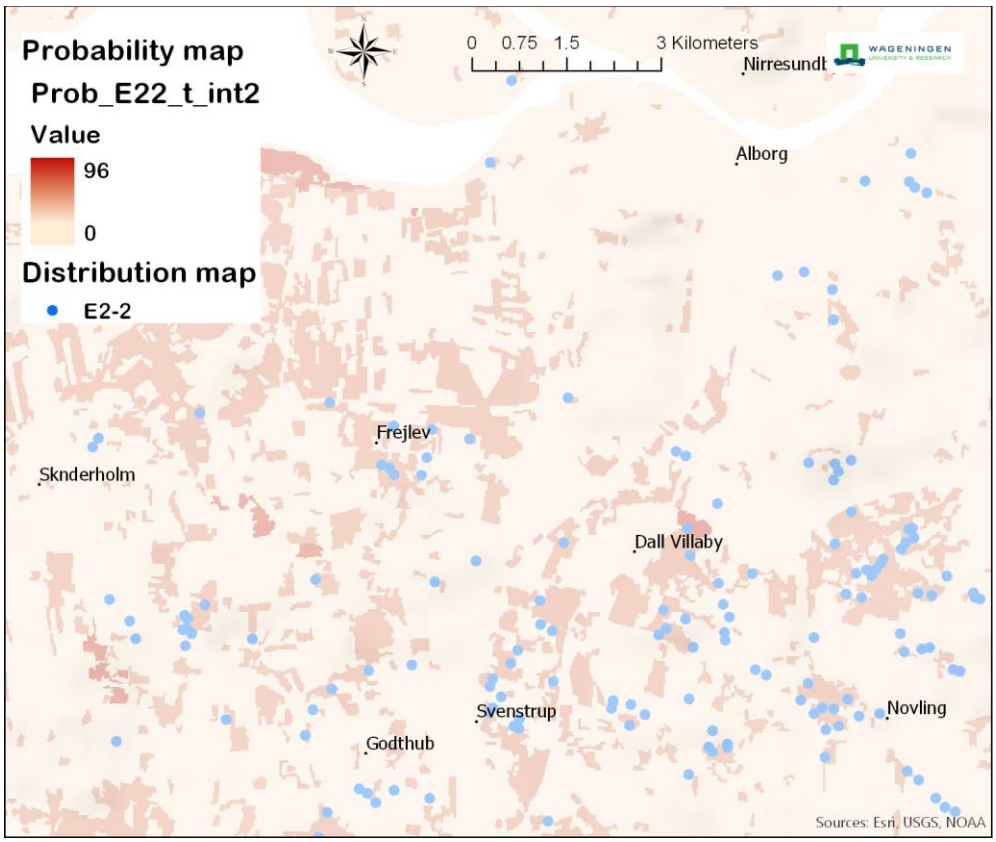


E2.2 Low and medium altitude hay meadow

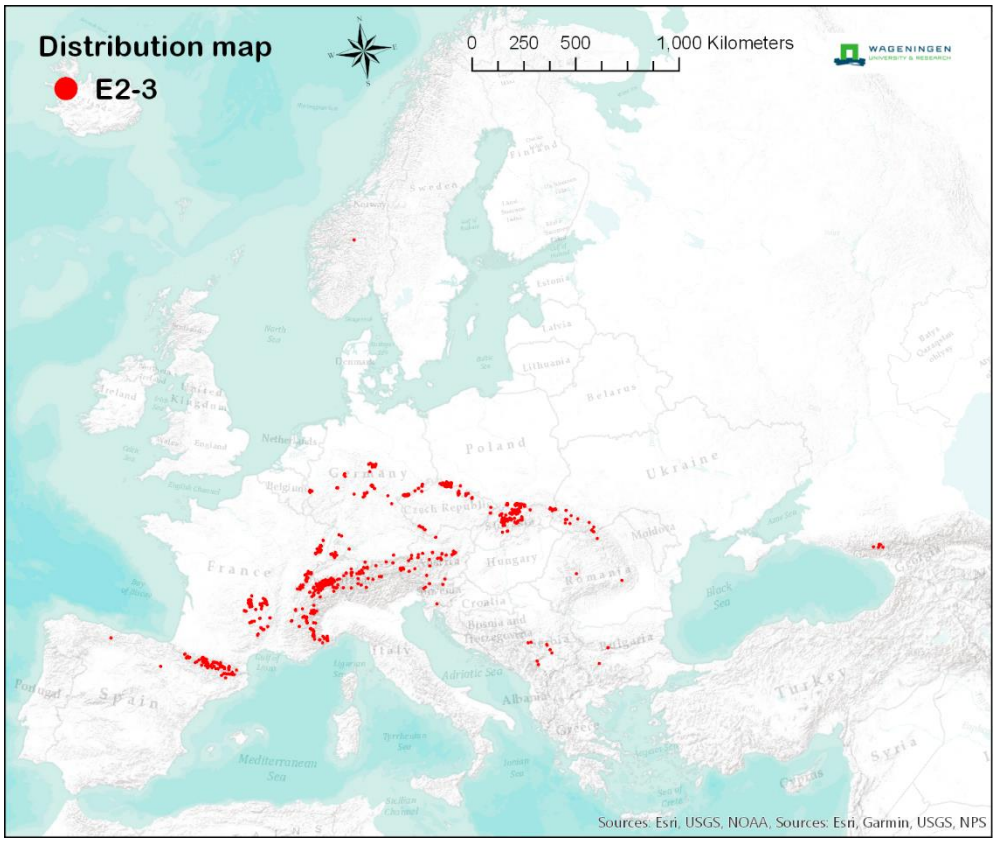


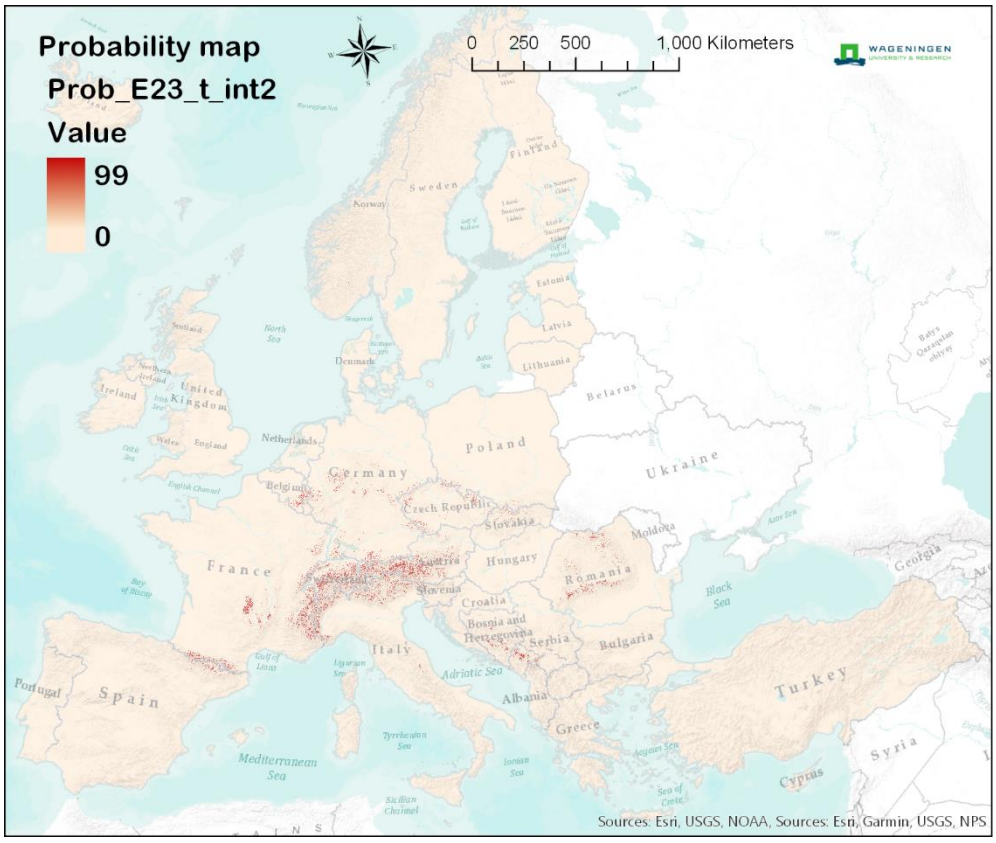


Example detail of the European habitat probability map at 20 m resolution for E2.2 Low and medium altitude hay meadow

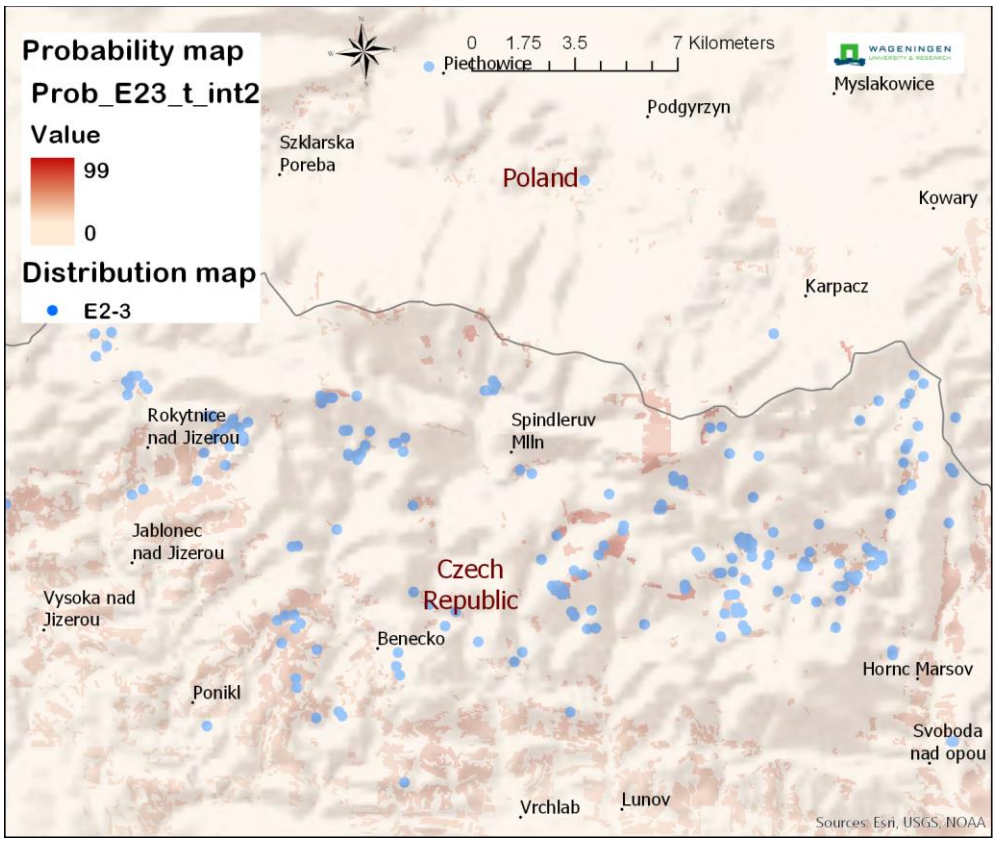


E2.3 Mountain hay meadow

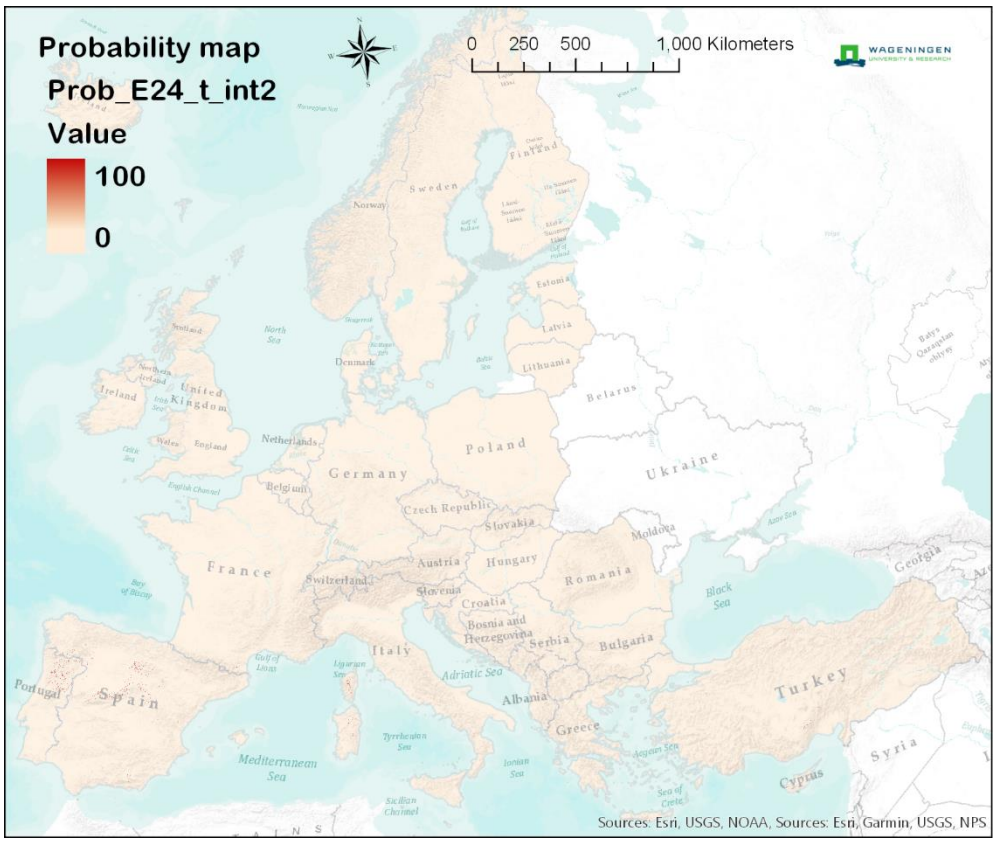


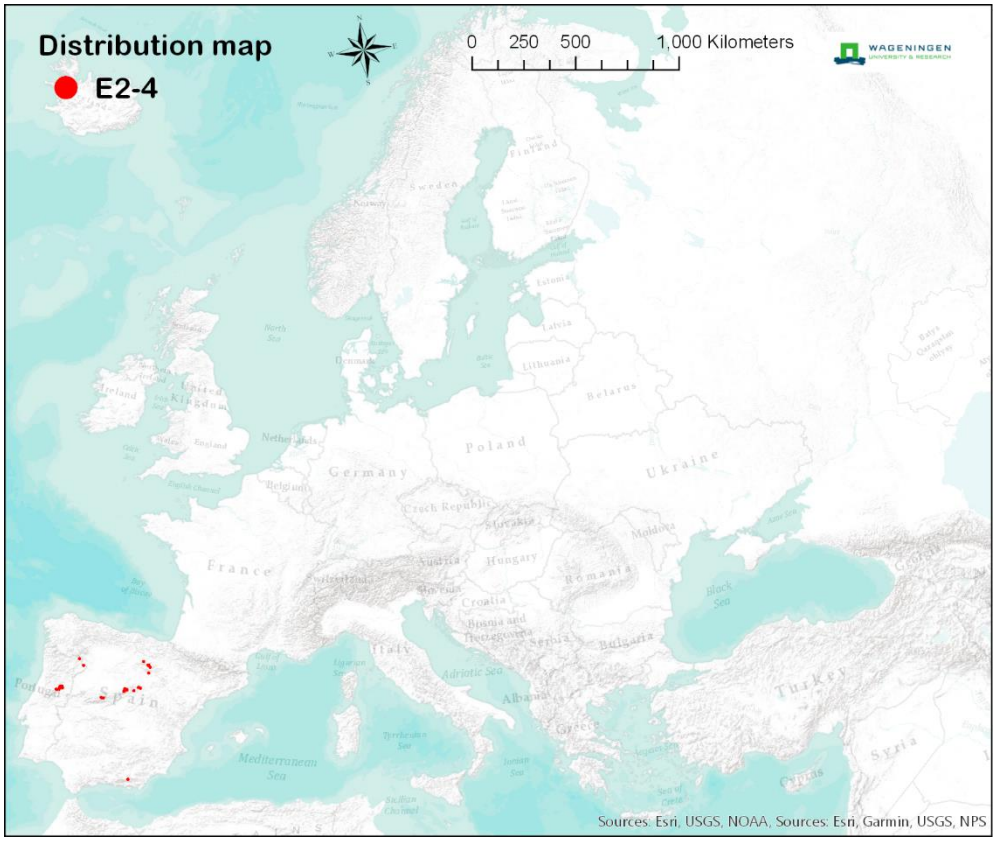


Example detail of the European habitat probability map at 20 m resolution for E2.3 Mountain hay meadow

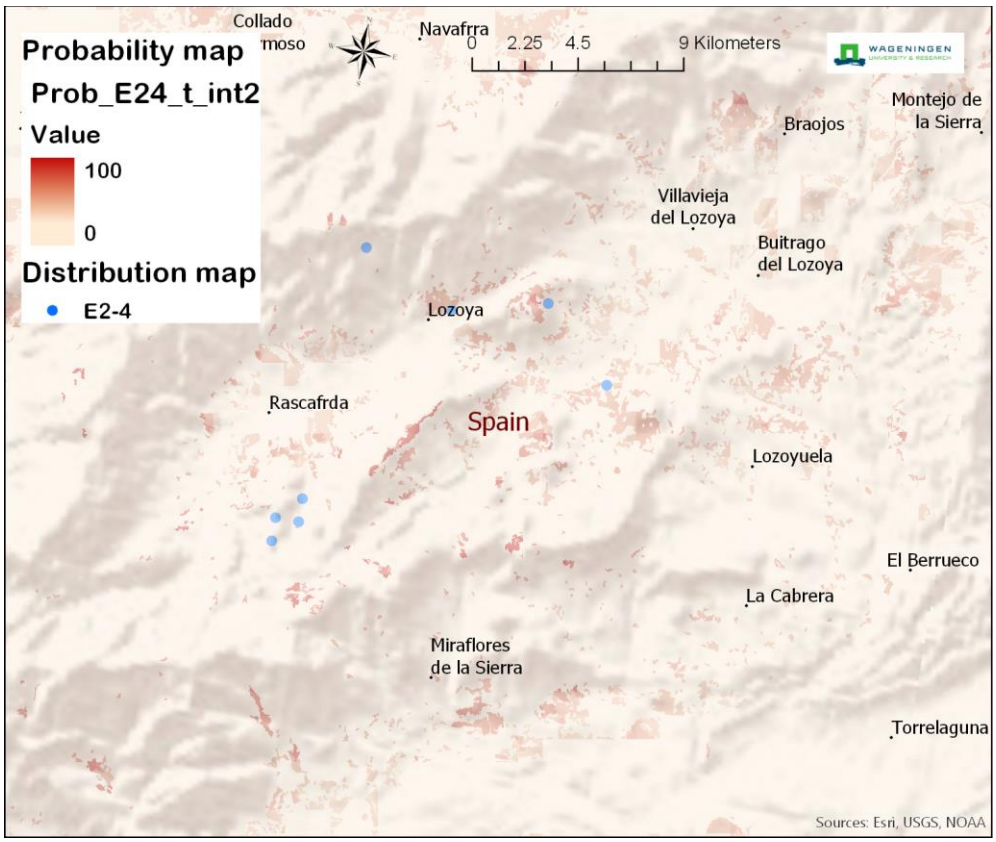


E2.4 Iberian summer pasture (vallicar)

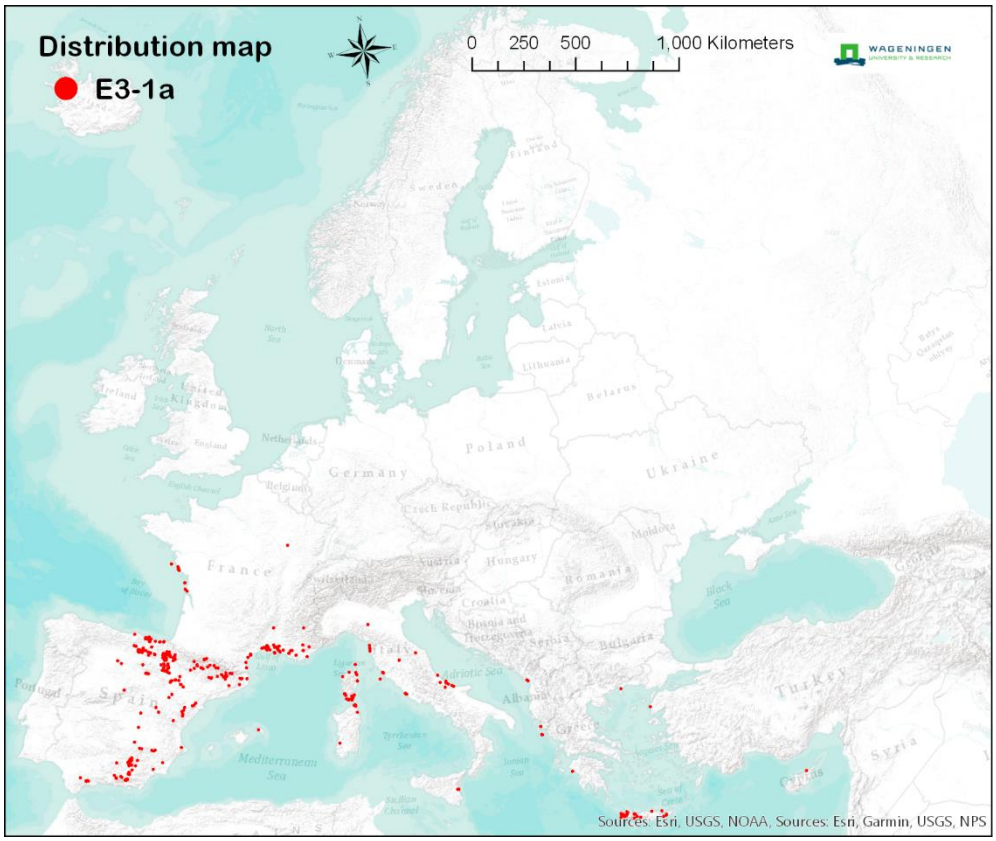


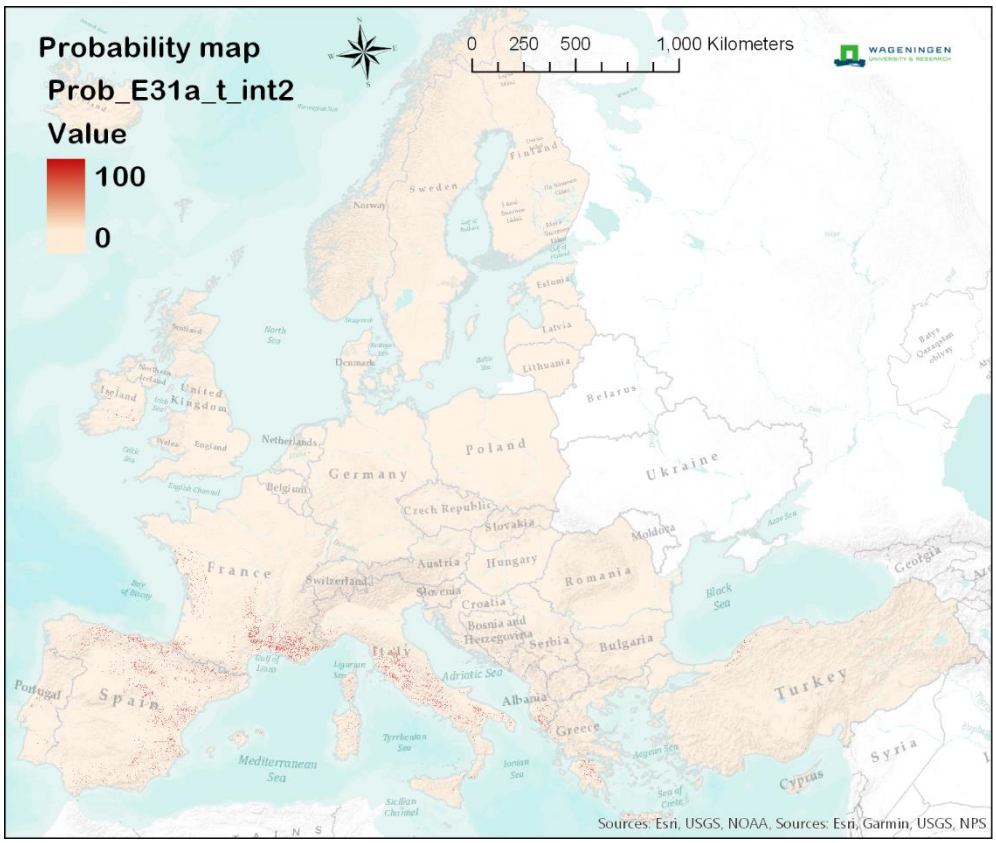


Example detail of the European habitat probability map at 20 m resolution for E2.4 Iberian summer pasture (vallicar)

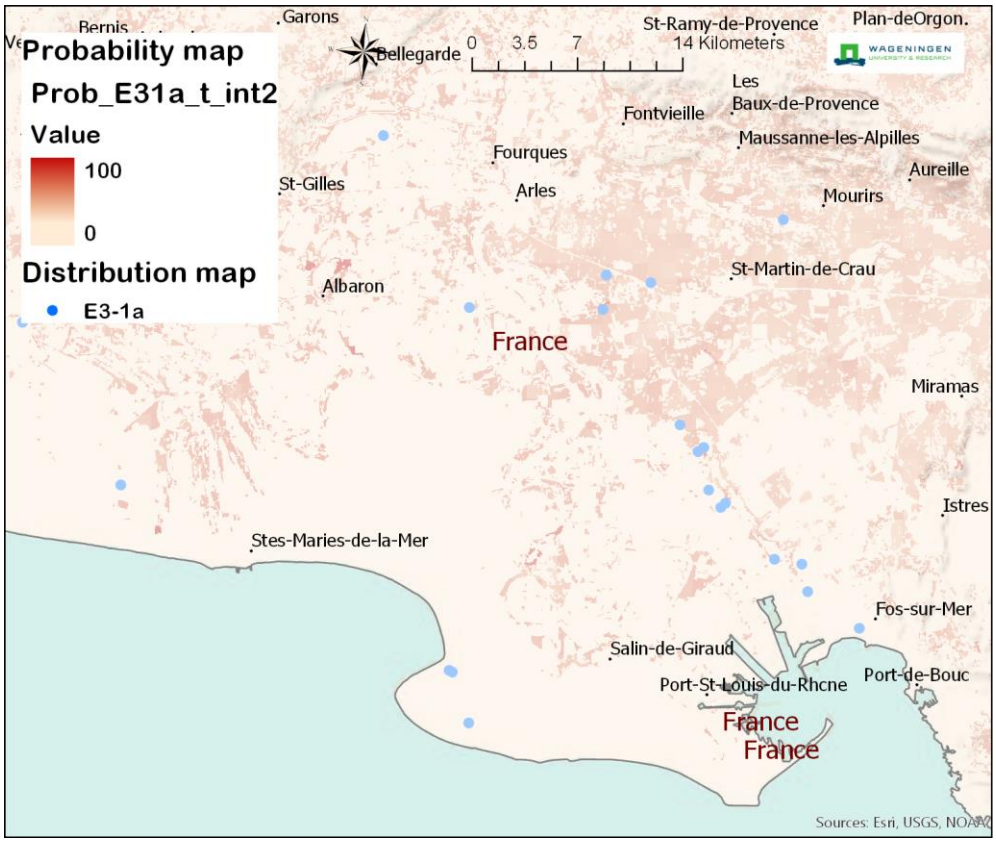


E3.1a Mediterranean tall humid inland grassland

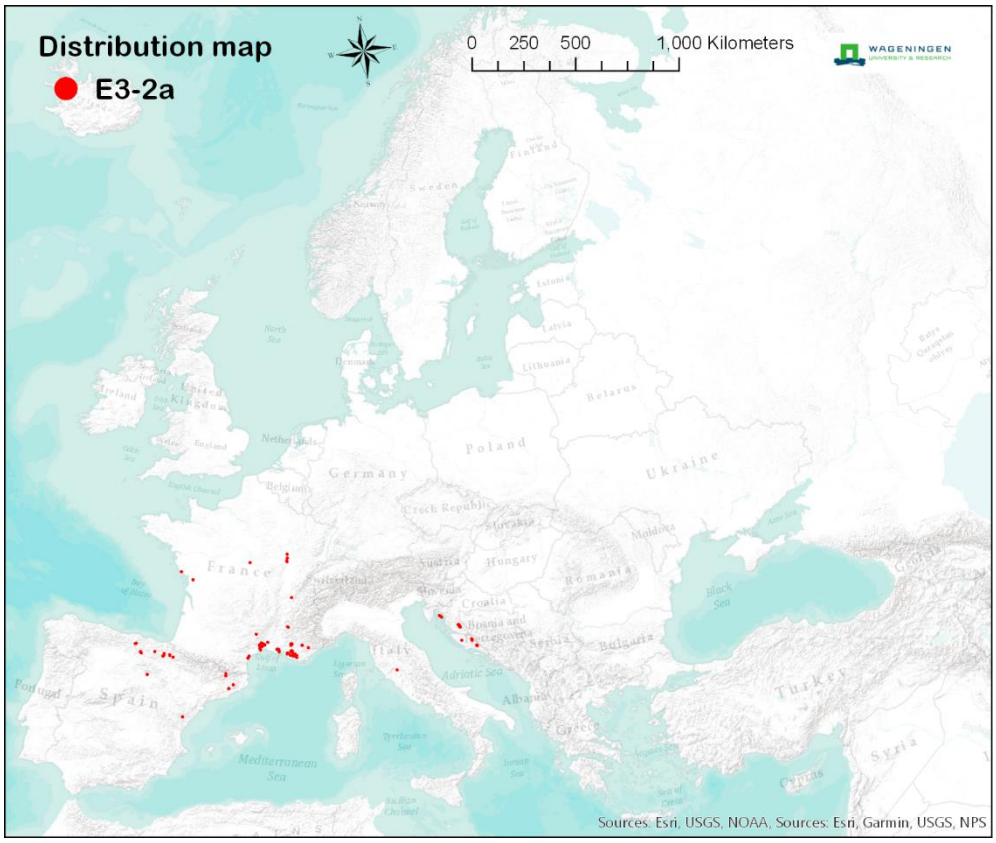


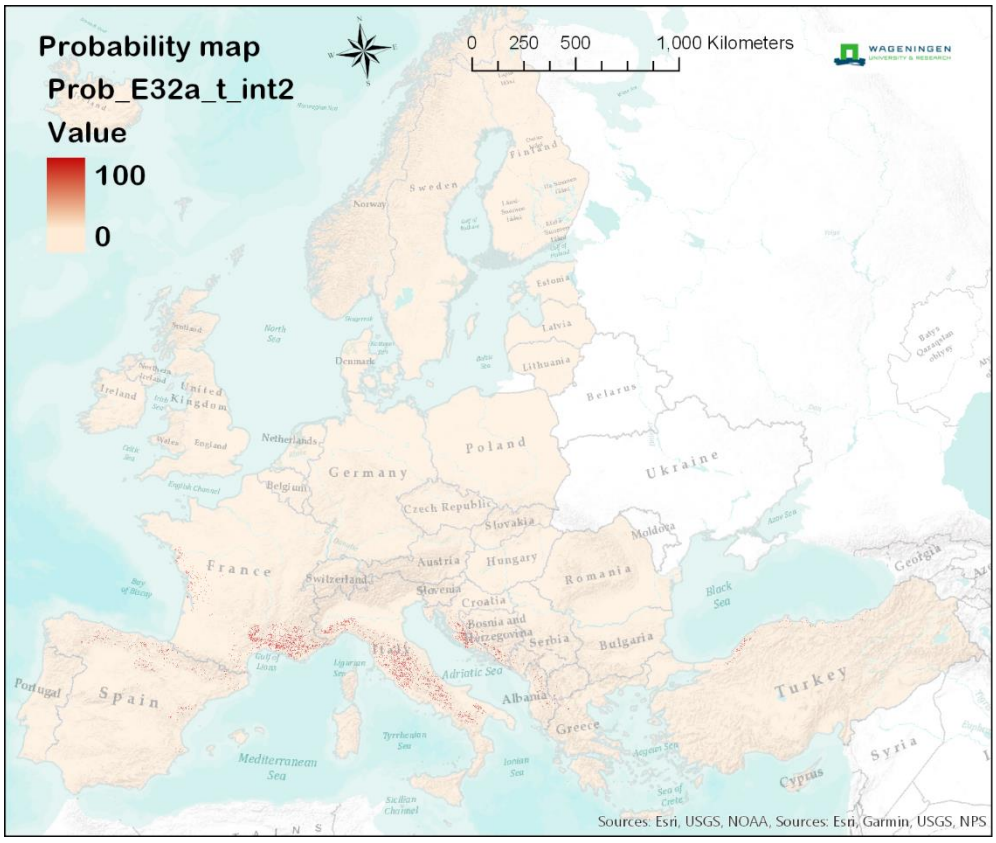


Example detail of the European habitat probability map at 20 m resolution for E3.1a Mediterranean tall humid inland grassland

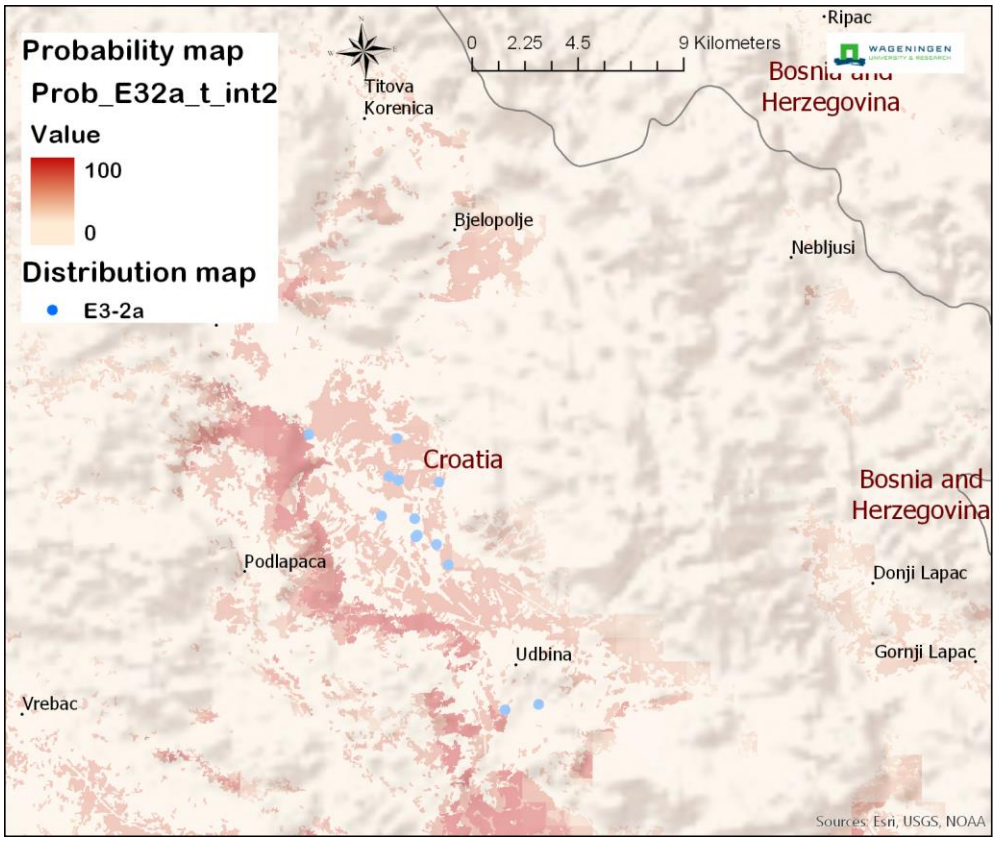


E3.2a Mediterranean short moist grassland of lowlands

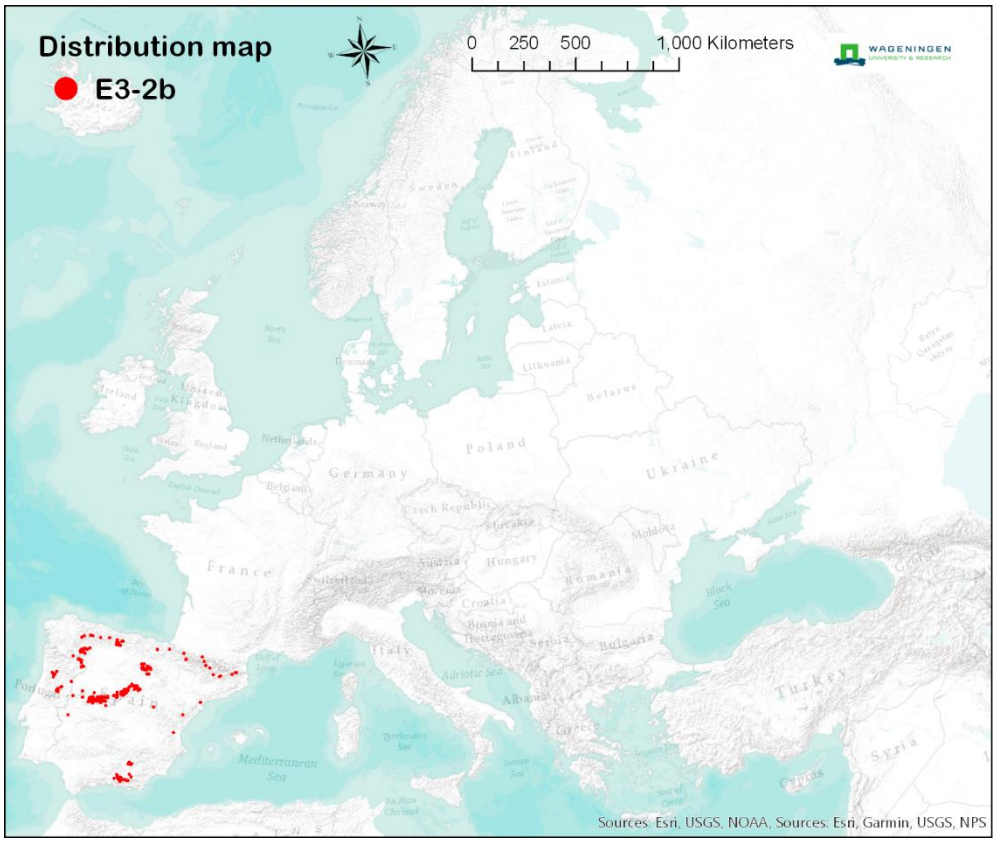


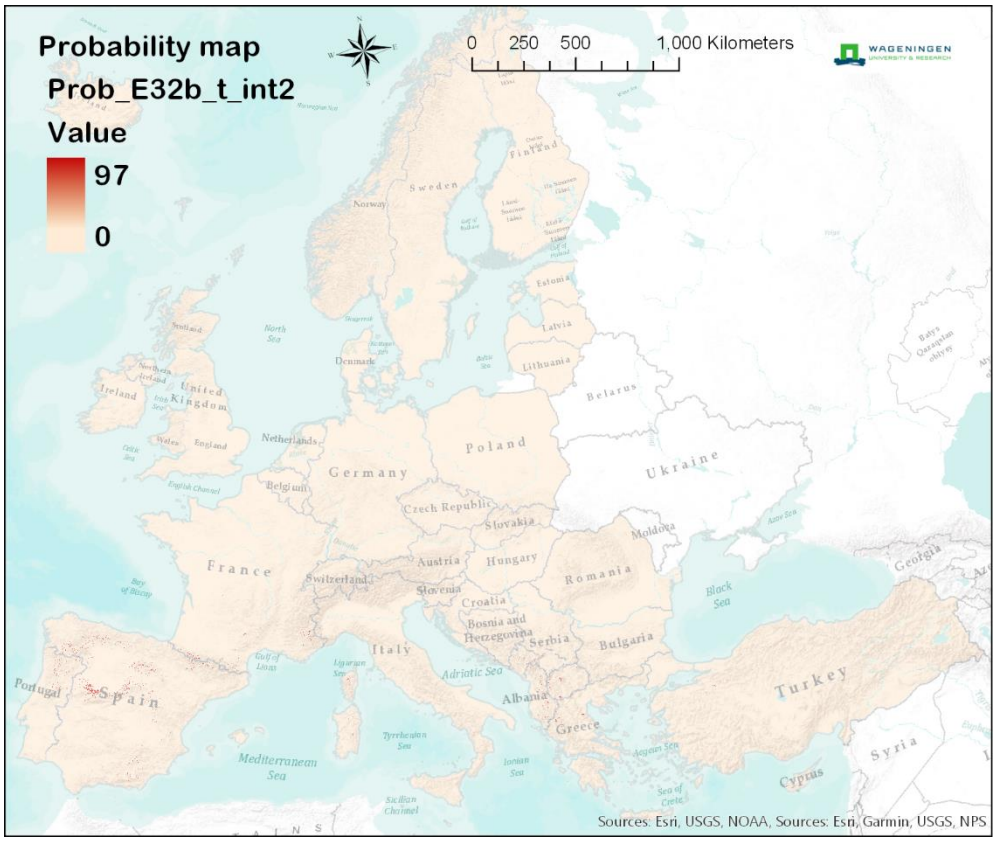


Example detail E3.2a Mediterranean short moist grassland of lowlands

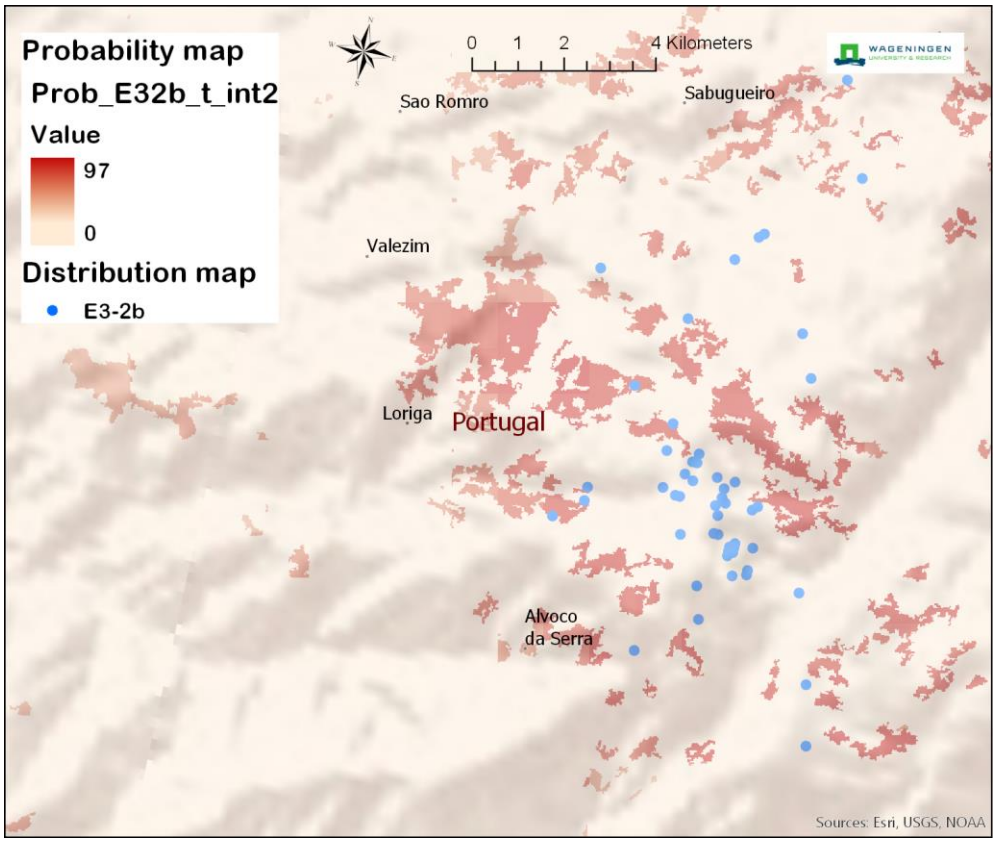


E3.2b Mediterranean short moist grassland of mountains

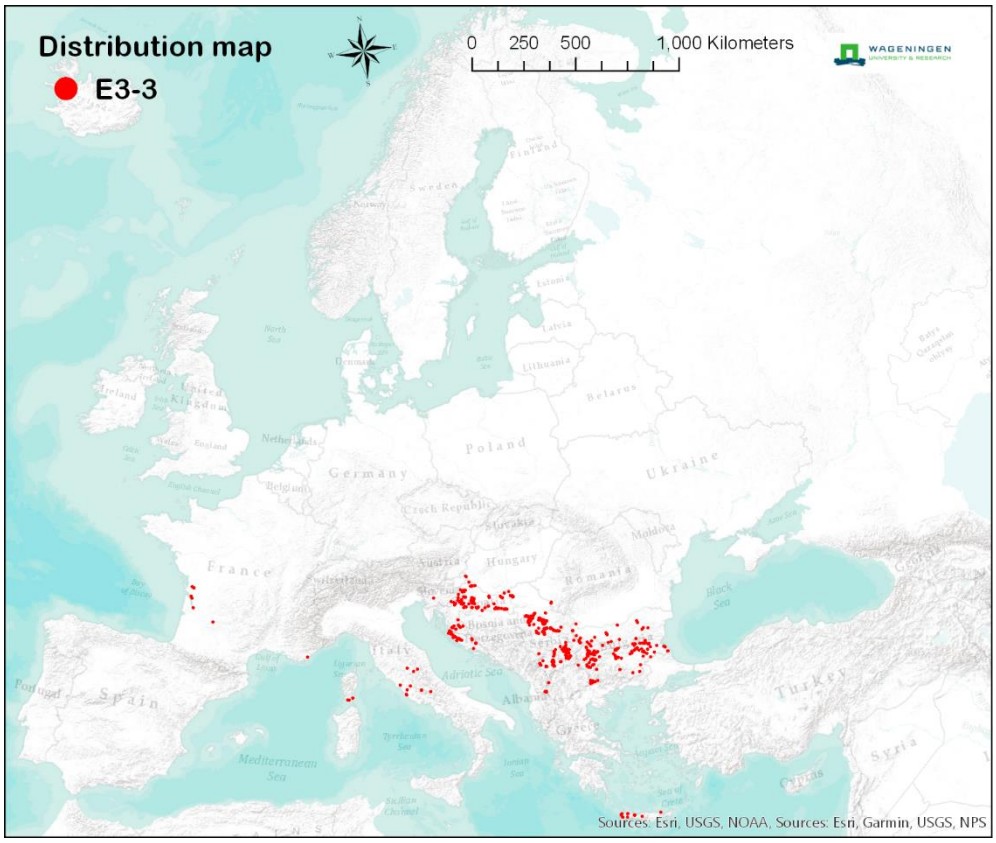


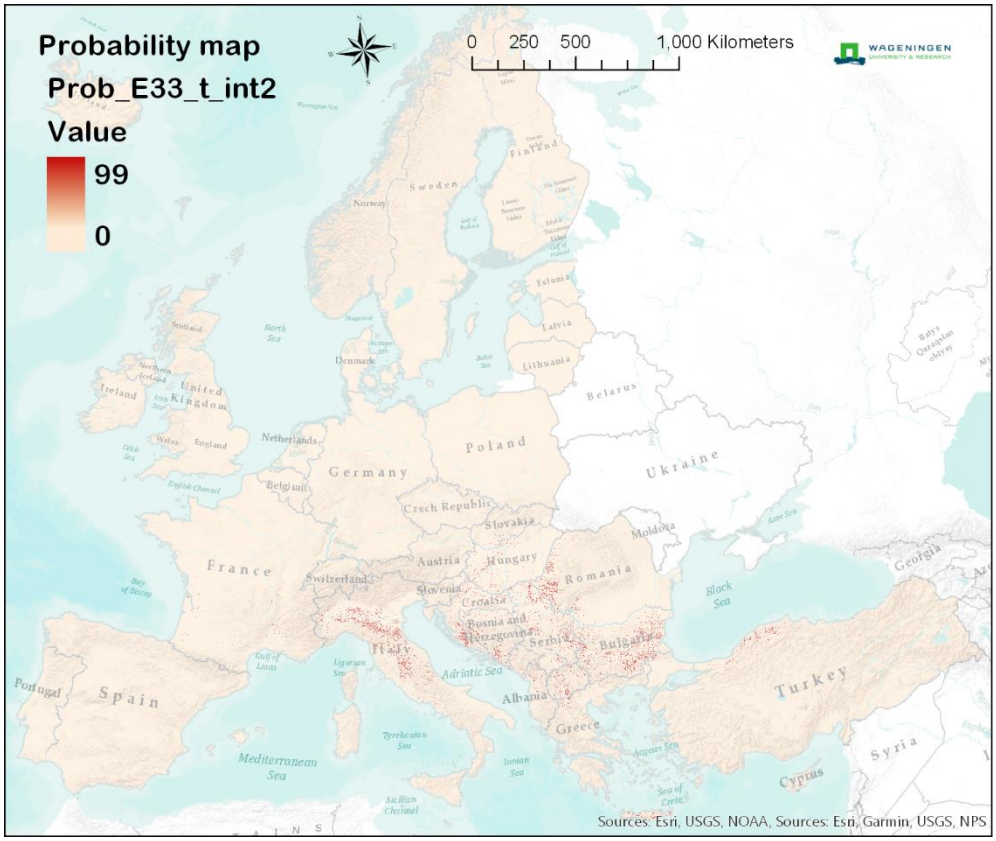


Example detail of the European habitat probability map at 20 m resolution for E3.2b Mediterranean short moist grassland of mountains

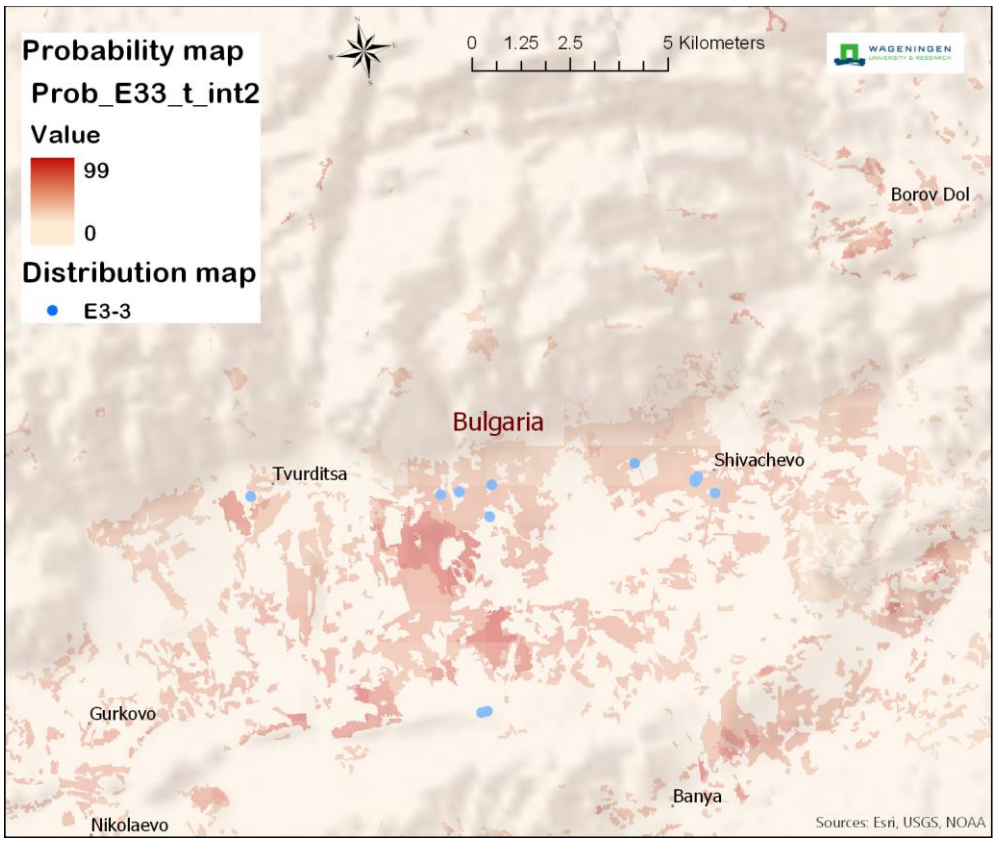


E3.3 Submediterranean moist meadow

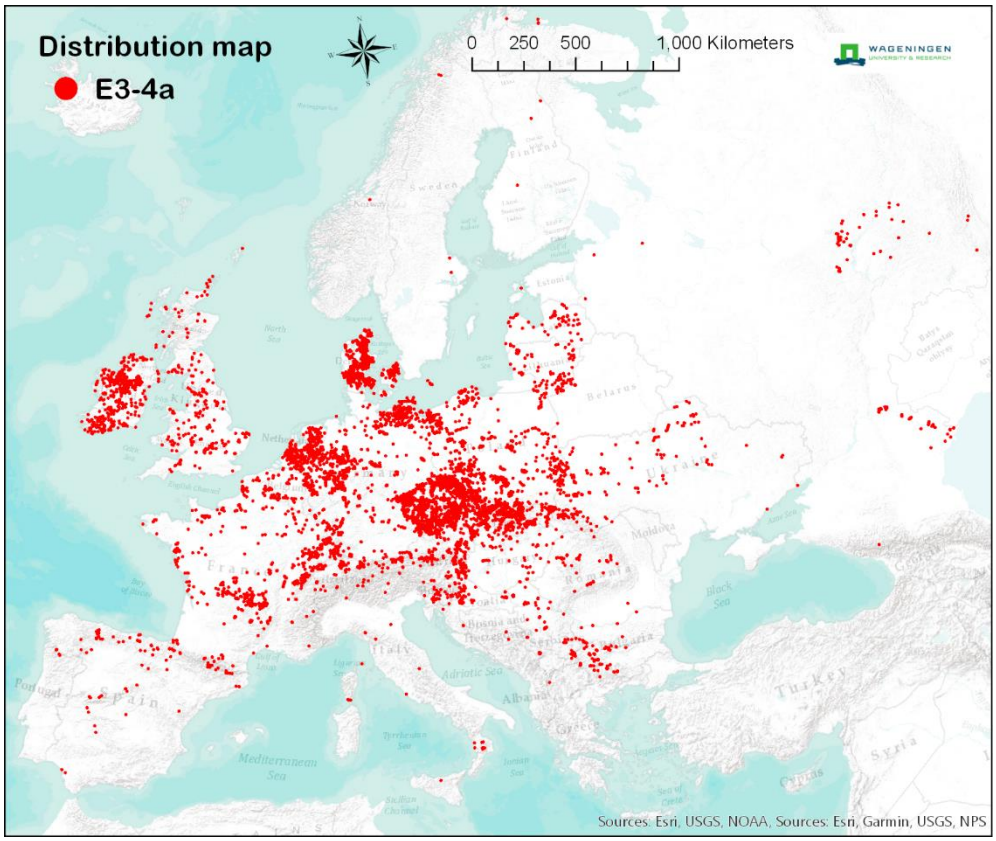


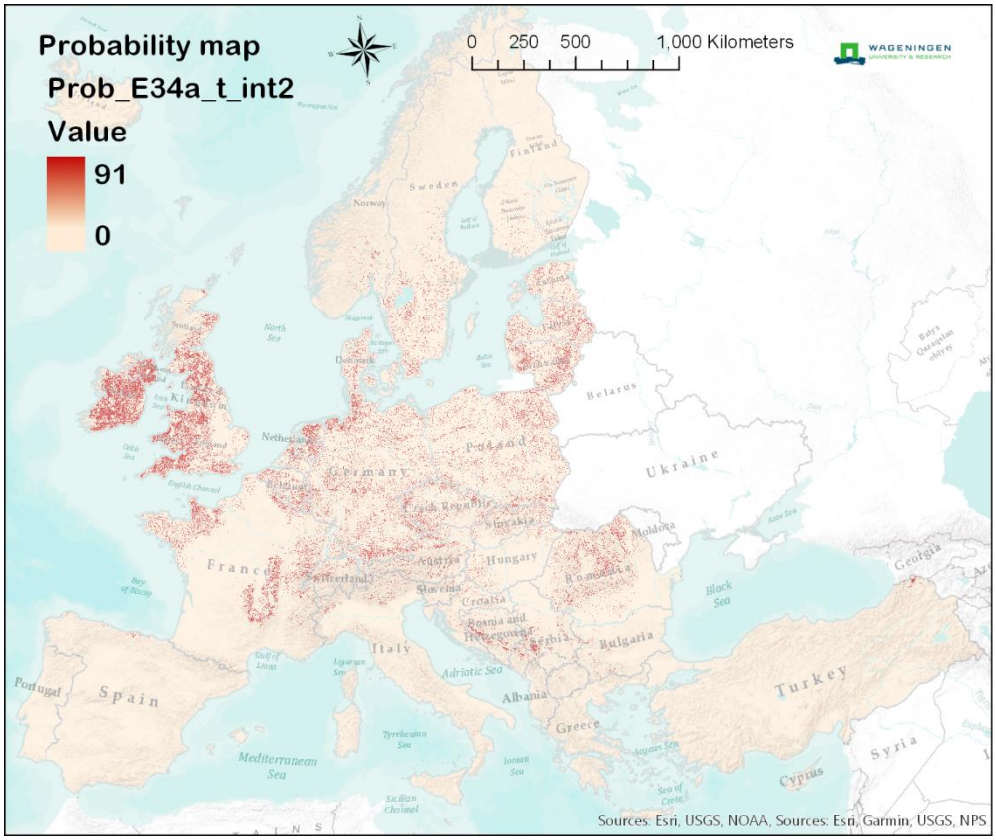


Example detail of the European habitat probability map at 20 m resolution for E3.3 Submediterranean moist meadow

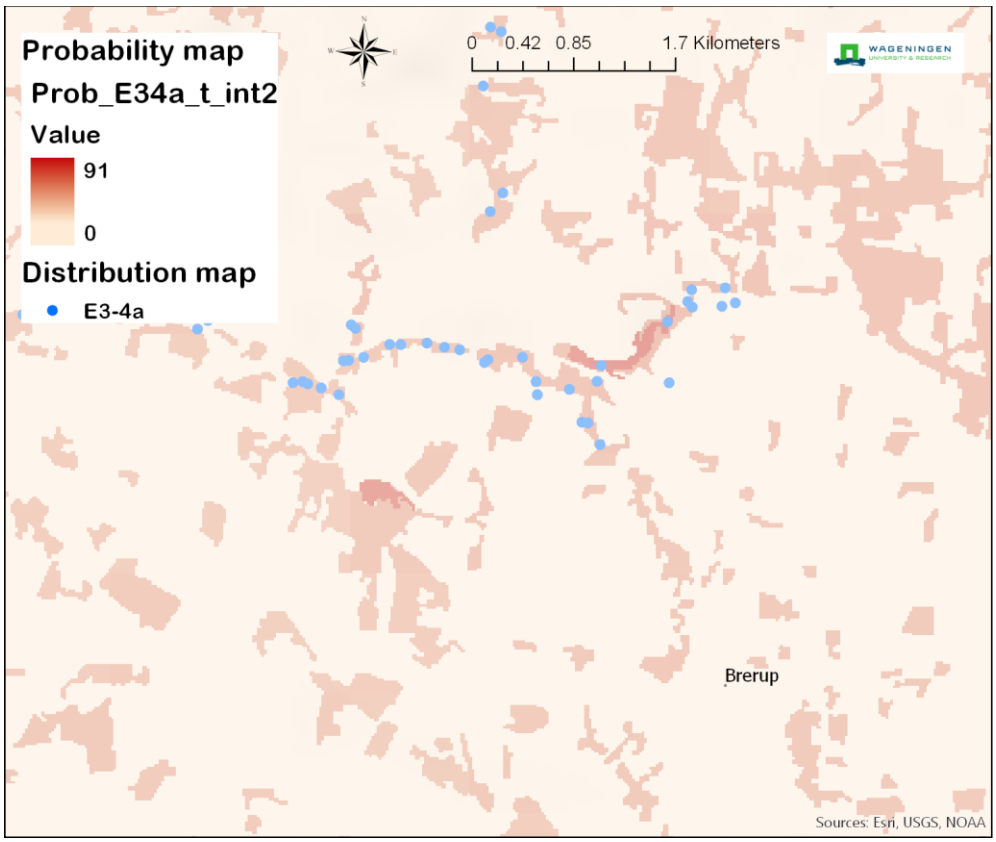


E3.4a Moist or wet mesotrophic to eutrophic hay meadow

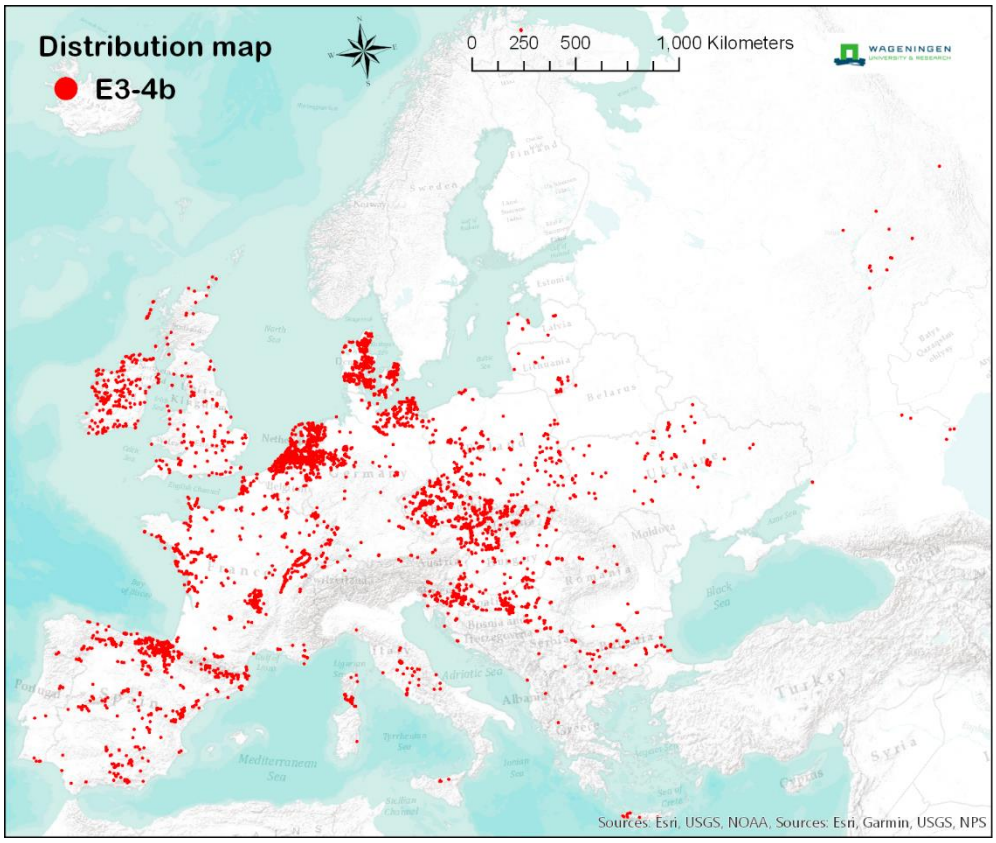


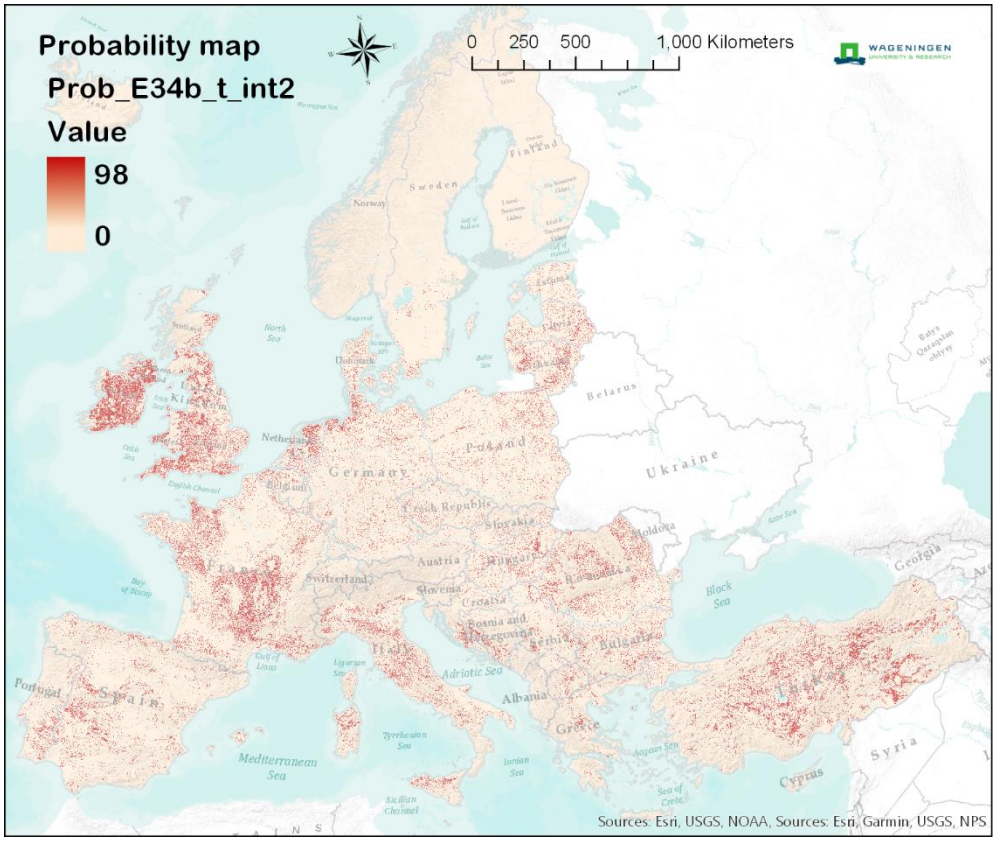


Example detail of the European habitat probability map at 20 m resolution for E3.4a Moist or wet mesotrophic to eutrophic hay meadow

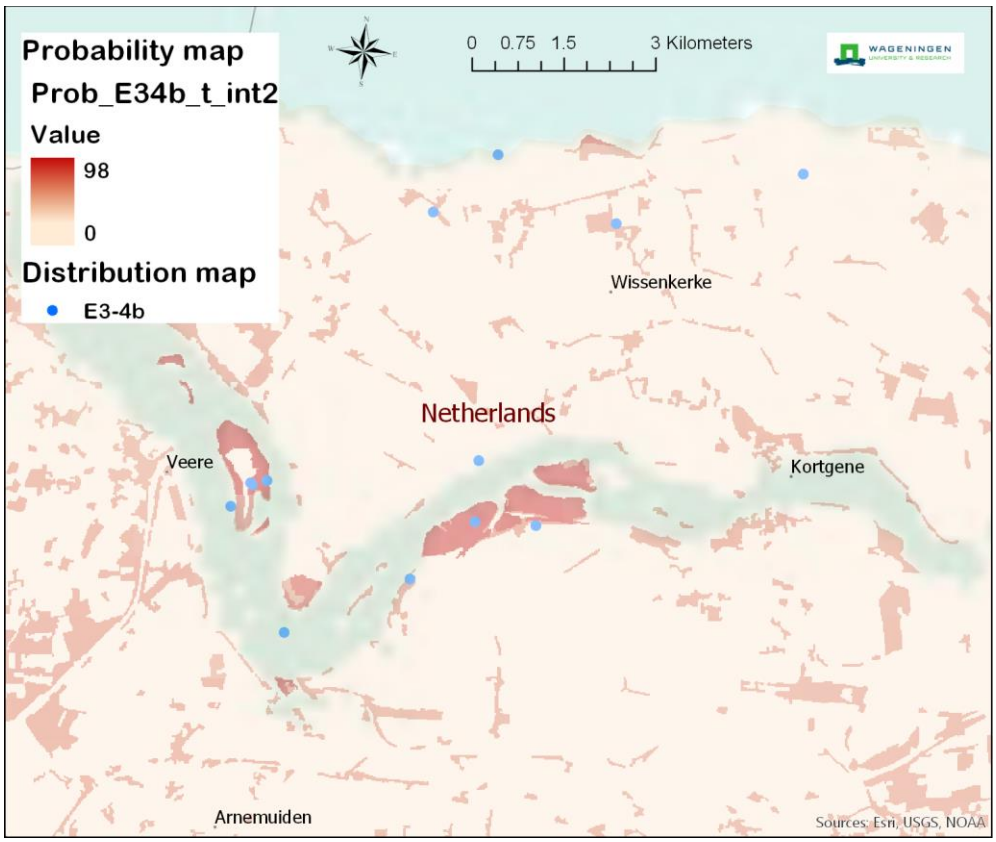


E3.4bMoist or wet mesotrophic to eutrophic pasture

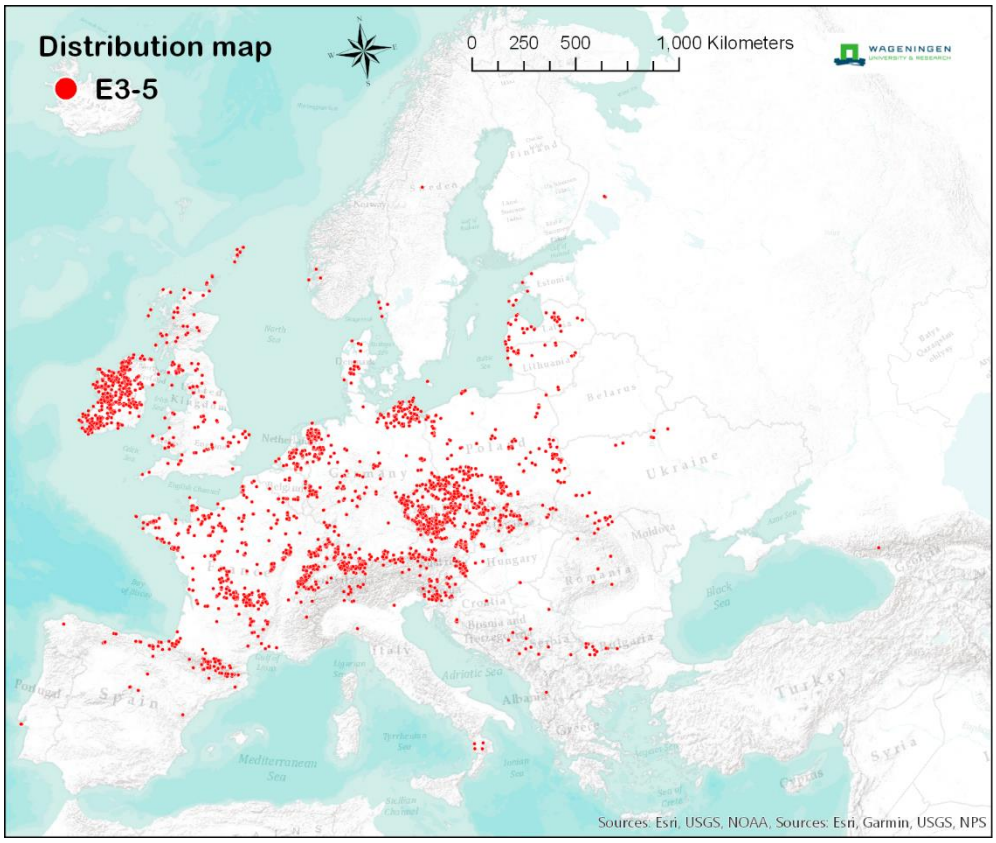


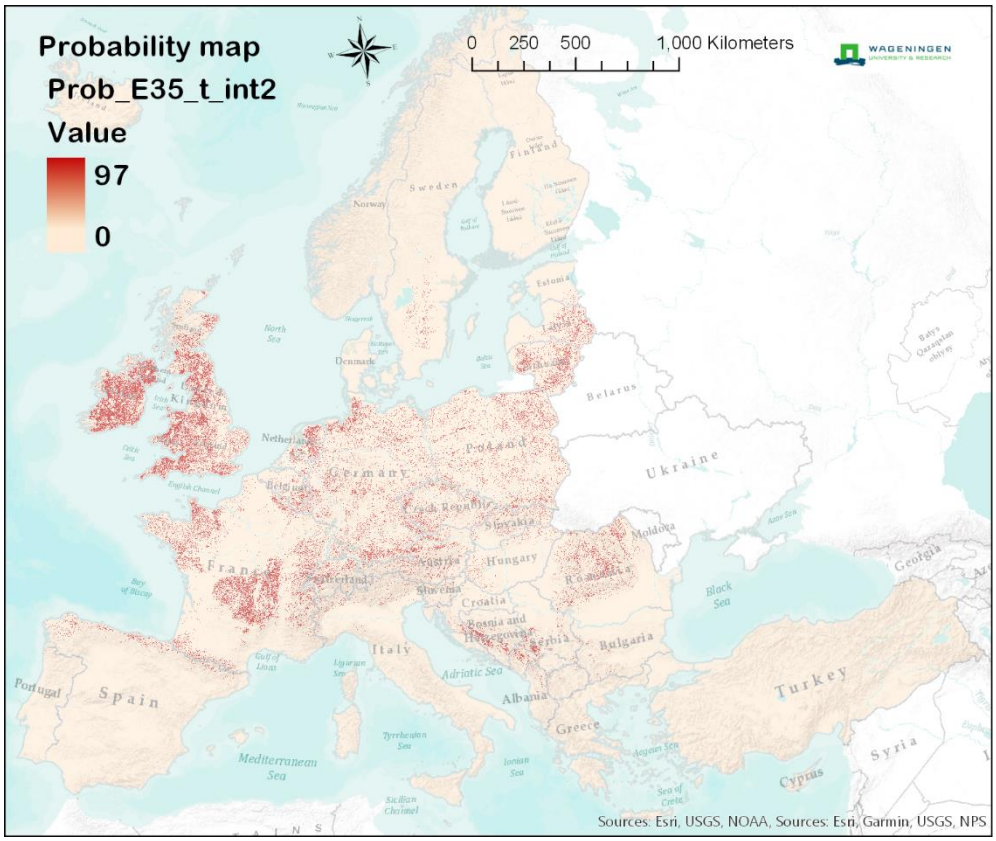


Example detail of the European habitat probability map at 20 m resolution for E3.4b Moist or wet mesotrophic to eutrophic pasture

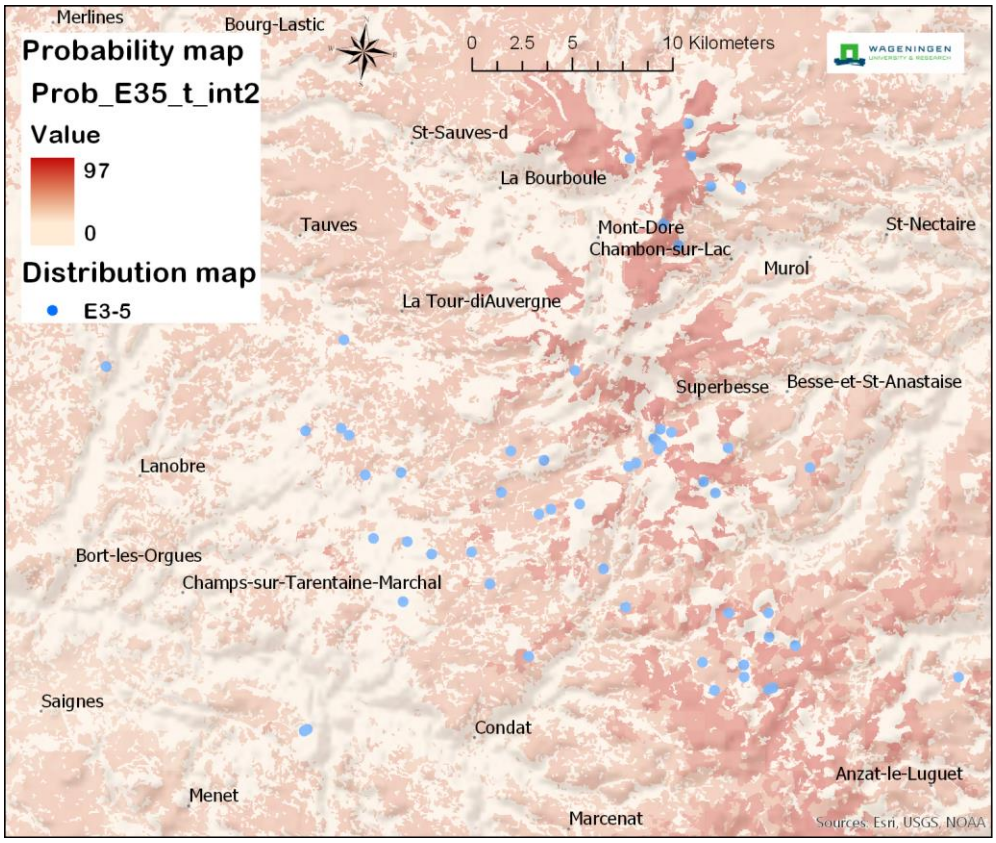


E3.5 Temperate and boreal moist or wet oligotrophic grassland

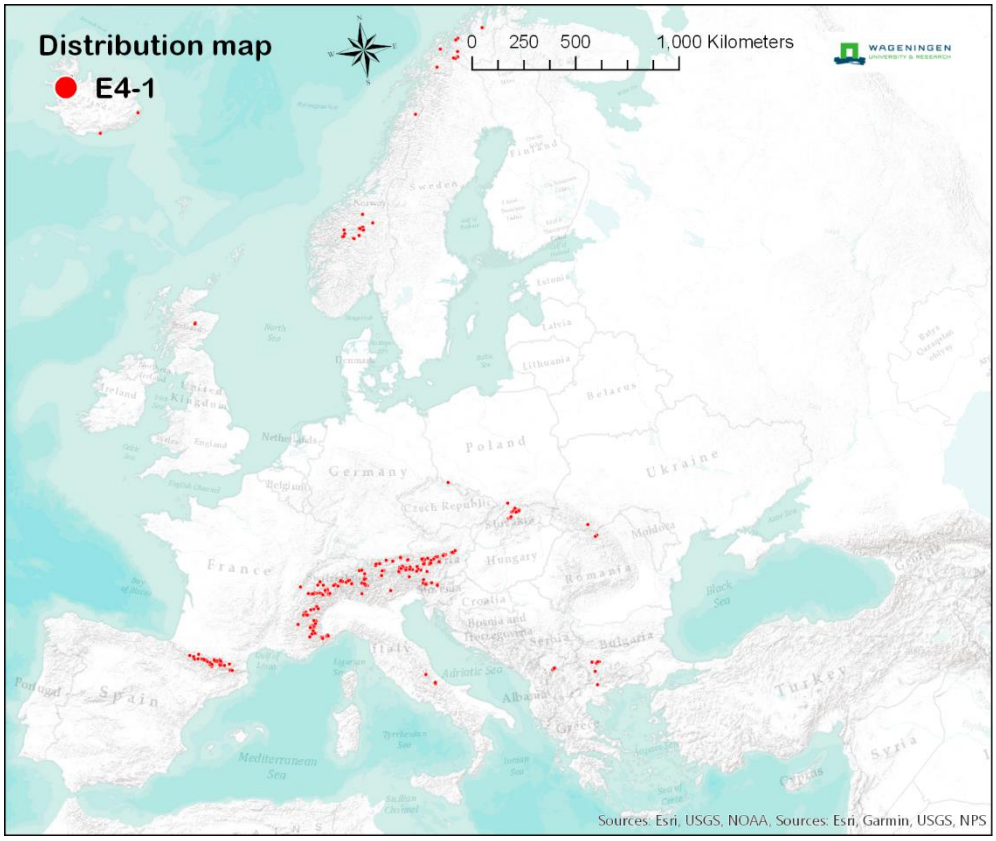


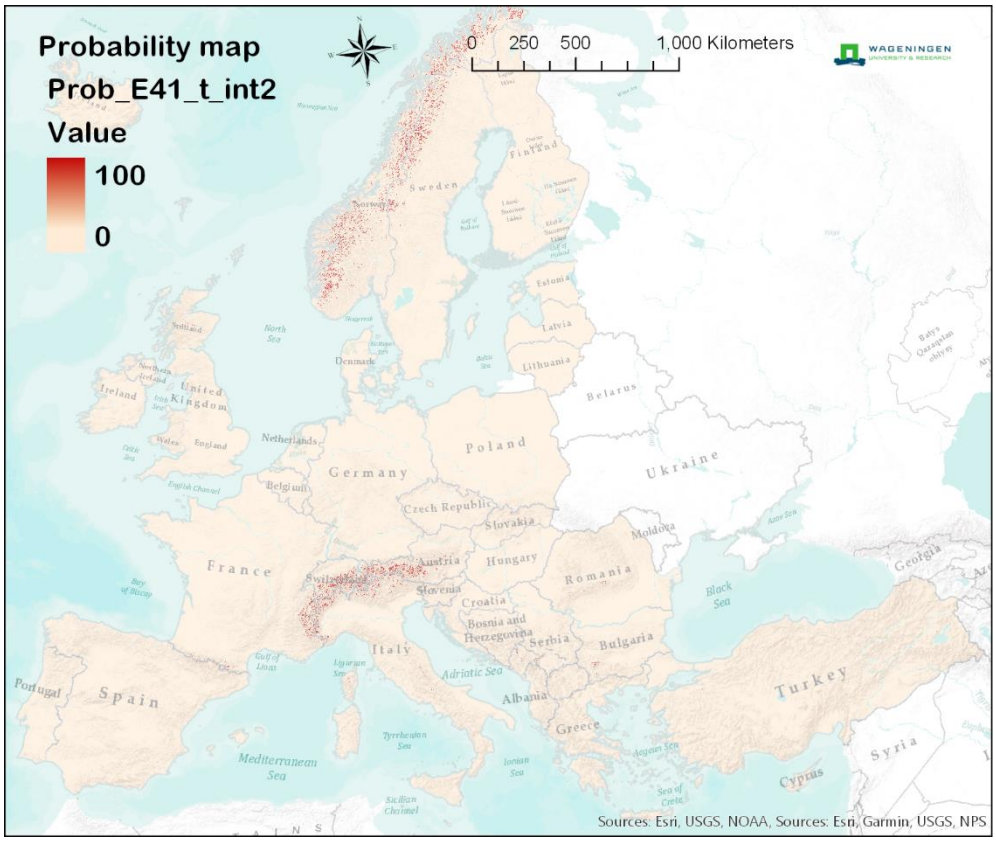


Example detail of the European habitat probability map at 20 m resolution for E3.5 Temperate and boreal moist or wet oligotrophic grassland

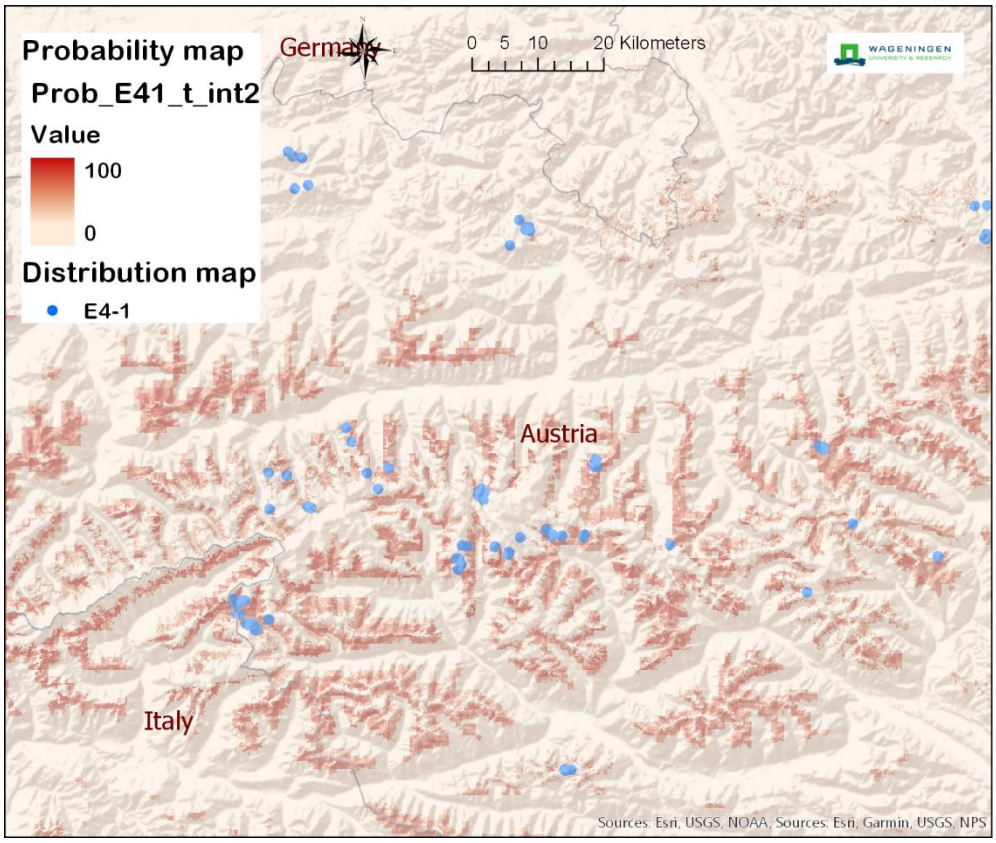


E4.1 Vegetated snow-patch

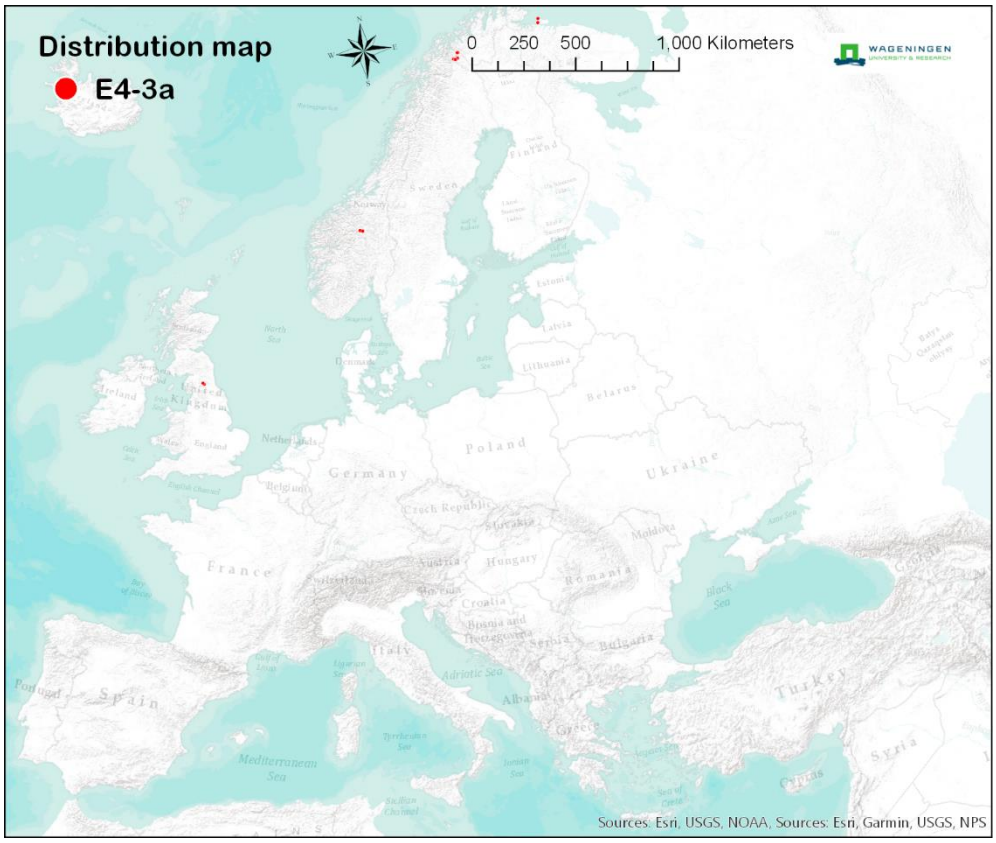


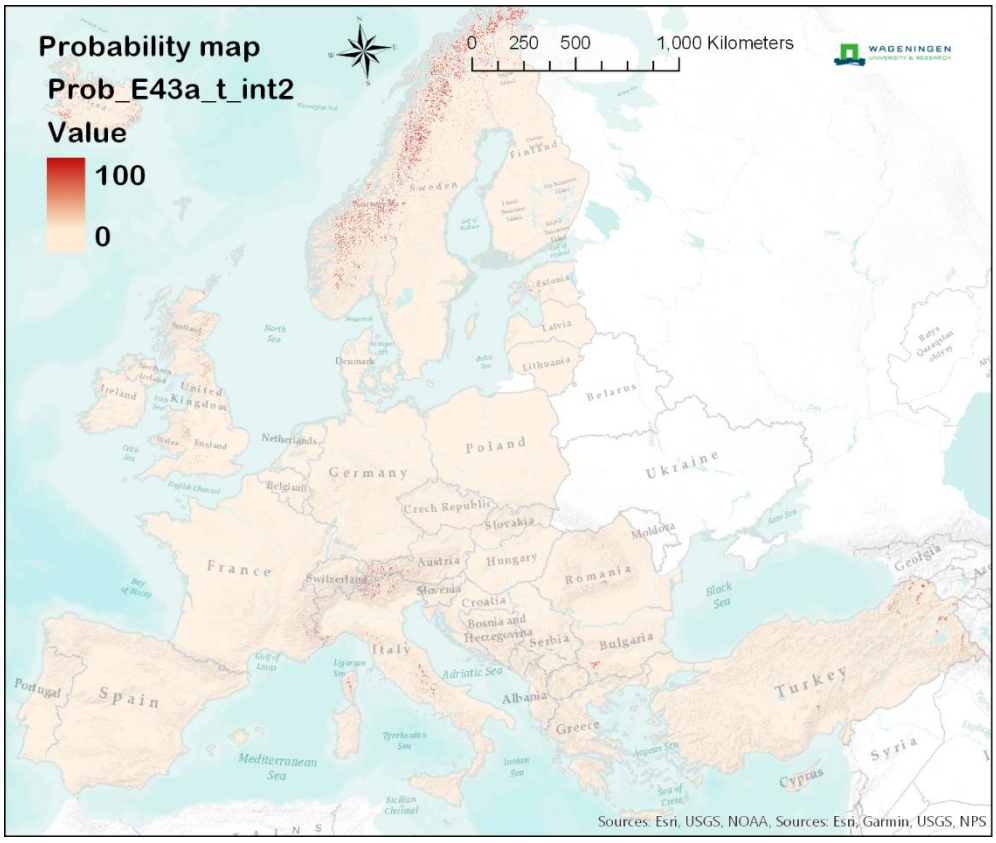


Example detail of the European habitat probability map at 20 m resolution for E4.1 Vegetated snow-patch

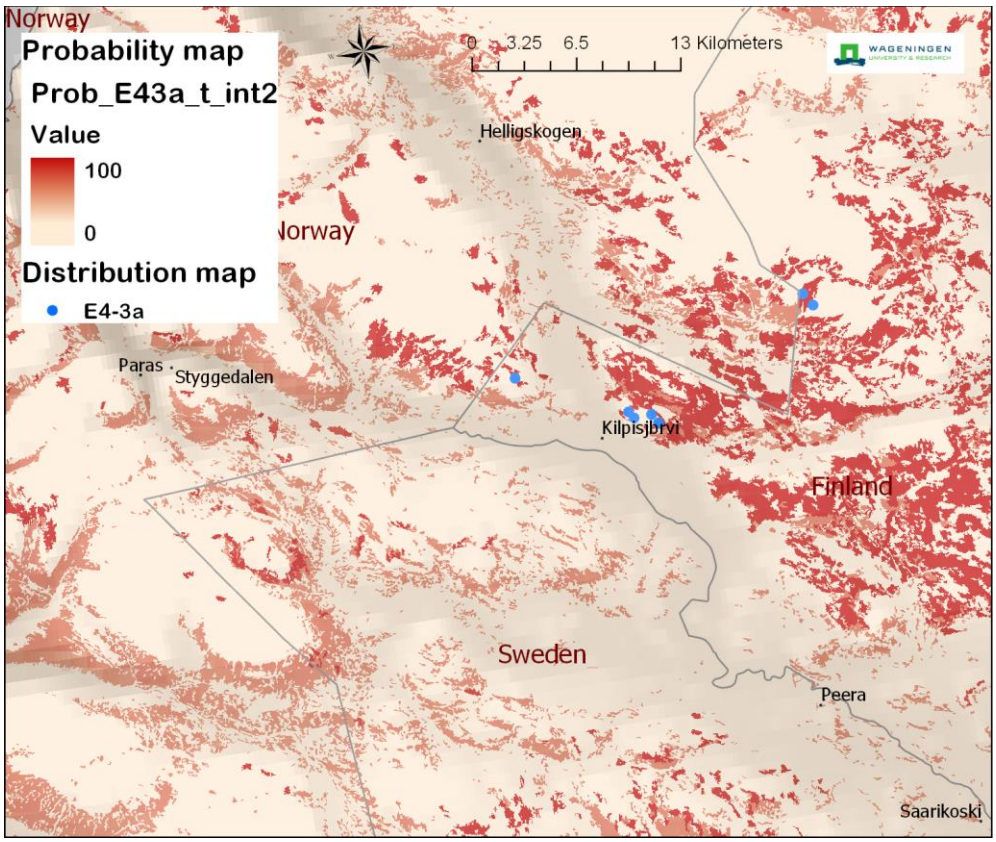


E4.3a Boreal and arctic acidophilous alpine grassland

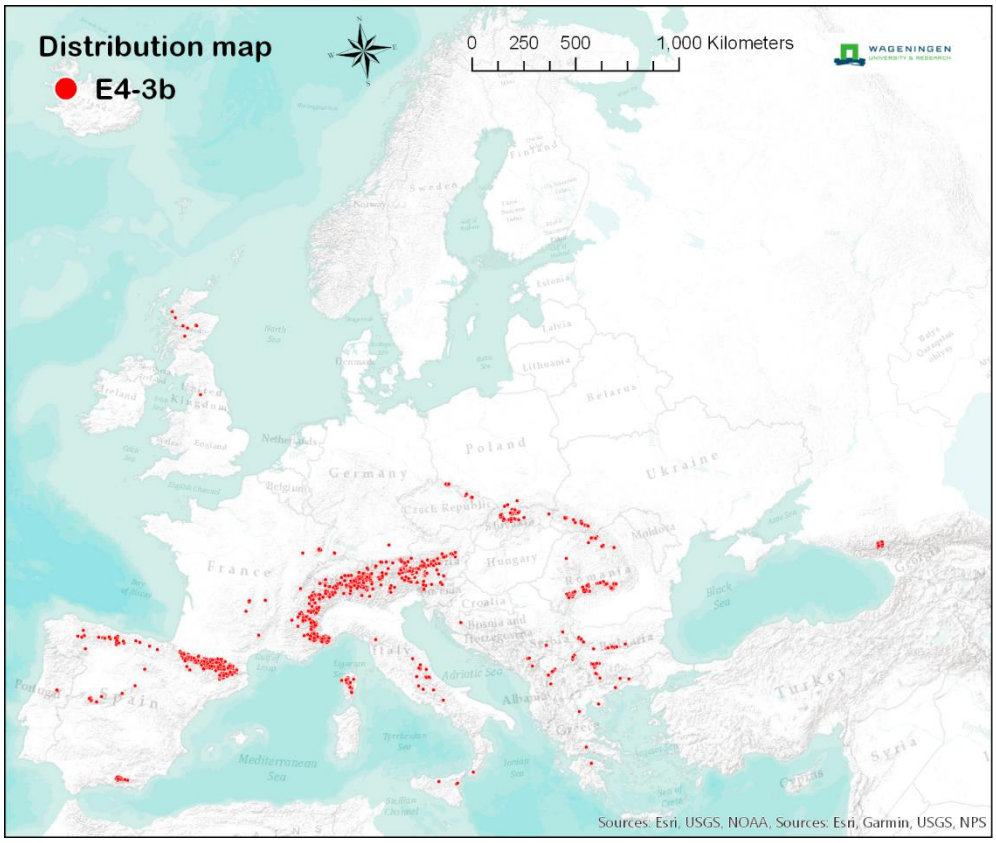


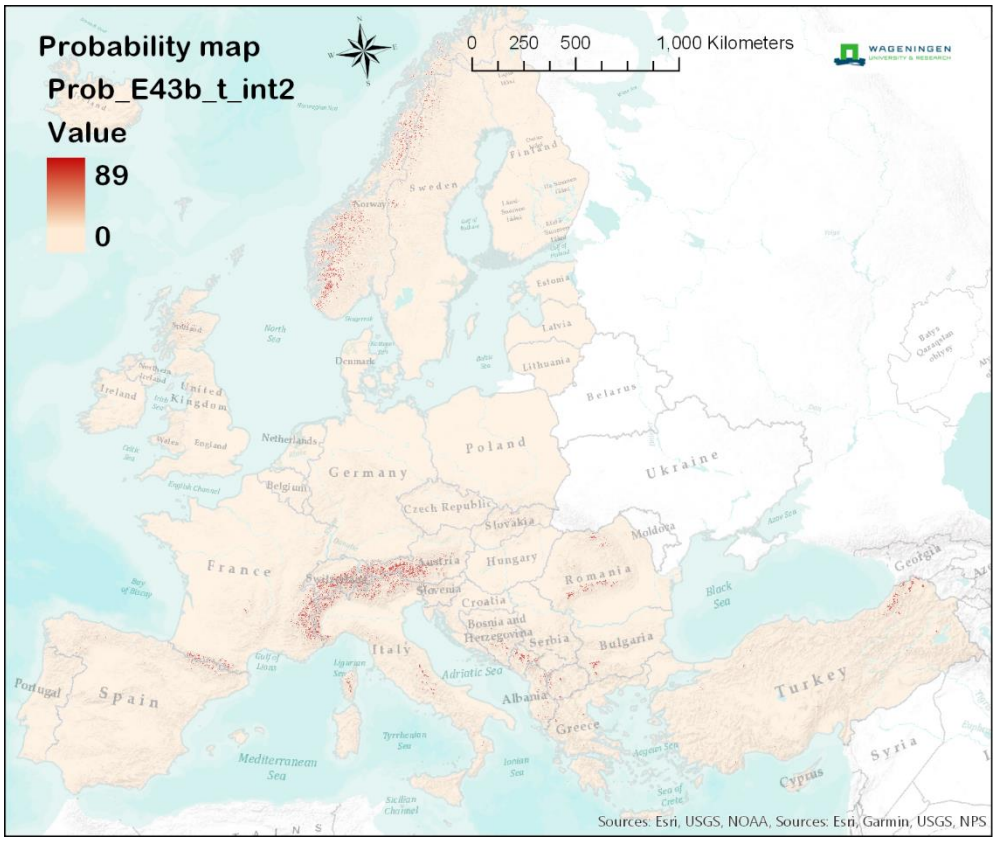


Example detail of the European habitat probability map at 20 m resolution for E4.3a Boreal and arctic acidophilous alpine grassland

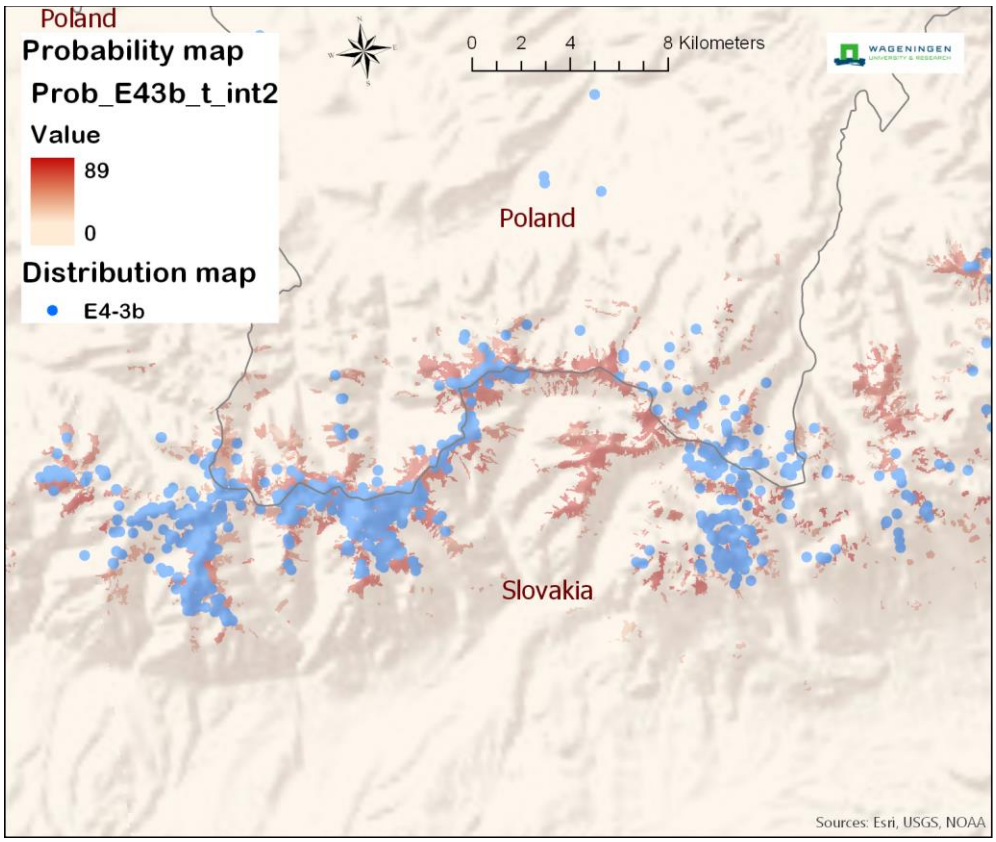


E4.3bTemperate acidophilous alpine grassland

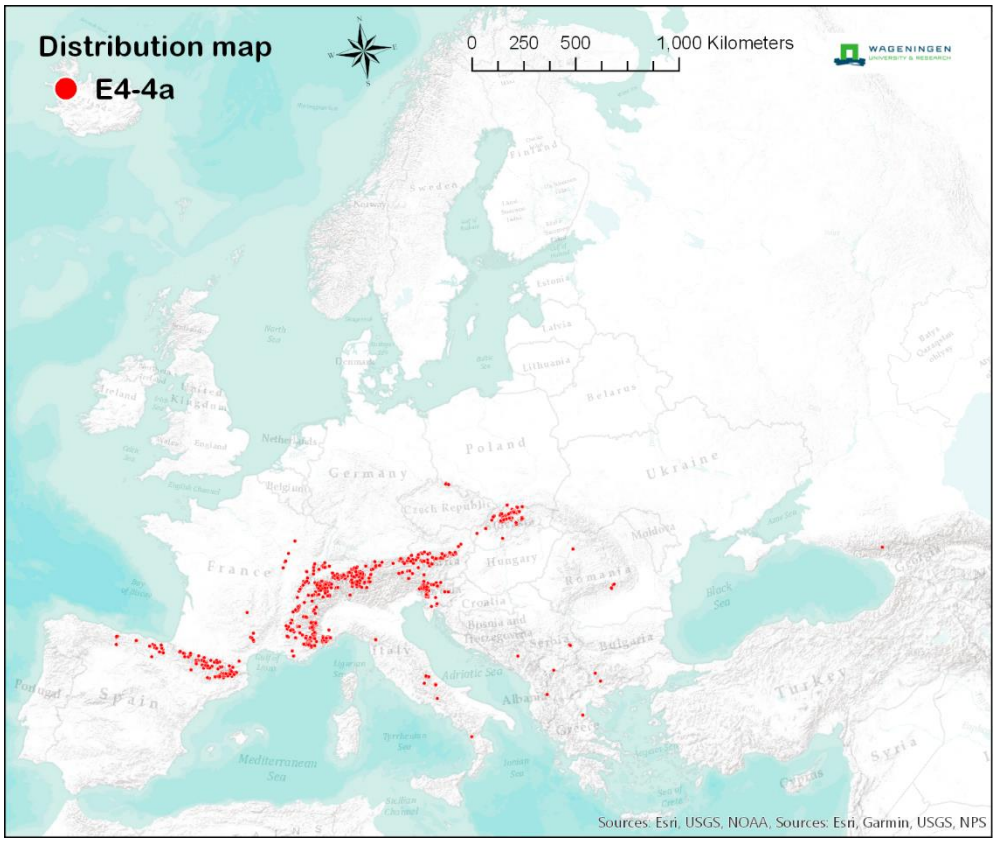


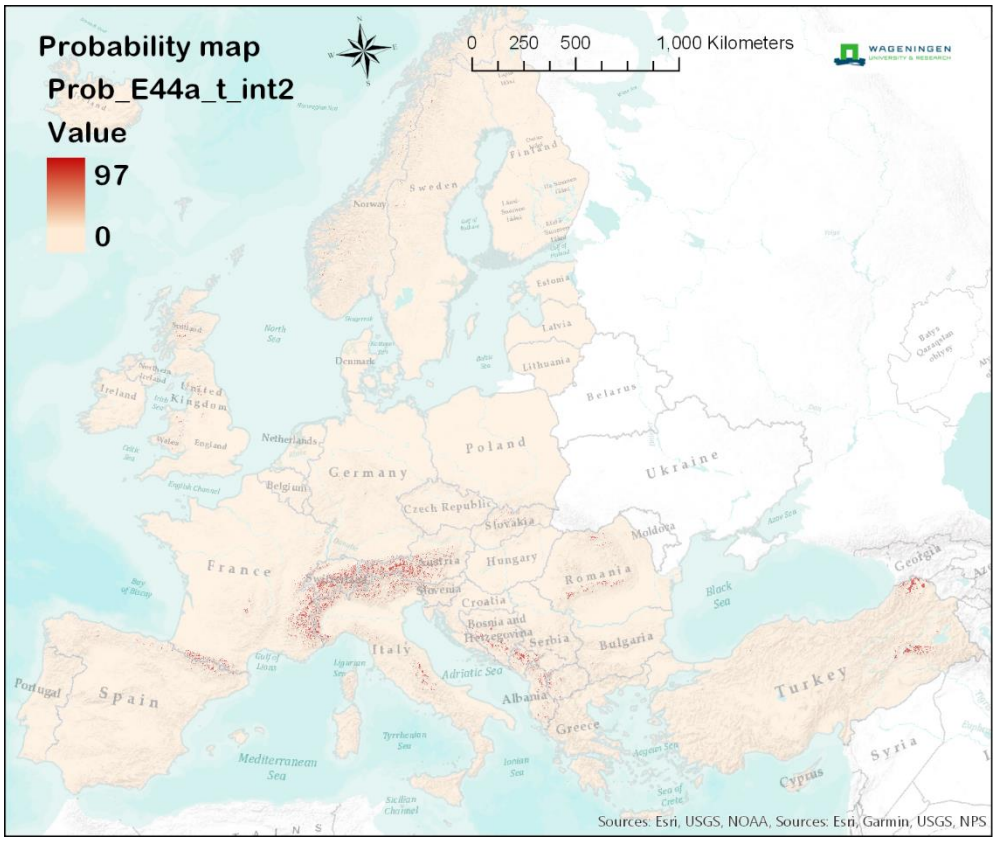


Example detail of the European habitat probability map at 20 m resolution for E4.3b Temperate acidophilous alpine grassland

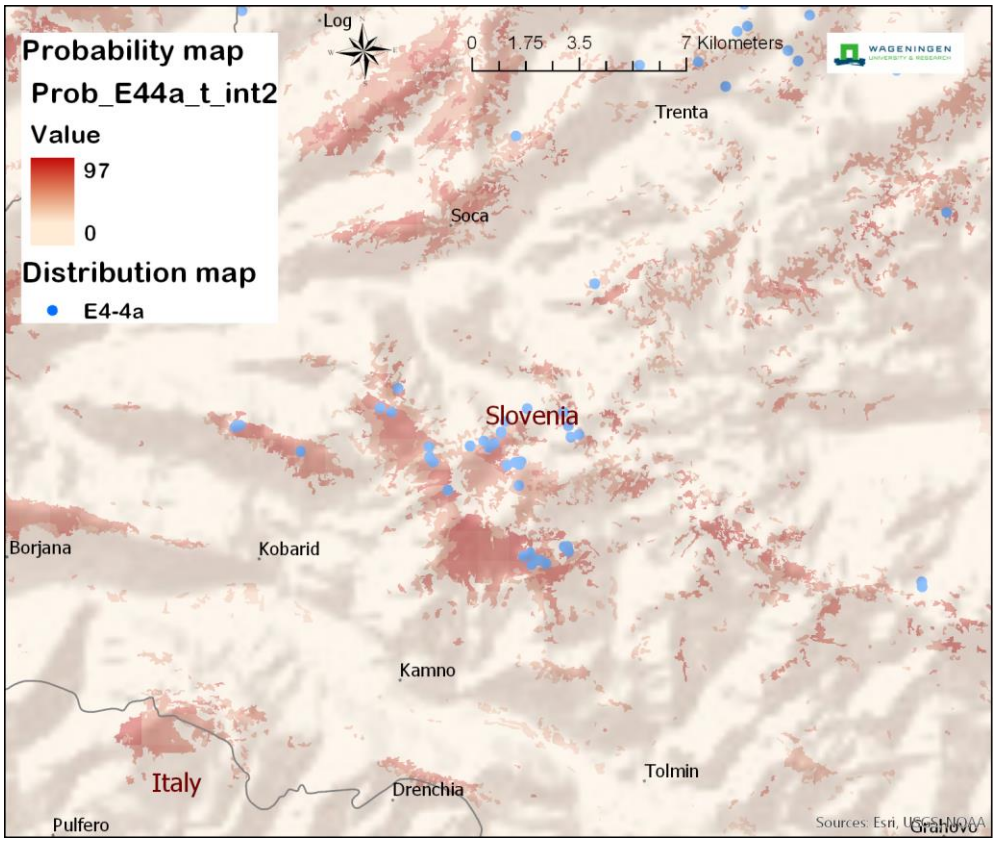


E4.4a Arctic-alpine calcareous grassland

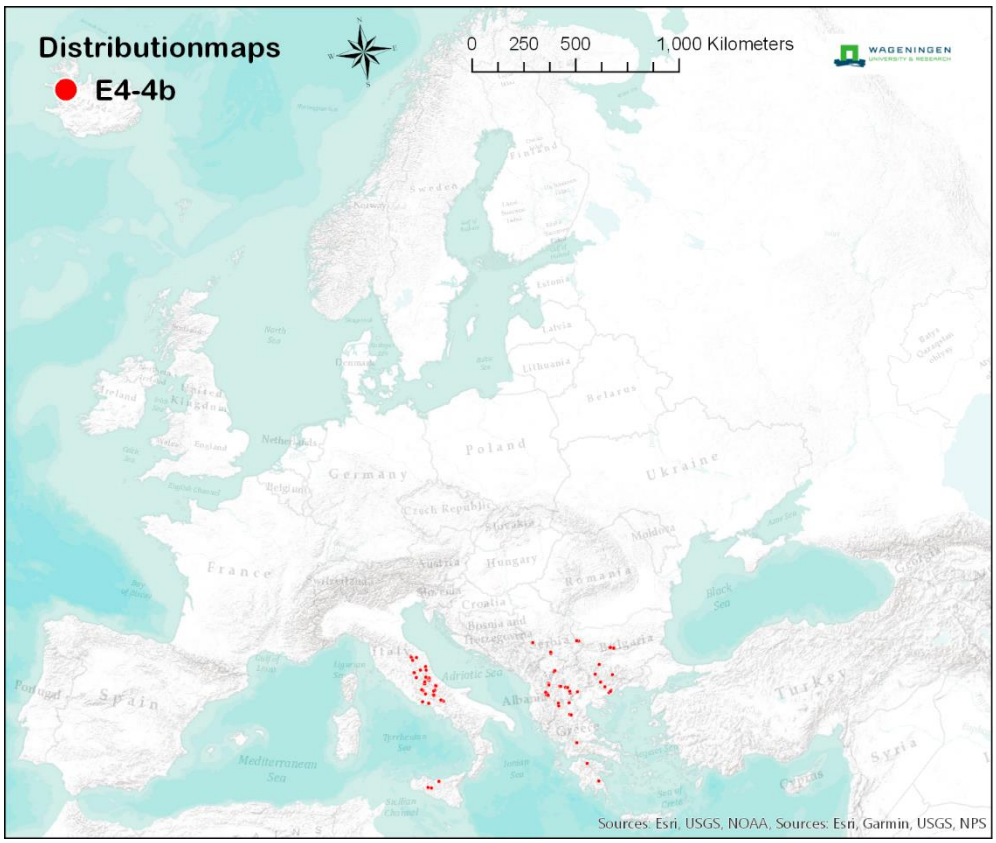


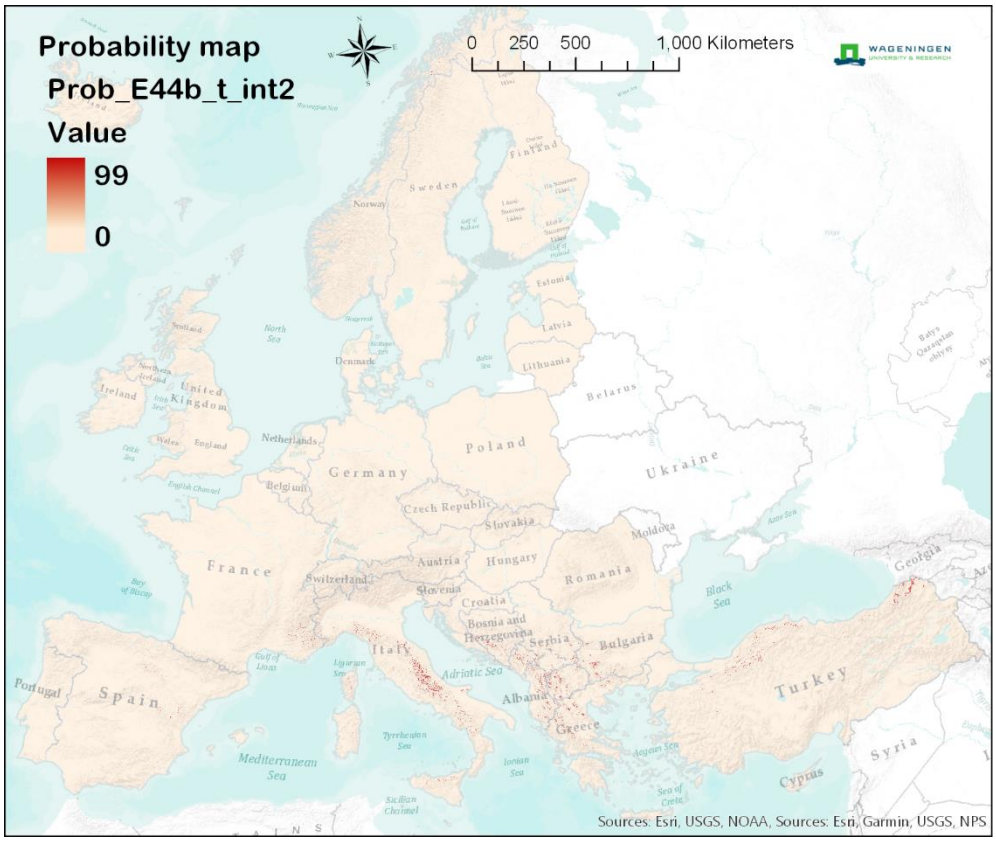


Example detail of the European habitat probability map at 20 m resolution for E4.4a Arctic-alpine calcareous grassland

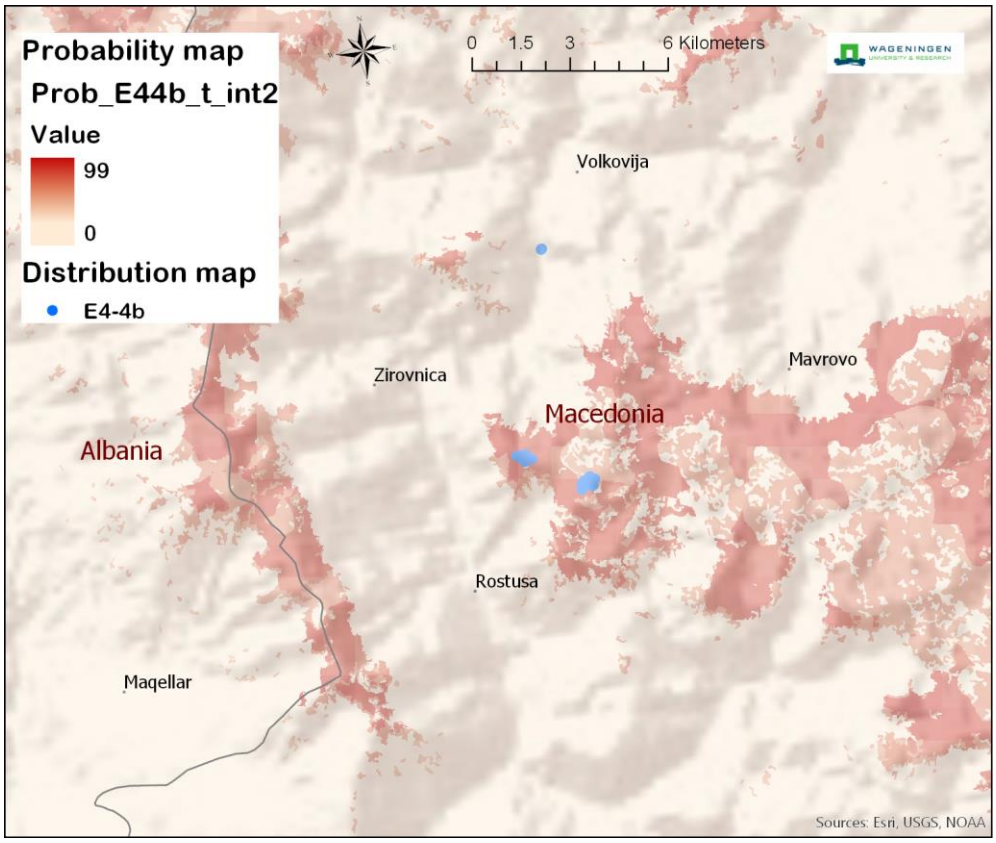


E4.4b Alpine and subalpine calcareous grassland of the Balkan and Apennines

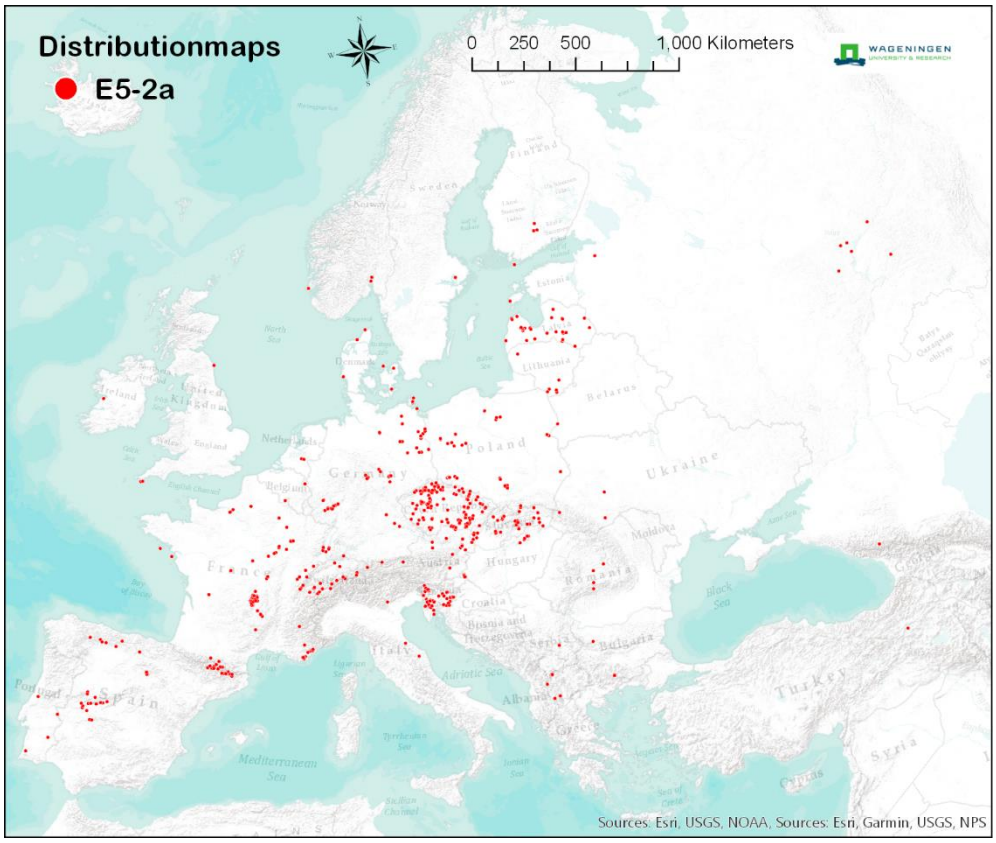


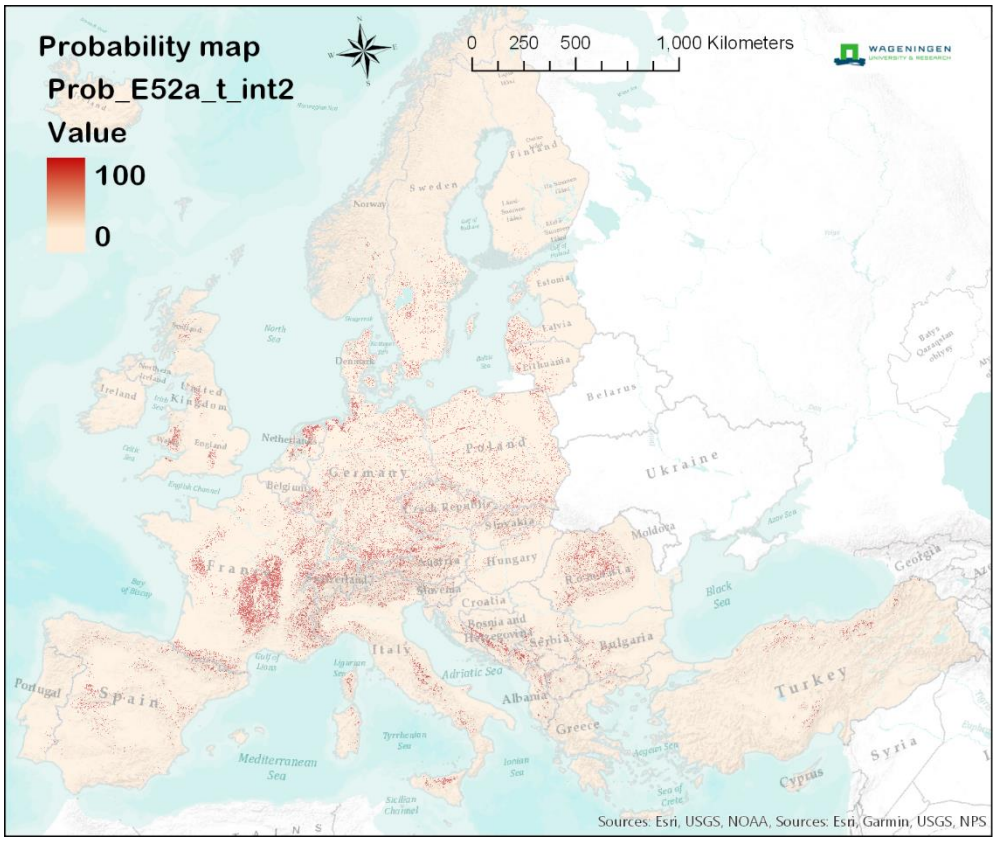


Example detail of the European habitat probability map at 20 m resolution for E4.4b Alpine and subalpine calcareous grassland of the Balkan and Apennines

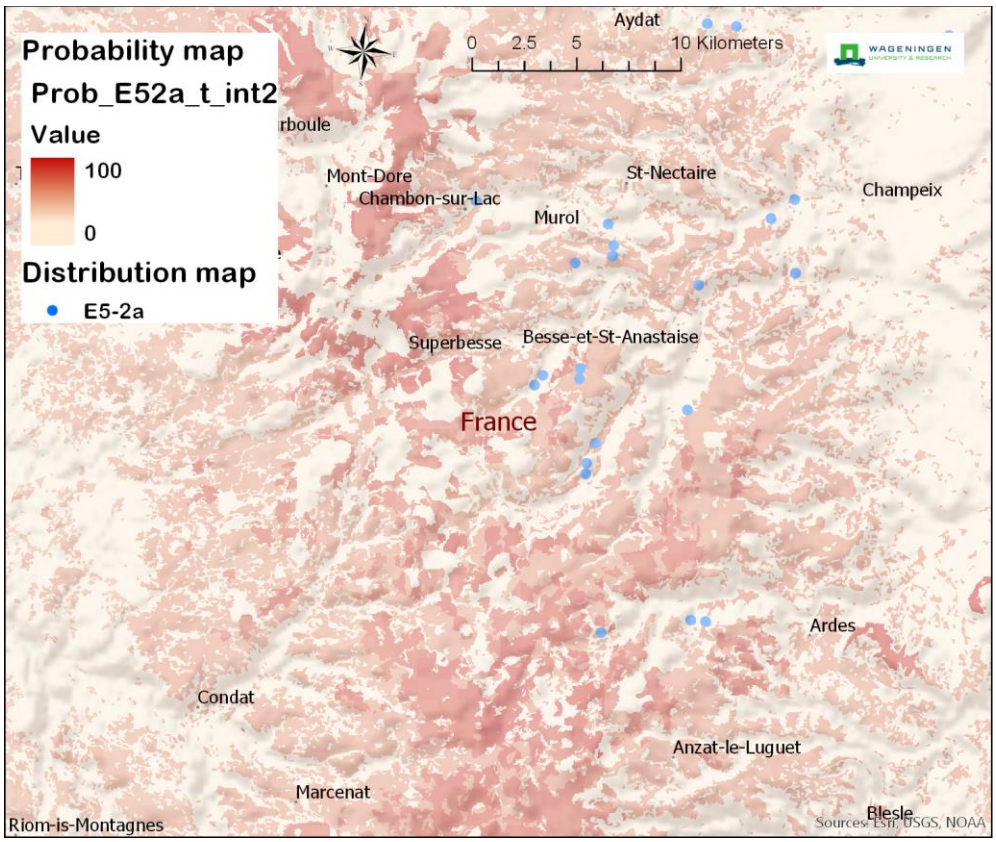


E5.2a Thermophilous woodland fringe of base-rich soils

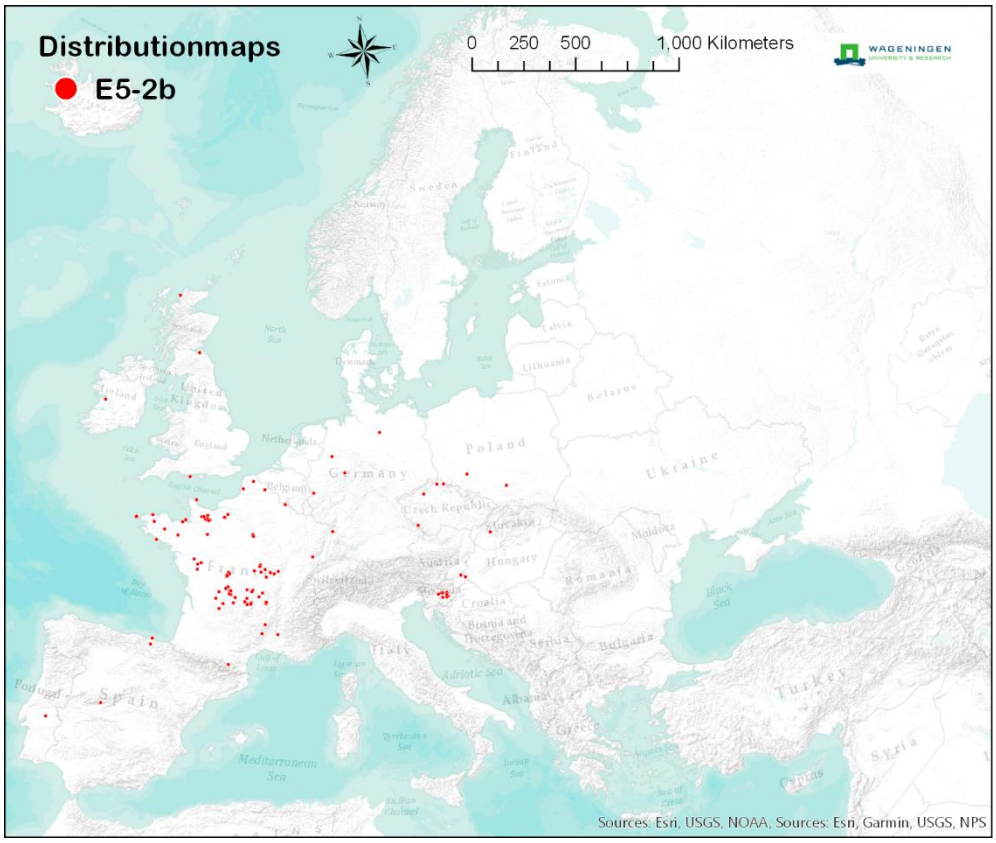


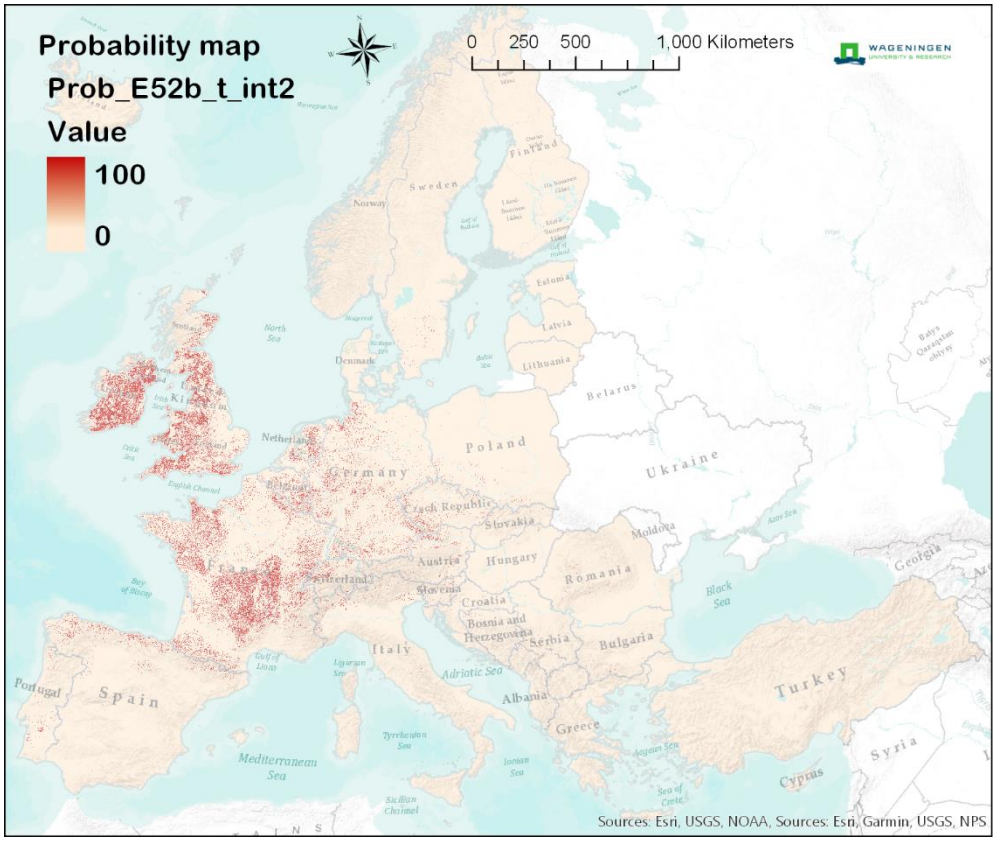


Example detail of the European habitat probability map at 20 m resolution for E5.2a Thermophilous woodland fringe of base-rich soils

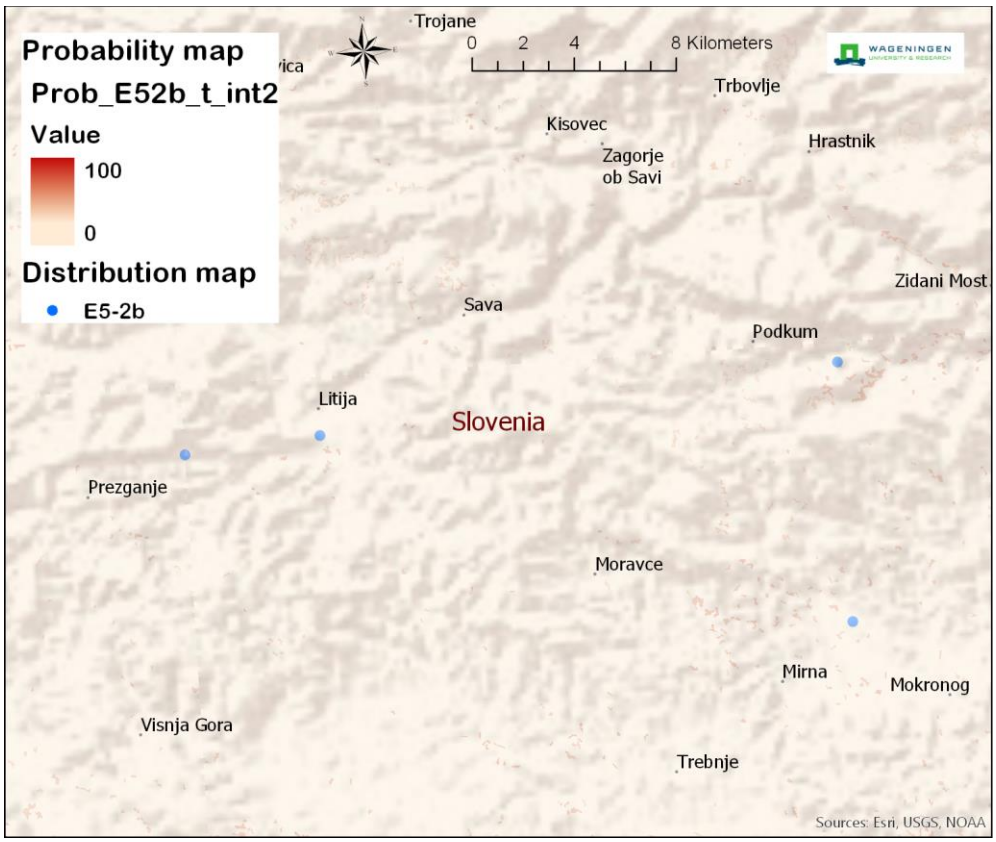


E5.2bThermophilous woodland fringe of acidic soils

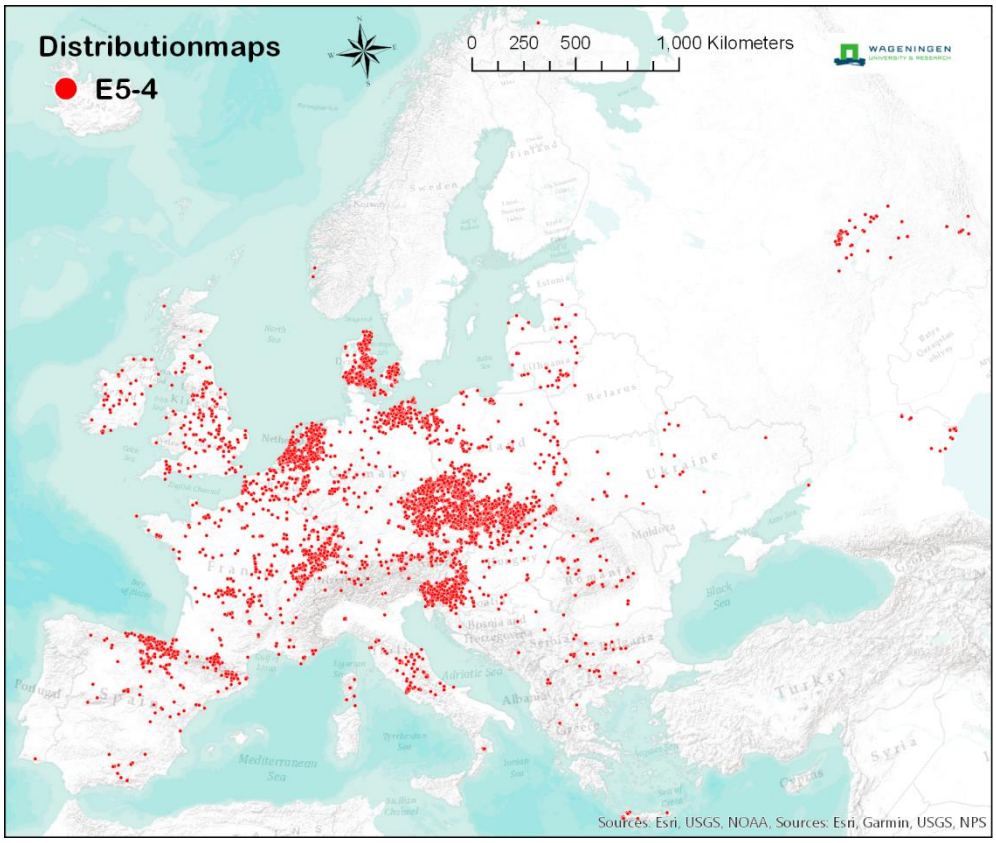


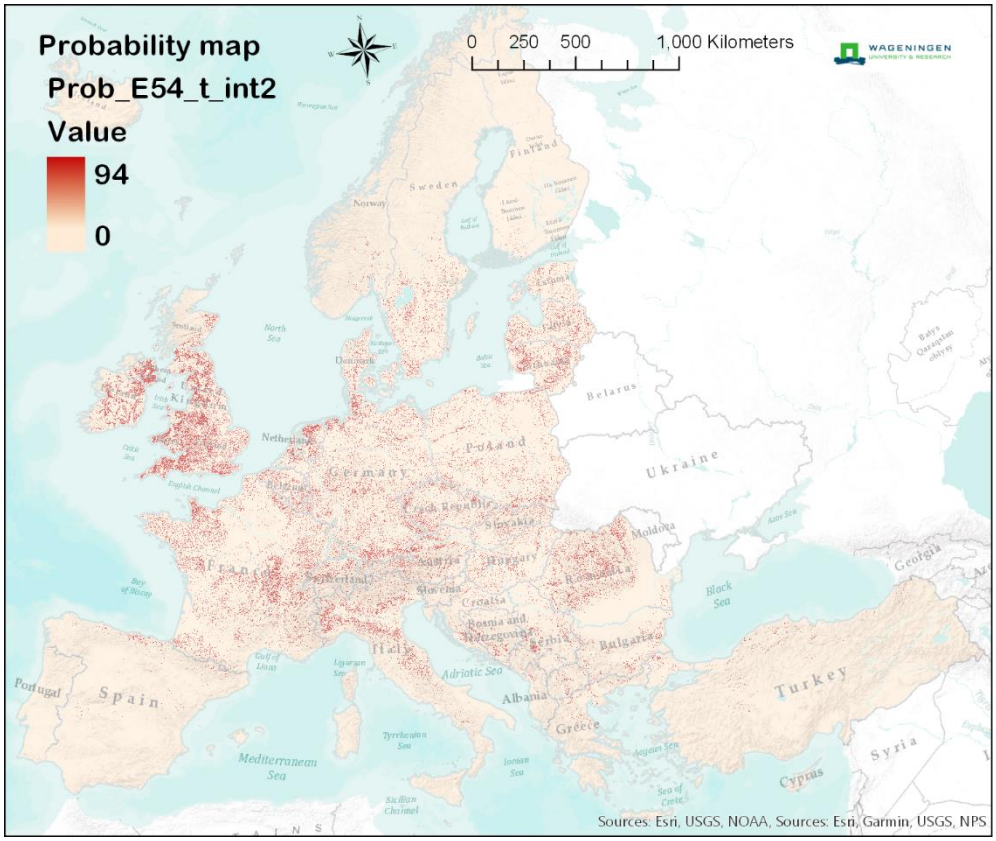


Example detail of the European habitat probability map at 20 m resolution for E5.2b Thermophilous woodland fringe of acidic soils

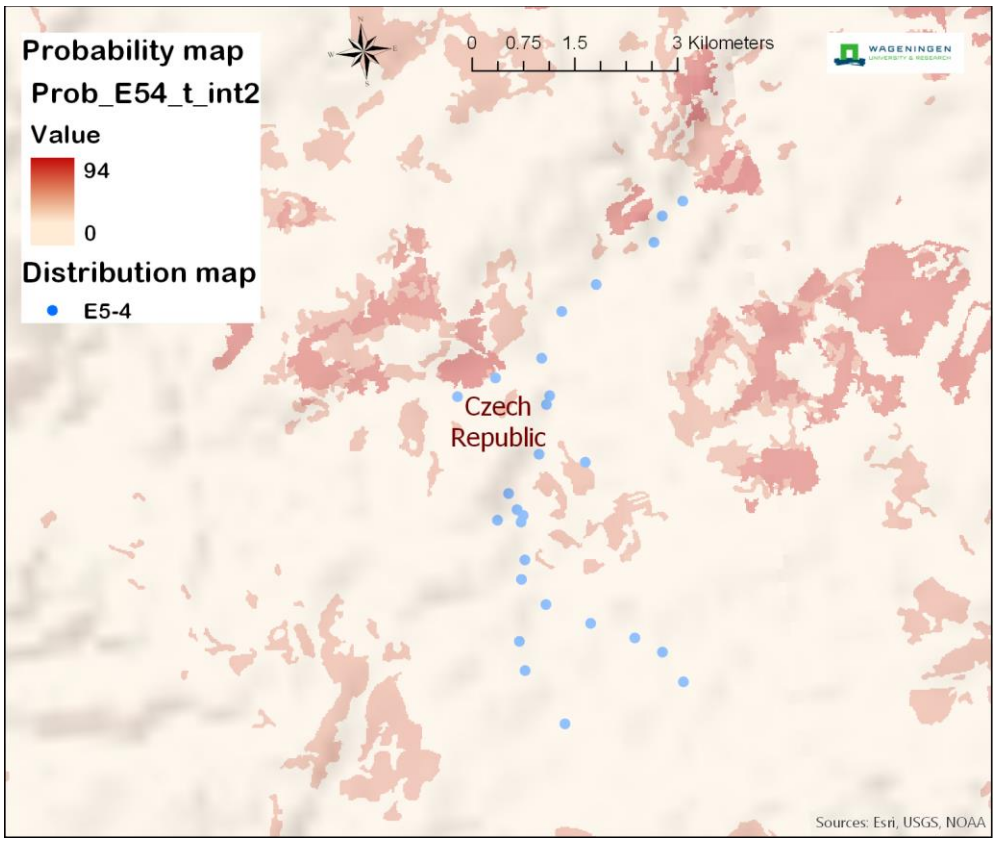


E5.4 Lowland moist or wet tall-herb and fern fringe

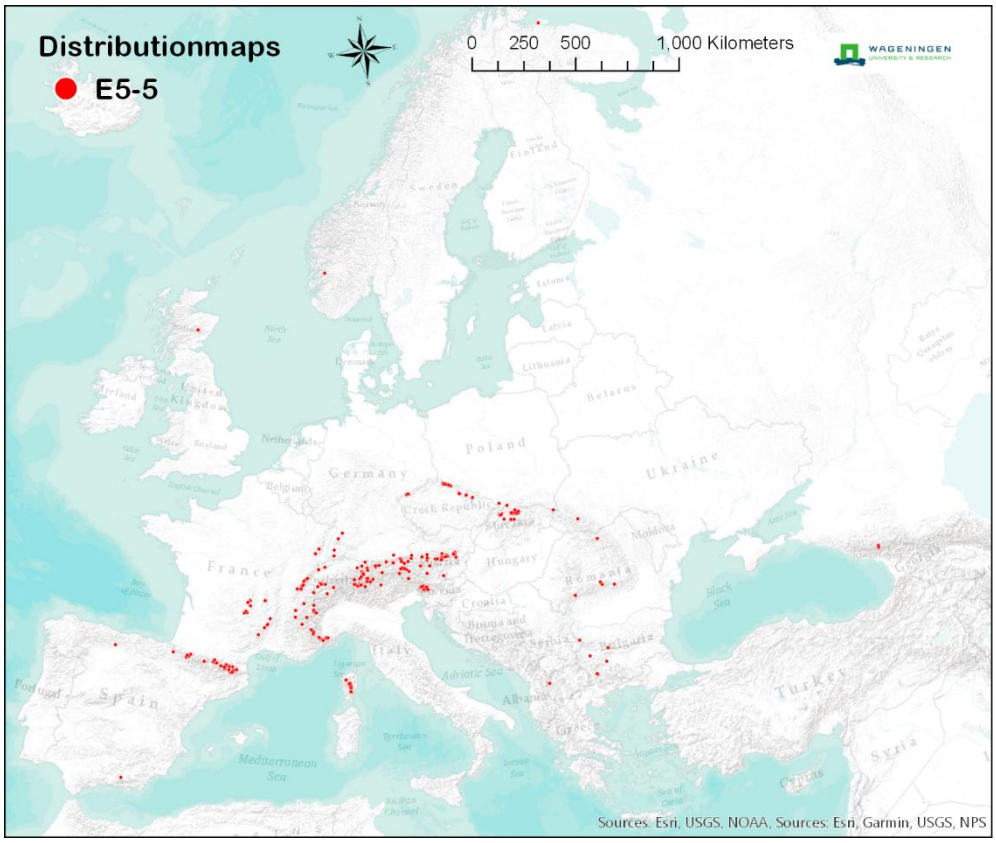


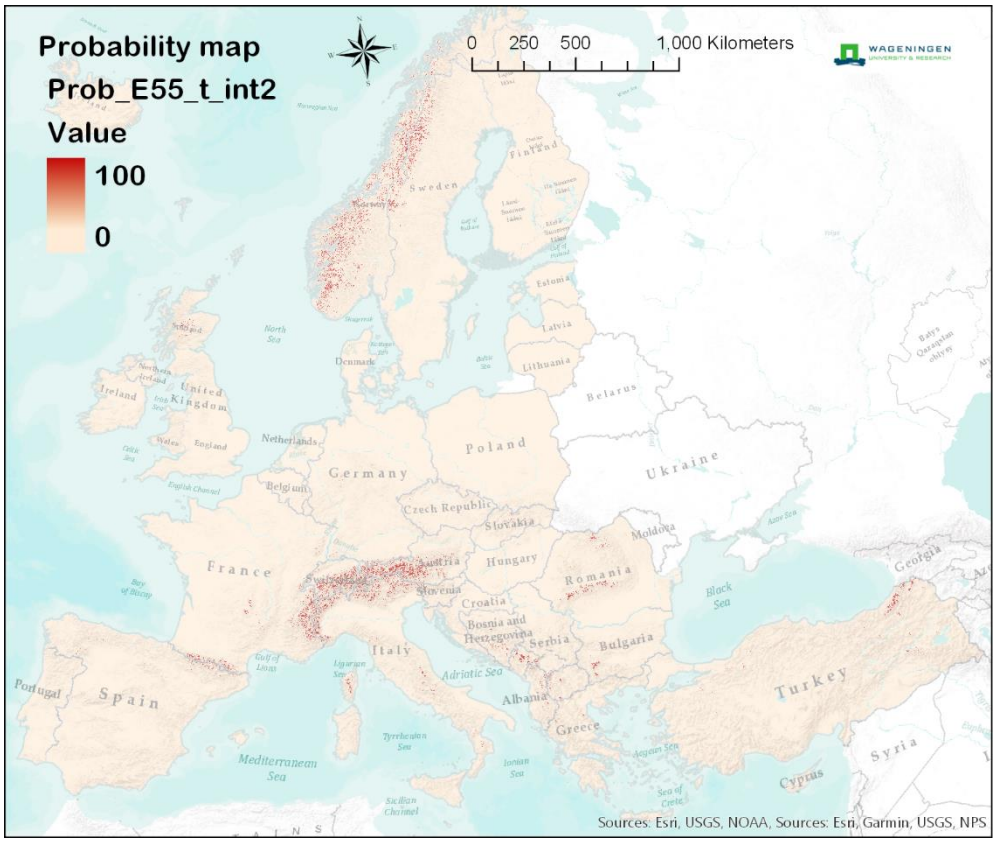


Example detail of the European habitat probability map at 20 m resolution for E5.4 Lowland moist or wet tall-herb and fern fringe

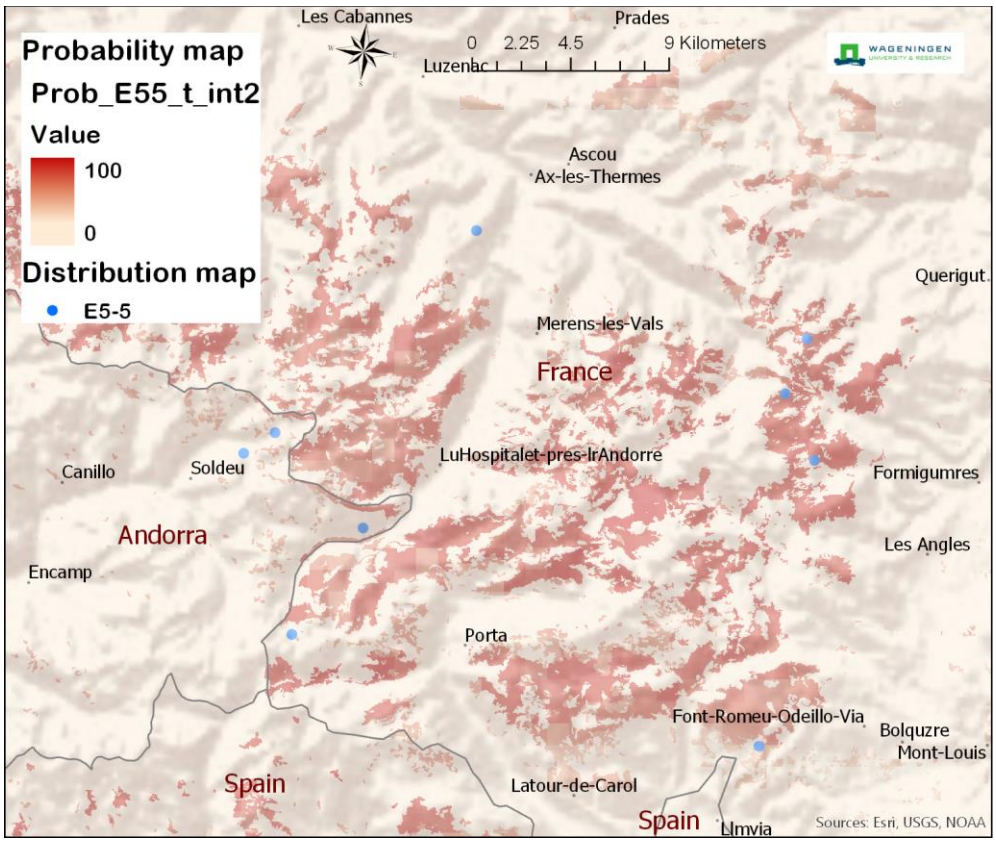


E5.5 Subalpine moist or wet tall-herb and fern fringe

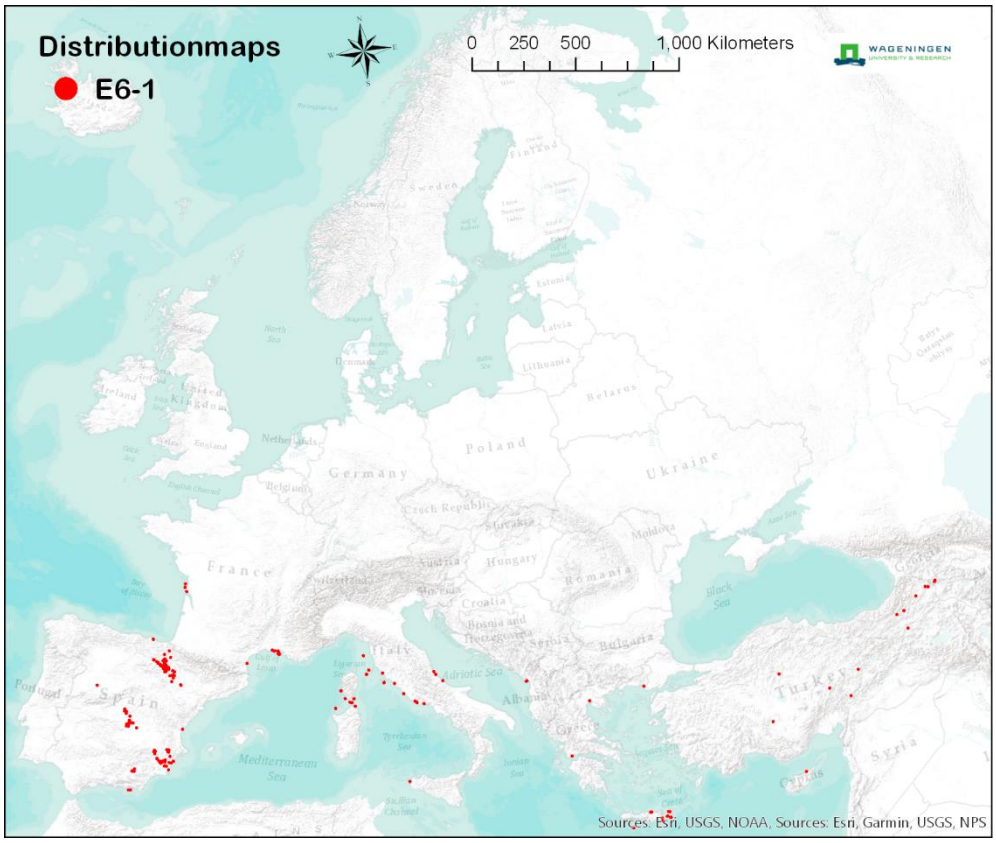


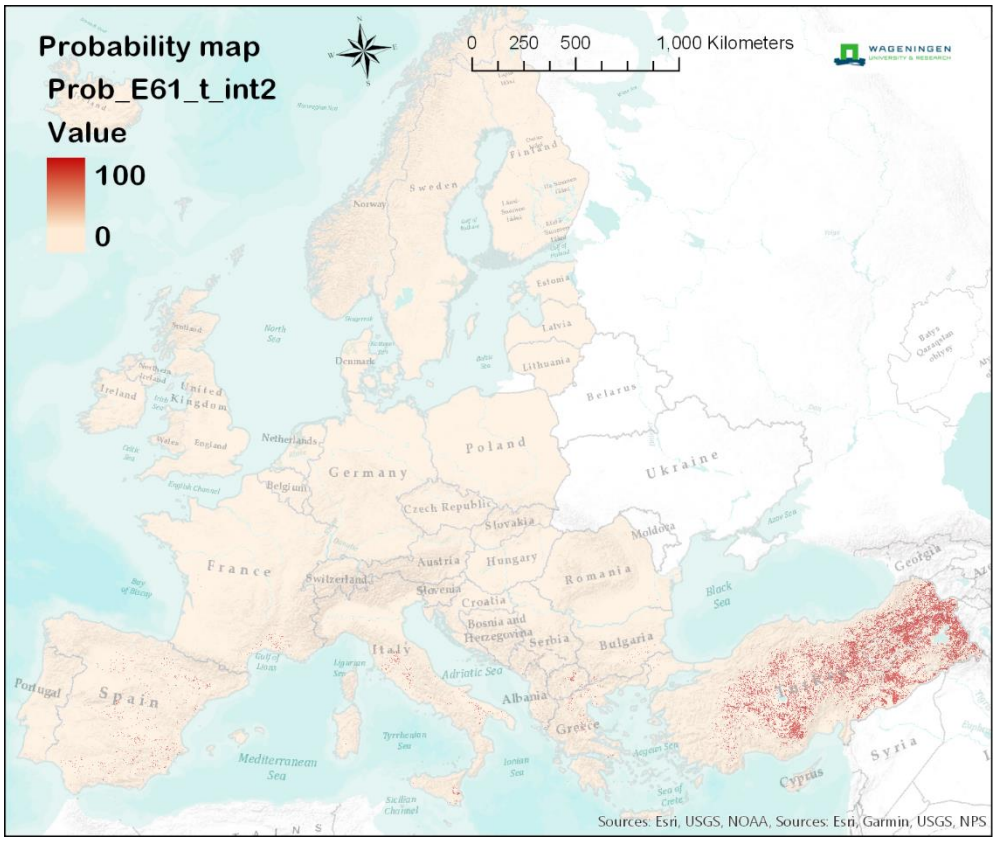


Example detail of the European habitat probability map at 20 m resolution for E5.5 Subalpine moist or wet tall-herb and fern fringe

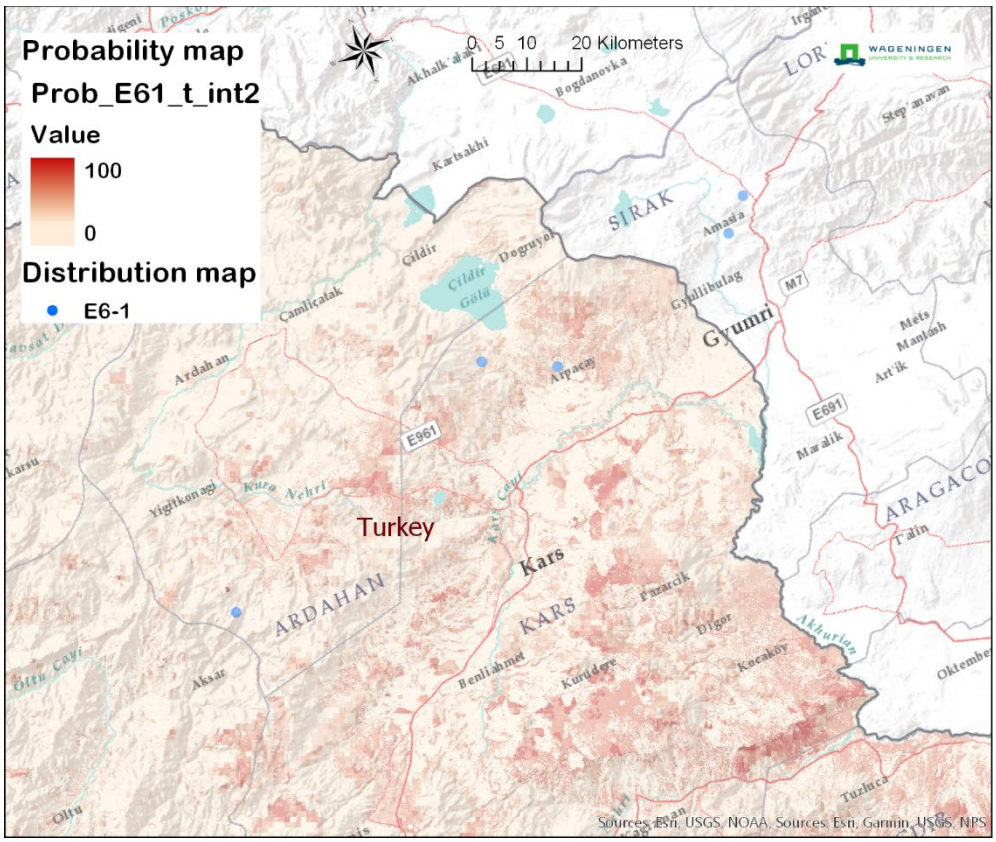


E6.1 Mediterranean inland salt steppe

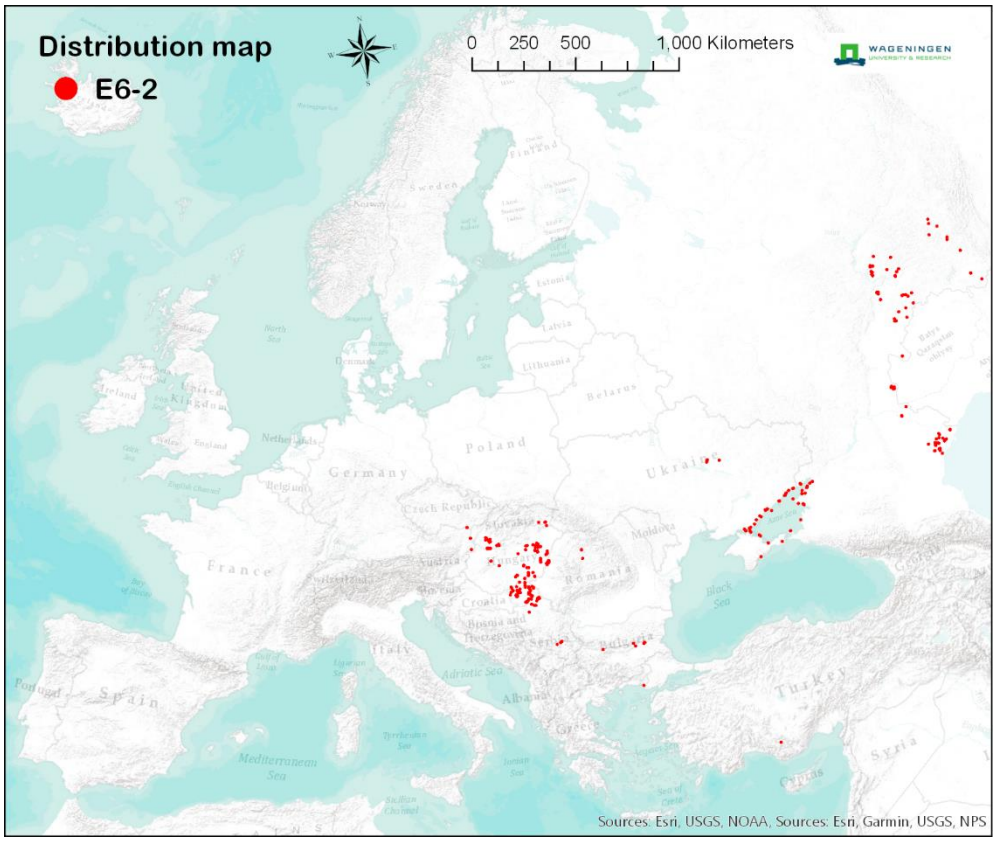


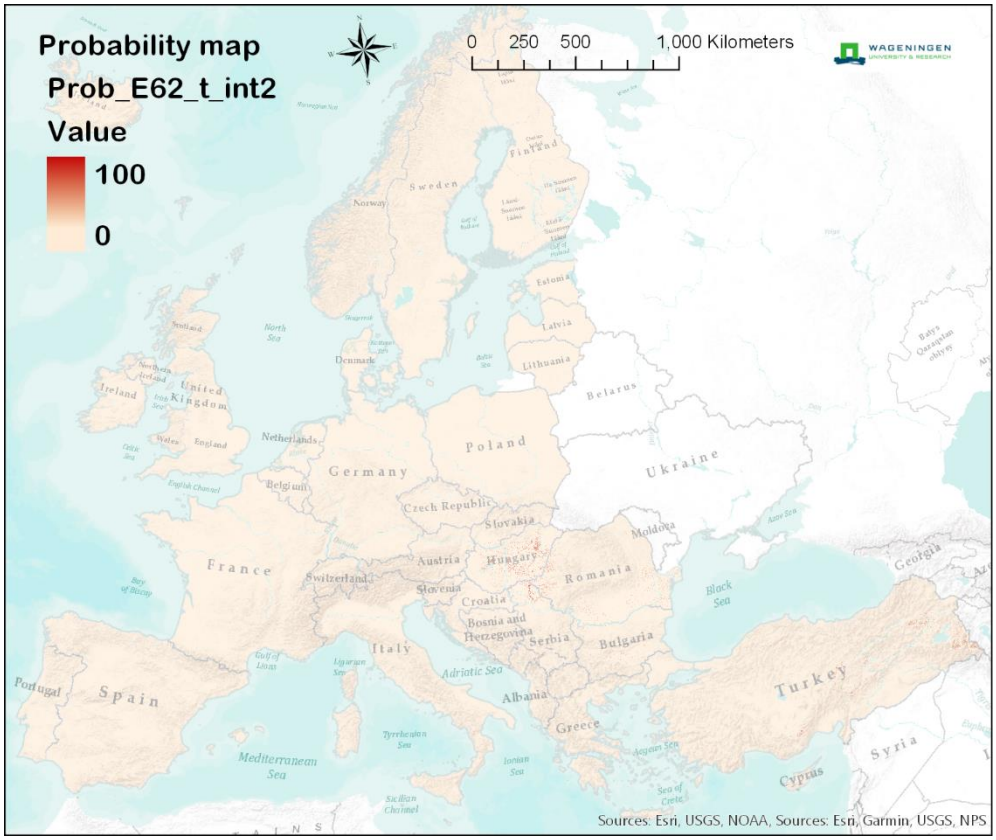


Example detail of the European habitat probability map at 20 m resolution for E6.1 Mediterranean inland salt steppe

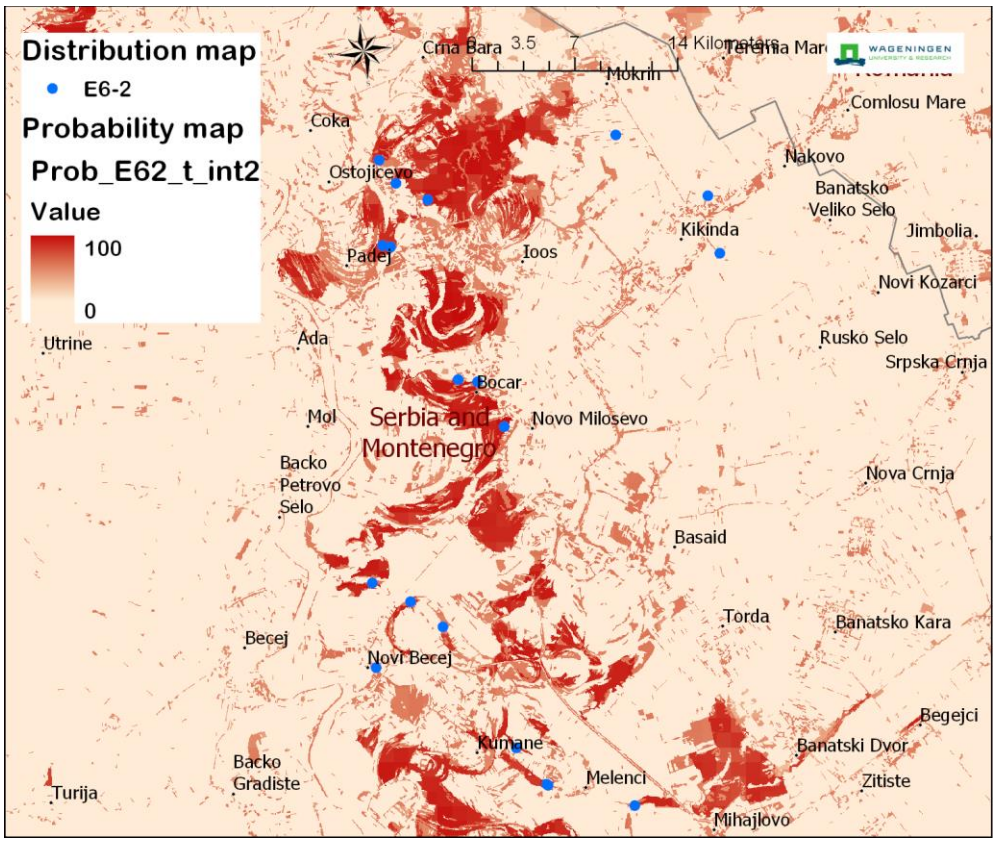


E6.2 Continental inland salt steppe

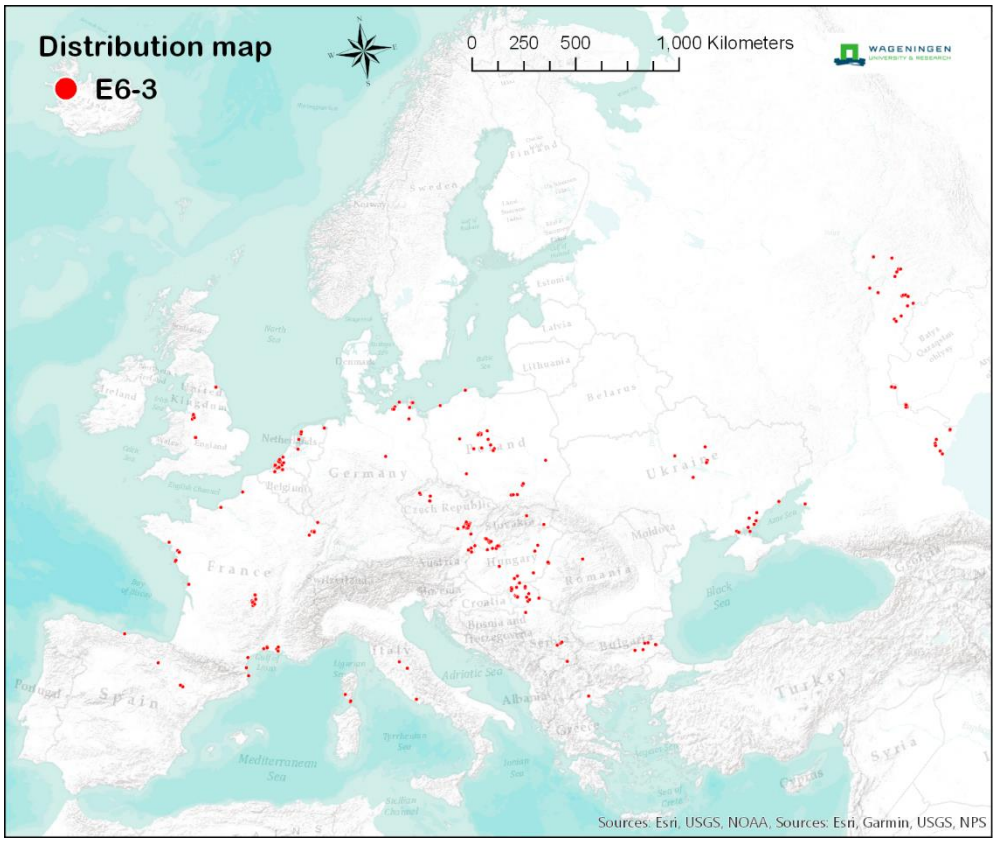


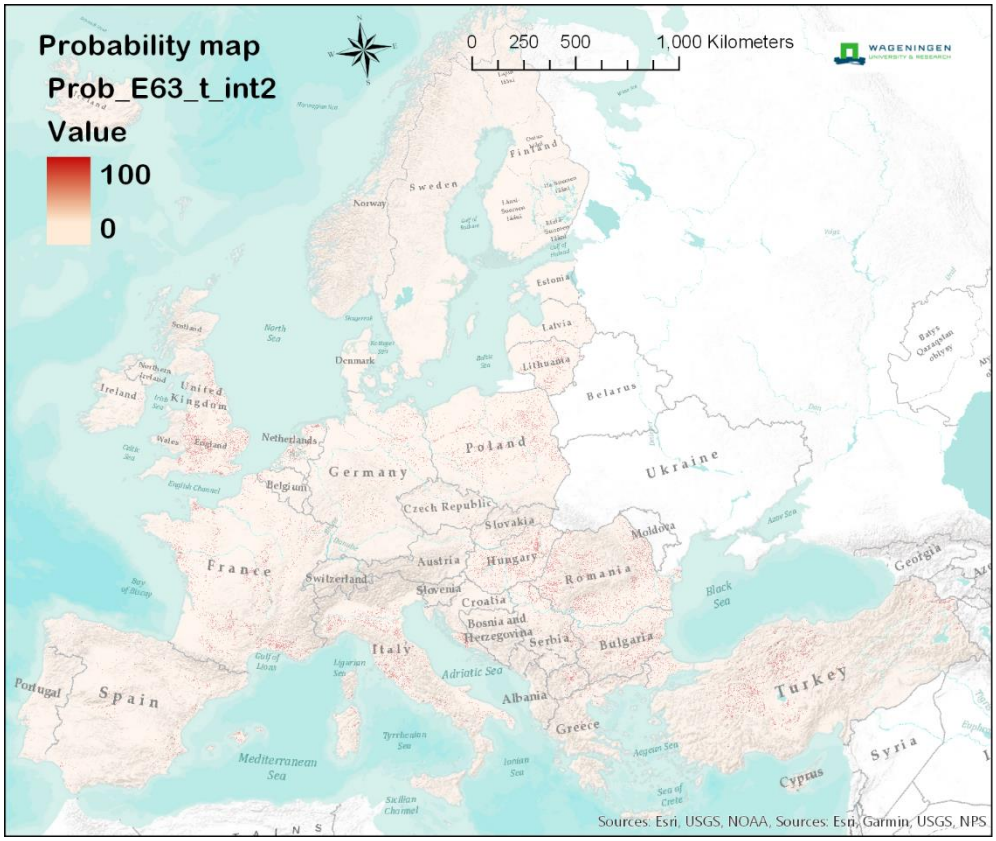


Example detail of the European habitat probability map at 20 m resolution for E6.2 Continental inland salt steppe



E6.3 Temperate inland salt marsh





Example detail E6.3 Temperate inland salt marsh