

This is an extract from the following report:

# Vegetation analysis and distribution maps for EUNIS habitats

*Report EEA/NSV/14/006*

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## **4 Description and distribution of the revised EUNIS forest habitat types – Task 3**

### **4.1 Background**

#### **4.1.1 Existing EUNIS habitat text descriptions**

From the start, the aim of a European habitat classification has been to provide a comprehensive and definitive reference list that is scientific, unambiguous and easily understood (Moss & Roy 1998; Moss 2008). To this end, an integral feature of the EUNIS Habitat Classification is the habitat text descriptions which are incorporated into the underlying database, accessible as an interface via the EUNIS website portal and available in the hard-copy download of the Classification published as Davies *et al.* (2004).

Such text descriptions were not at first included for the CORINE Biotopes that were the forerunner of EUNIS, simply English language titles of the habitats (Internal Technical Handbook 1988, partially updated 1989; see Moss & Roy 1998). The later development of the CORINE Biotopes Manual (Devillers *et al.* 1991) included a descriptive text for each habitat, together with phytosociological and scientific references. When the classification was expanded to the whole Palaearctic, the published version of the classification (Devillers & Devillers Terschuren 1993) did not include text descriptions, simply habitat codes and titles, but in 1995 these were added to the underlying PHYSIS database that had first been released the previous year.

The development of the existing text descriptions in the EUNIS Habitat Classification from earlier versions is detailed in Hill *et al.* (2004a, 2004b): of the 31 forest habitats under consideration here, only 7 retain their original Palaearctic Habitats Classification description but changes in the rest appear to have been relatively minor. The text descriptions are variable in length, detail and content. For the Forest habitats, they all start with some kind of general statement about the character of the habitat though some habitats are termed 'woodland', some 'forest', on the basis, according to the glossary, of whether the tree canopy is open or closed. All descriptions mention one or more tree species which help define the type, in 31% there are some details about structure, often the pattern of dominance, in 2% mention of particular species-richness of the canopy, endemism or composition of the field layer. For 63% of the habitats there is a reference to the biogeographic or bioclimatic zone, in 16% to altitudinal level, in 37% to terrain and in 9% to soils. For 16% of the habitats, there are qualifiers to clarify what is excluded from the habitat.

#### **4.1.2 The EUNIS glossary**

There is a glossary appended to the EUNIS Habitats Classification (Davies et al. 2004, since been updated in 2006, version supplied by Doug Evans of the ETC-BD) and this has been derived from various sources: for terrestrial habitats, 28% of terms originate from the Institut Royal des Sciences naturelles de Belgique (presumably the Palaearctic Habitats Classification glossary that was also included in Moss & Roy (1998; Annex III), 16% from the General Multilingual Environmental Thesaurus of EIONET and the remainder from a variety of published dictionaries of the environment, ecology or science and technology in general. In fact, many of the terms in the Glossary, particularly more specific geographical and topographic terms, are redundant, never figuring in the text descriptions of the forests, though they might occur elsewhere.

#### **4.1.3 EUNIS habitat parameters**

Within and alongside the text descriptions, EUNIS also incorporates references to habitat attributes termed 'parameters'. So-called 'defining parameters', which refer to, for example, biogeographic zones, substrate type, hydrology and biotic impacts, have been used as criteria for the keys to the habitats for the upper 3 hierarchical levels of EUNIS (Davies et al. 2004). In fact, for the forests, second-level divisions are based not on the physical characteristics of the habitat, but on whether the tree canopy is broadleaved, deciduous, evergreen or mixed; and, at level 3, dominant tree species are often invoked to separate the forest types. Negotiating the fuzzy boundaries that often exist between habitats is aided in the keys by the use of extensive and detailed footnotes to the decision points.

On the EUNIS habitat fact sheets, the text description of each habitat is also accompanied by categorical information under the heading 'Descriptive or diagnostic parameters' on levels of wetness/dryness and chemical characteristics of the substrate, habitat usage but also dominant life-forms and % cover (Davies *et al.* 2004).

The 1995 Paris Workshop on the CORINE Biotopes Sites Database and Habitat Classification recognised that a more thoroughgoing parameterisation of the habitats would improve the utility of the classification (Moss & Roy 1998) and the task was scoped then in terms of a generalisation of the parameter framework that had already been developed for the Nordic Vegetation Classification (Påhlsson 1994). The parameters, categories and look-ups in EUNISHAB 2006 represent the current state of database architecture but they are not linked systematically to the 'Descriptive or diagnostic parameters' of the fact sheets in the EUNIS Habitat Classification itself.

#### **4.1.4 Other considerations and sources for describing European habitats**

The Habitats Directive provides 'a common framework for the conservation of wild animal and plant species and natural habitats of Community importance' (CEC 2003) and the definitions provided in Annex 1 include a text description derived from the CORINE Biotopes Manual (Devillers et al. 1991). For each priority habitat (and some non-priority habitats) in the EUR-12, this was later incorporated into more formalised descriptive sheet which established 'clear, operational, scientific definitions of habitat types using pragmatic descriptive elements and taking into account regional variation' and a 'minimal interpretation' was provided for the remaining non-priority habitats based on CORINE (CEC 1995). Text descriptions for new habitats and revisions of existing habitat definitions were produced for EUR15, EUR25, EUR27 and EUR28 with the accession of new countries in 1993, 1995, 2004, 2007 and 2013. The new and revised descriptions were based on a mix of information from the PHYSIS database which gives access to descriptions at EUNIS-4 and EUNIS-5, then subject to negotiation with the existing Member States and accession countries (Evans et al. 2013). Although there is a simple 1:1 correspondence between a EUNIS-3 Forest type and an Annex 1 habitat in only a minority of cases (33%), information at these lower levels allows the often complex relationships between the remainder to be explored. However, unlike the definitions of the EUNIS habitats, the interpretations of the Annex 1 habitats have acquired legislative force through the implementation of the Habitats Directive.

*The Diversity of European Vegetation* (Rodwell et al. 2002) established the idea of a simple English language descriptor for each alliance that included, as far as possible, standardised references to the vegetation type, the typical physiography and the geographical range, though these were not based on explicit standards nor were the terms used summarised in a glossary. The crosswalk to EUNIS-3 included in that overview enabled such tags to be used to interpret those EUNIS habitats. In the more ambitious EuroVegChecklist, such descriptors have been provided for the more comprehensive range of alliances using terminology summarised in a glossary appended to the typology. This has been compiled bottom-up from the definitions provided by contributors to the EuroVegChecklist, so no terms are redundant. It also incorporates many non-contentious definitions and some frameworks for describing geographical regions, altitudinal levels and bioclimatic zones that have found widespread, though not always universal, favour. Some of these are more applicable to certain parts of Europe than others, like the World Bioclimatic Classification (Rivas-Martínez et al. 2012). Only a minority of terms in this EuroVegChecklist glossary are common to the EUNIS Glossary mentioned above (Davies et al. 2004, revised 2006).

For all the ultimate mapping units of the *Map of the Natural Vegetation of Europe* (including 338 forest types), there is a modular descriptive text

including the vegetation characters and environmental parameters shown in Figure 4.1 (Bohn et al. 2000-2004). There is also a comprehensive and standardised glossary of phytogeographical terms, vegetation and climate zones, ecological and geobotanical terms, geological, geomorphological and edaphic terms and details of the standard environmental classifications used like the Walter & Leith climate types and the FAO soil classification.

Geographical distribution (countries, area in km <sup>2</sup> , number polygons)
Main syntaxa/plant communities
Structural features
Dominant & frequent species by layer
Diagnostic species
Ecological variants
Geographical variants
Natural accompanying vegetation
Adjacent climax communities
Land use
Site conditions (landscape, geomorphology, altitudinal belt, geology)
Soil conditions
Climate (Walter & Leith type, mean annual temperature, average annual precipitation, average temperature warmest month, average temperate coldest month, local peculiarities)
Importance for nature protection
Type sites
References
Author(s)
Images

*Figure 4.1 The characteristics and parameters for the mapping units of the Map of the Natural Vegetation of Europe (Bohn et al. 2000-2004).*

The current 'Red List of European Habitats' project funded by DG(Env) uses as its Habitats Typology a modified version of EUNIS (Rodwell et al. 2013) which incorporates, with some further very minor modifications, the changes for Forests recommended in Schaminée et al. (2013) and which can take advantage of the changes to the classification of Heaths and Scrub recommended in this report. Very relevant to the current task of providing revised descriptions of EUNIS habitats is the fact that much more detailed Red List Habitat Definitions are being prepared by experts for the territorial assessments of extent and quality. These Definitions include an audit trail from EUNIS, a detailed text description, crosswalk to the EuroVegChecklist and other relevant typologies, species lists and further details of the character and status of habitats across Europe and images. An example of a Habitat description is provided in Figure 4.2.

## G1.8 Acidophilous *Quercus* woodland

### Author and date

John Rodwell, September 2014

### Relationship to EUNIS

= G1.8 Acidophilous [*Quercus*]-dominated woodland

### Habitat description

These are oak-dominated woodlands typical of acidic, impoverished and free draining soils with mor humus on arenaceous sedimentaries, lime-poor metamorphic and igneous rocks and sandy and gravelly superficial deposits through the nemoral zone. Extending from the Atlantic fringe of northern Portugal and Spain, across north-west and central Europe into southern Scandinavia, the northern Balkans and on into Russia, the habitat is everywhere limited by the survival of suitable terrain, often very fragmentary and scattered now in the prevailingly agricultural semi-natural landscape. Variations in climate across this wide overall range, from extreme Atlantic on the western fringes of Ireland and the British Isles, Lusitanian in northern Iberia, through Continental to Boreal in the east and sub-Mediterranean in the south, have an effect on the associated flora, even though this is not in general very rich.

The characteristic oaks here are *Quercus robur* and *Q. petraea*, often occurring with a subordinate proportion of *Betula pendula* and/or *B. pubescens*, which can be pioneers in this habitat following fire or clear-felling, are relatively short-lived survivors in mature forest and which have been selected against in the coppice management or timber extraction often imposed on these woodlands. Through much of the range in central and north-western Europe, *Fagus sylvatica* is a potential competitor for canopy dominance on the better-quality soils and co-dominant *Fagus-Quercus* canopies are better classified under G1.6b *Fagus* woodland on acid soils. On highly acidic soils to the Boreal east of the range, *Pinus sylvestris* replaces the oaks as the dominant tree in woodlands with much the same field layer. Overall, other associated trees are typically very few in this habitat: *Sorbus aucuparia* and *Frangula alnus* occur through much of the range, *Castanea sativa*, *Sorbus torminalis* and *Pyrus cordata* in the Sub-Atlantic heartland and, to the west, *Ilex aquifolium* can be abundant.

The field layer is generally rather species-poor with calcifuge sub-shrubs, herbs and cryptogams most characteristic and lending a heathy appearance, especially under lighter shade and where grazing is absent. Constant through much of the range are *Vaccinium myrtillus*, *Calluna vulgaris* (in more open places), *Deschampsia flexuosa*, *Agrostis capillaris*, *Anthoxanthum odoratum*, *Holcus mollis*, *Carex pilulifera*, *Potentilla erecta*, and *Hieracium sabaudum*. The commonest bryophytes overall are *Polytrichum formosum*, *Hypnum cupressiforme*, *Pleurozium schreberi* and *Leucobryum glaucum*.

Regional variations in the flora in relation to climatic differences can be seen in each of the layers of the vegetation moving away from the Sub-Atlantic woodlands of central and western France, the lower Rhineland and north-east Italy/south-west Switzerland. In the more Atlantic climate of the north-west, there is a further contingent of herbs such as *Galium saxatile*, *Teucrium scorodonia*, *Hypericum pulchrum*, *Luzula sylvatica* and *Blechnum spicant* and to the western seaboard of Ireland and the British Isles an extraordinary additional richness in cryptogams and ferns which, with annual precipitation up to 3000mm, lends this habitat a great luxuriance. It is this vegetation which forms the richer core of Annex 1 91A0 Sessile Oakwoods in the British Isles.

On the Atlantic fringe of Portugal and Spain, with annual precipitation up to 2000mm but with warmer summers and milder winters, *Q. petraea* tends to be less prominent than further north but there is often some *Q. pyrenaica* along with *B. pubescens* spp. *celtiberica* and *Arbutus unedo*. *Cytisus scoparius*, *Ulex gallii* and *Erica arborea* enrich the sub-shrub layer, with the lianes *Rubia peregrina* and *Tamus communis*. Herbs such as *Pseudarrhenatherum longifolium*, *Potentilla montana*, *Daboecia cantabrica*, *Crepis lampanoides*, *Luzula forsteri*, *Euphorbia dulcis*, *Melitis melissophyllum*, *Silene nutans*, *Polygonatum odoratum*, *Galium rotundifolium*, *Arenaria montana*, *Genista florida*, *Rumex papillaris* give a South Atlantic or more Mediterranean feel to the flora.

In northern Europe and southern Scandinavia, some Eurasian Temperate and Boreal species such as *Vaccinium vitis-idaea*, *Maianthemum bifolium* and *Luzula pilosa* begin to appear in these woodlands and examples on the Baltic-North Sea plain form the core of the Annex 1 9190 Old acidophilous oakwoods with *Quercus robur* on sandy plains.

Further east, through Germany, Poland, Belarus, Ukraine and into Russia, where *Pinus sylvestris* begins to challenge the dominance of *Quercus* spp. on impoverished acid soils, *Juniperus communis* and *Euonymus verrucosa* are additional woody species and, among the herbs, *Trientalis europaea*, *Rubus saxatilis*, *Pyrola rotundifolia*, *Orthilia secunda*, *Calamagrostis arundinacea*. At the extreme east of the range, where there is usually less than 800mm precipitation and winter temperatures down to -12°C, *Carex digitata*, *Galium schultesii* and *Chamaecystus ruthenicus* are characteristic. Among the bryophytes *Dicranum polysetum*, *Eurhynchium angustifolium* and *Rhodobryum roseum* are distinctive here.

Further south, at the eastern sub-Mediterranean limit of this habitat in Czechia, Austria, the northern Balkans and Romania, the warmer climate is reflected in the appearance of *Quercus cerris*, *Q. delechampii* and *Q. polycarpa* in the canopy, *Pyrus communis* and *Euonymus verrucosa* among the shrubs and *Genista tinctoria*, *G. germanica*, *Cytisus nigricans*, *Rubus hirtus*, *Gentiana asclepiadea* and *Vincetoxicum hirundinaria* in the herb layer.

#### Countries list

AT, BA, BE, BG, CH, CZ, DE, DK, ES, FI?, FR, GR, HU, IE, IT, LT, LV, MK, NL, NO, PL, RO, RS, SE, SI, SK, UK (24 + 1?)



Winter aspect of Atlantic stand of G1.8 Acidophilous *Quercus* woodland (Annex 1 91A0 Old sessile oakwoods) in the UK (Photograph Jeff Lunn).

Figure 4.2 An example of a Red List Habitat description.

## **4.2 Description in a standard format of the revised EUNIS forest habitat types**

Like the existing EUNIS habitat and Annex I habitat descriptions and the EuroVegChecklist descriptors, the Red List Habitat definitions sit rather lightly to the questions of explicit standardised parameter frames and terminology; and there are unresolved questions about the compatibility of terms in the various glossaries that are currently applied to the description of habitats. Furthermore, there is actually no accepted standard format for the description of a EUNIS habitat. Here we therefore provide only a provisional response to the challenge of what such descriptions should look like and in Chapter 5 recommend the next steps for developing what we believe to be the considerable potential of such descriptions and parameterisation.

What we would recommend is that the descriptions are regarded essentially as definitions: they should provide, as accurately, briefly and precisely as possible, the key distinguishing features of the habitat. They are not the place for small essays in ecology or status, particularly where the habitat is more readily recognisable. In general, any detail provided should reflect the variability in the habitat, not its species-richness or structural complexity.

The descriptions we provide have a roughly standardised shape:

- ▶ we have used the term 'woodland' throughout, irrespective of the degree of canopy closure which is the criterion used in the EUNIS Glossary for distinguishing 'woodland' from 'forest'. Canopy closure is not always uniform within a type and these two terms have confusing resonances in different parts of Europe;
- ▶ we include a general reference to the character of the woodland, whether it is broadleaved or coniferous, deciduous evergreen but, with details of species composition now available through analysis of constituent relevés or data tables for the alliances of each habitat, we believe that there is no need to repeat this information in the description except where it has definitive value;
- ▶ we mention woodland structure or species-richness only when it is a diagnostic feature of the woodland type;
- ▶ we use non-technical terms as far as possible to describe terrain, soil types, altitudinal belts;
- ▶ though we recognise that local environmental conditions in one biogeographic zone may correspond to those prevailing more widely elsewhere, we use the ETC-BD terminology to refer to the biogeographic zone generally



typical of a habitat distribution and otherwise avoid any specialised terminology to describe climatic relationships or broad geographical distribution.

The new descriptions along with the original are attached as Appendix C.

#### **4.3 Maps of distribution of phytosociological relevés and probability of occurrence based on distribution models for each of the revised EUNIS forest habitat types**

##### **4.3.1 Data selection**

The locations of vegetation relevés available for the Braun-Blanquet project were used for the modelling of the EUNIS forest types. The selection of relevés belonging to the individual EUNIS forest types has been done on the basis of a supervised classification of more than 500,000 relevés in JUICE 7.0 (Tichý 2002). This supervised classification was performed using a computer expert system newly developed to identify relevés belonging to the individual EUNIS forest types. The procedure followed these steps:

- (1) Relevés identified during the preparation of the 2013 report (Schaminée et al. 2013) as belonging to the particular EUNIS types based on their syntaxon assignment were marked and grouped in this dataset.
- (2) The degree of concentration of occurrences of each species within each group of relevés (i.e. each EUNIS type) was calculated using the phi coefficient of association (Sokal & Rohlf 1995) standardized for the identical number of relevés across all groups, which was arbitrarily set to 1% of the total data set (Tichý & Chytrý 2006). The species with the highest values of phi were considered as diagnostic for each EUNIS type.
- (3) Lists of European species of trees and shrubs occurring in this data set were compiled.
- (4) The functional species groups were created using an expert judgement based on the lists of diagnostic species for EUNIS types and lists of trees and shrubs. These functional groups were defined in such a way that they could clearly separate the EUNIS forest habitat types based on their occurrence and total cover of their species. In general some functional groups included woody species and others included herb-layer species. Each group included species of similar ecology and distribution. The concept of functional species groups used here is described in Landucci et al. (submitted).
- (5) Total covers of each functional species group were calculated assuming the

random overlap of covers of their individual species based on the approach proposed by Chytrý et al. (2005) and newly formally described by Fischer (2015).

- (6) Formal definitions of all EUNIS forest habitat types (Level 3, with modifications proposed by Schaminée et al. 2013) were prepared in a form of logical formulas. These formulas combined total covers of individual species or species groups using logical operators AND, OR and AND not, following the proposals of Bruijnzeel (1997). Details of the approach used here are described in Landucci et al. (submitted). For example, the logical formula for the habitat type G1.8 Acidophilous *Quercus* woodland is the following:

$((\langle \#TC \text{ Quercus petraea-robur GR15} \rangle \text{ AND } \langle \#TC \text{ Quercus petraea-robur GR } \#TC \text{ Trees EXCEPT } \#TC \text{ Quercus petraea-robur} \rangle) \text{ AND } \langle \#TC \text{ Quercion roboris GR15} \rangle) \text{ NOT } \langle \#TC \text{ Quercus-thermo-herbs GR05} \rangle$

This means that the total cover (#TC) of the functional species group *Quercus petraea-robur* (includes deciduous temperate oak species *Quercus petraea* and *Q. robur*) is greater than 15% (GR15) and at the same time the total cover of this group is greater than the total cover of any other tree species (#TC Trees EXCEPT #TC *Quercus petraea-robur*) and at the same time the total cover of the functional group *Quercion roboris* (includes herb species diagnostic of acidophilous *Quercus* woodlands) is greater than 15% and at the same time the functional group *Quercus-thermo-herbs* (includes herb species diagnostic of thermophilous *Quercus* woodlands) is not greater than 5%.

- (7) Lists of species belonging to each functional species group, formal definitions of all EUNIS forest habitat types and instructions for handling taxonomic concepts and nomenclature of individual species were included in a single file with a computer code that can be read by JUICE 7.
- (8) All relevés in the data set were assessed whether they meet conditions of each logical formula, using JUICE 7, and based on this, they were assigned to individual EUNIS forest habitat types.

In total more than 140,000 relevés were assigned to EUNIS forest habitat types in this way. The advantage of this procedure was that (i) relevés not assigned to syntaxa could be classified, (ii) new relevés obtained since the last year could be included and (iii) assignments of relevés to the types were based on uniform criteria applied consistently across the whole European data set. This data set was then used to create maps of known distributions and to serve as an input for the habitat suitability modelling. Where more than 5,000 relevés were available for a habitat type the data set was restricted to only one location per each grid cell of 5km x 5 km.

Excluded from the classification process were forest types located outside the geographic scope (Macaronesia), or floristically difficult to define according to the national classifications (B1.7, G1.D, G2.8, G2.9). However, B1.7 has been included by taking into account all forest relevés (selected by the expert system) that are located within the coastal dune area of the Map of the Natural Vegetation of Europe (Bohn et al. 2000-2004) with a buffer of 1 km.

#### **4.3.2 Habitat suitability modelling**

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 the most meaningful environmental predictors commonly used for modelling non-tropical plant and vegetation diversity, and are not mutually strongly correlated.

As environmental data (and their sources) the following layers have been used:

- PET = Potential Evapotranspiration  
<http://www.cgiar-csi.org/data/global-aridity-and-pet-database>
- Soil\_pH = Topsoil pH  
[www.isric.org](http://www.isric.org)
- Solar = Solar radiation  
<http://www.worldgrids.org/doku.php?id=wiki:inmsre3>
- BioClim 4 = Temperature Seasonality (standard deviation \*100)  
<http://www.worldclim.org/bioclim>
- BioClim 8 = Mean Temperature of Wettest Quarter  
<http://www.worldclim.org/bioclim>
- BioClim 12 = Annual Precipitation  
<http://www.worldclim.org/bioclim>
- BioClim 15 = Precipitation Seasonality (Coefficient of Variation)  
<http://www.worldclim.org/bioclim>

- BioClim 18 = Precipitation of Warmest Quarter  
<http://www.worldclim.org/bioclim>
- NDVI peak = the Maximum NDVI  
 (HANTS 2012)
- Water = Distance to water (rivers, lakes, sea)  
 derived from the shapefile 'Inland\_Waters.shp'

Maxent is expected to perform well for estimating the geographic distribution of EUNIS habitats in Europe. However, as with any other modelling technique 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 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 from the forest plot database, assuming that they reflect the general geographic bias of forest sampling in Europe. The second approach concerns a random selection of 10,000 background points in the whole study area, assuming that the presence data describe a representative subset of the real distribution range of the target habitat.

In Appendix C the results of the analysis are presented. 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 in the distribution of European forest 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 forests, 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. In the overview of forest types on the first page of the Appendix, the preference for one of the two outputs is indicated in the columns 'Forest' (assuming biased data) and 'Random' (assuming non-biased data).

For each EUNIS forest type the following data are presented:

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

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

The habitat suitability maps will be further processed in the ETC/BD Task 1.7.5.C: 'Ecosystem mapping and assessment' in which the maps will be further downscaled to actual land cover situation based on remotely sensed information such as the JRC Forest Map (and 20 m spatial resolution GIO HR layer Forest) and phenological data as derived from RS data, e.g. MODIS time series (HANTS).

## Appendix C: Descriptions of EUNIS Forest habitat types

In the following, the EUNIS Forest habitats have been given their revised names, beneath which is given the original text description, then the draft revised description. Red text indicates those Forest habitats where Schaminée et al. (2013) recommended some revision, either splitting or fusion of adjacent units and then splitting. Where such changes have occurred, the original text description is repeated for each new unit. Green text indicates those habitats where further revision, either splitting or fusion of adjacent units, has been proposed for the Red List of European habitats project.

In the revised description, 'woodland' is used where the habitat has a large measure of uniformity, 'woodlands' where the habitat unites rather diverse woodland types. All biogeographic zones have been given lower-case initial letters (e.g. mediterranean) to avoid confusion with similarly named geographic regions.

### **B1.7 Coastal dune woodland**

Original description: Coastal dunes colonised by woodland or riparian thickets.

Deciduous or evergreen woodlands variously dominated by durmast oak (*Quercus robur*), mixed broadleaves, evergreen oaks (*Quercus* spp.), Scot's Pine (*Pinus sylvestris*), thermophilous pines (*Pinus* spp.) or willows (*Salix* spp.) on stable dune sands along the Baltic, Atlantic, Mediterranean and Black Sea coasts, often indistinguishable from equivalent forests further inland.

### **G1.1 Temperate and boreal softwood riparian woodland**

Original description: Riparian woods of the boreal, boreo-nemoral, nemoral and submediterranean and steppe zones, with one or few dominant species, typically *Alnus*, *Betula*, *Populus* or *Salix*. Includes woods dominated by narrow-leaved willows *Salix alba*, *Salix eleagnos*, *Salix purpurea*, *Salix viminalis* in all zones including the mediterranean. Excludes riverine scrub of broad-leaved willows, e.g. *Salix aurita*, *Salix cinerea*, *Salix pentandra* (F9.1).

Willow- and poplar- (*Salix*- and *Populus*-) dominated woodland 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.

### **G1.2 Temperate and boreal hardwood riparian woodland**

Original description: Mixed riparian forests, sometimes structurally complex and species-rich, of floodplains and of galleries beside slow- and fast-flowing rivers of the nemoral, boreo-nemoral, steppe and submediterranean zones. Gallery woods with *Acer*, *Fraxinus*, *Prunus* or *Ulmus*, together with species listed for G1.1. Floodplain woodland characterized by mixtures of *Alnus*, *Fraxinus*, *Populus*, *Quercus*, *Ulmus*, *Salix*.

Ash-alder (*Fraxinus excelsior*-*Alnus glutinosa*/*A. incana*) and mixed deciduous broadleaved woodland of fresh mineral soils on less-frequently flooded river terraces and flushed valley sides in the lowlands and foothills of the nemoral and boreal zones and locally in the submediterranean.

### **G1.3 Mediterranean and Macaronesian riparian woodland**

Original description: Alluvial forests and gallery woods of the mediterranean region. Dominance may be of a single species, of few species or mixed with many species including *Fraxinus*, *Liquidambar*, *Platanus*, *Populus*, *Salix*, *Ulmus*. Excludes mediterranean *Salix* woods (G1.1) and shrubby riparian vegetation (F9.3).

Deciduous broadleaved woodland, most commonly dominated by poplars (*Populus*), willows (*Salix*), oriental plane (*Platanus orientalis*) or *Liquidambar*, on periodically flooded alluvium or gravel terraces and streamsides in humid localities in the mediterranean zone and Macaronesia. Also includes streamside *Rhododendron ponticum* and birch (*Betula pendula* var. *fontqueri*) woodlands in Spain.

### **G1.4 Broadleaved swamp woodland on non-acid peat**

Original description: Broadleaved swamp woodland not on acid peat. Includes *Alnus*, *Populus*, *Quercus* swamp woods. Excludes *Salix* carr, with shrubby willows, e.g. *Salix aurita*, *Salix cinerea*, *Salix pentandra* (F9.2).

Deciduous broadleaved woodland, commonly dominated by alder (*Alnus glutinosa* and *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.

### **G1.5 Broadleaved swamp woodland on acid peat**

Original description: Broadleaved woodland on wet acid peat, dominated by *Betula pubescens* or rarely *Alnus glutinosa*, sometimes with an admixture of conifers or shrubby *Salix* species. *Sphagnum* spp. are normally prominent in the ground vegetation.

Deciduous broadleaved or mixed woodland 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*) but with increasing amounts of Scot's pine (*Pinus sylvestris*) towards the boreal zone.

#### **G1.6a Fagus woodland on non-acid soils**

Original description: Forests dominated by beech *Fagus sylvatica* in western and central Europe, and *Fagus orientalis* and other *Fagus* species in southeastern Europe and the Pontic region. Many montane formations are mixed beech-fir or beech-fir-spruce forests, which are listed under G4.6.

Beech- (*Fagus sylvatica* and *F. orientalis*) dominated woodland 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, are always subordinate in cover and usually in height, though broadleaved associates are more extensive and diverse on richer soils and, like the usually sparse shrub layer, show regional climate-related variation. The field layer can be species-rich.

#### **G1.6b Fagus woodland on acid soils**

Original description: Forests dominated by beech *Fagus sylvatica* in western and central Europe, and *Fagus orientalis* and other *Fagus* species in southeastern Europe and the Pontic region. Many montane formations are mixed beech-fir or beech-fir-spruce forests, which are listed under G4.6.

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.

#### **G1.7 Thermophilous deciduous woodland**

Original description: Forests or woods of submediterranean climate regions and supramediterranean altitudinal levels, and of western Eurasian steppe and substeppe zones, dominated by deciduous or semideciduous thermophilous *Quercus* species or by other southern trees such as *Carpinus orientalis*, *Castanea sativa* or *Ostrya carpinifolia*. Thermophilous deciduous trees may, under local microclimatic or edaphic conditions, replace the



evergreen oak forests in mesomediterranean or thermomediterranean areas, and occur locally to the north in central and western Europe.

Deciduous or evergreen woodland of thermophilous and drought-resistant trees, especially oaks (*Quercus* spp.), with a subordinate tier of regionally-varied associates, through the sub-mediterranean zones, drier and warmer situations further north, extending into more humid higher altitudes in the mediterranean zone.

### **G1.8 Acidophilous *Quercus* woodland**

Original description: Forests of *Quercus robur* or *Quercus petraea* on acid soils with an herb layer mostly constituted by the ecological groups of *Deschampsia flexuosa*, *Vaccinium myrtillus*, *Pteridium aquilinum*, *Lonicera periclymenum*, *Holcus mollis*, and of *Maianthemum bifolium*, *Convallaria majalis*, *Hieracium sabaudum*, *Hypericum pulchrum*, *Luzula pilosa*, and the mosses *Polytrichum formosum* and *Leucobryum glaucum*.

Oak-dominated woodland (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 some regional distinctiveness and towards the very humid western Atlantic seaboard have extraordinary richness of ferns and cryptogams.

### **G1.9a Boreal and nemoral *Betula* woodlands on mineral soils**

Original description: Forests or woods dominated by *Betula*, *Populus tremula* or *Sorbus aucuparia*. Excludes swamp woods (G1.4), woods on wet peat (G1.5) and riparian woods (G1.1).

Open, low canopy climax birch woodlands (*Betula pubescens* ssp. *czerepanovii* = *B. tortuosa* or ssp. *carpatica*) with a heathy or herb-rich field layer in the boreal region and nemoral mountains of Cantabria and the Sudeten.

### **G1.9b Mediterranean *Betula* and *Populus tremula* woodlands on mineral soils**

Original description: Forests or woods dominated by *Betula*, *Populus tremula* or *Sorbus aucuparia*. Excludes swamp woods (G1.4), woods on wet peat (G1.5) and riparian woods (G1.1).

Diverse climax woodlands dominated by birch (*Betula pubescens* and its vicariants) 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.

### **G1.A Mesotrophic and eutrophic deciduous woodland, not dominated by *Fagus***

Original description: Woods, typically with mixed canopy composition, on rich and moderately rich soils. Includes woods dominated by *Acer*, *Carpinus*, *Fraxinus*, *Quercus* (especially *Quercus petraea* and *Quercus robur*), *Tilia* and *Ulmus*. Excludes acid *Quercus* woodland (G1.8) and woodland with a large representation of southern species such as *Fraxinus ornus* or *Quercus pubescens* (G1.7).

Deciduous mixed broadleaved woodland on drought-free mineral soils, neutral to base-rich and of moderate to high nutrient status, through the lowlands and foothills of the nemoral zone extending locally into the boreal and submediterranean zones and pannonian region. The tree canopy is often diverse and structurally complex with a rich and extensive understorey and field layer showing striking regional variation and an often distinctive vernal aspect.

### **G1.B Non-riverine *Alnus* woodland on mineral soil**

Original description: Nonriparian, nonmarshy woods dominated by *Alnus* spp.

### **G2.1 Mediterranean evergreen *Quercus* woodland**

Original description: Woodland with dominant evergreen arborescent *Quercus*, e.g. *Quercus alnifolia*, *Quercus coccifera*, *Quercus ilex*, *Quercus rotundifolia*, *Quercus suber*

Woodland dominated by evergreen broadleaved oaks (most widely *Quercus ilex*) with associated sclerophyllous and lauriphyllous 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.

### **G2.2 Mainland lauriphyllous woodland**

Original description: Lauriphyllous and mixed lauriphyllous-xerophyllous evergreen forests of the Warm-Temperate Humid zones of the Eurasian continent and continental shelf islands and of humid enclaves within the Mediterranean zones. Lauriphyllous forests of the oceanic Macaronesian archipelagoes are listed separately under G2.3.

Evergreen lauriphyllous short-stature woodland, often dominant by bay (*Laurus nobilis*) or strawberry tree (*Arbutus unedo*) 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 G2.1.

### **G2.3 Macaronesian lauriphyllous woodland**

Original description: Humid to hyper-humid, mist-bound, luxuriant, evergreen, lauriphyllous forests of the cloud belt of the Macaronesian islands, extremely rich in floral and faunal species, among which many are restricted to these communities. Genera such as *Picconia*, *Semele*, *Gesnouinia*, *Lactucosonchus*, *Ixanthus* are entirely endemic to these communities, while others, such as *Isoplexis*, *Visnea* and *Phyllis* reach in them their maximum development; in addition, each of the formations of the various archipelagoes harbours distinctive endemic species. Laurel forests are the most complex and remarkable relict of the humid sub-tropical vegetation of the Miocene-Pliocene late Tertiary of southern Europe. Areas of intact forests have been drastically reduced to a level below which the preservation of their elements could not be sustained.

Evergreen lauriphyllous woodland on deep soils in the hyper-humid, frost-free, fog belt of the Macaronesian hills. The tree and shrub canopy is very diverse and rich in endemics, with striking differences related to climatic conditions across the different island groups, local topography and long isolation of the floras.

### **G2.4 *Olea europaea*-*Ceratonía siliqua* woodland**

Original description: Thermo-Mediterranean or thermo-Canarian woodland dominated by arborescent *Olea europaea* var. *sylvestris*, *Ceratonía siliqua*, *Pistacia lentiscus*, *Myrtus communis* or, in the Canary Islands, by *Olea europaea* ssp. *cerasiformis* and *Pistacia atlantica*. Most formations will be listed as arborescent matorral F5.1, but a few stands have a sufficiently tall, closed canopy to qualify for this unit.

Olive (*Olea europea*), carob (*Ceratonía siliqua*) and mastic (*Pistacia lentiscus*) woodland with a tall, closed tree canopy in the drought-prone lowlands and foothills of the Mediterranean and Macaronesia.

### **G2.5 Phoenix groves**

Original description: Woods, often riparian, formed by palm trees of the Mediterranean and Macaronesian zones, *Phoenix theophrasti* of Crete and western Anatolia, and *Phoenix canariensis* of the Canary Islands.

Fragmentary woodlands of palms (*Phoenix* spp.) and dragon trees (*Dracaena* spp.), dependent on periodic torrents, often along temporary stream-sides, in the very dry to arid eastern Mediterranean and Macaronesian lowlands.

## **G2.6 *Ilex aquifolium* woodland**

Original description: Woods dominated by tall arborescent *Ilex aquifolium*. They occur in the supra-Mediterranean level of Sardinia and Corsica and in Atlantic mountains of northwestern Spain, mostly as a facies of relict yew- holly forests G3.9. Other scattered occurrences exist in the nemoral zone of western Europe, as facies of beech forest G1.6 or acidophilous oak forest G1.8.

Holly- (*Ilex aquifolium*-) dominated woodland occurring in scattered localities across Europe and probably an arborescent survival of G3.9 *Taxus* woodland at middle altitudes in the Mediterranean zone and of G1.6 *Fagus* and G1.8 *Quercus* in the nemoral lowlands.

## **G2.7 Macaronesian heathy woodland**

Original description: Very tall, forest-like, formations dominated by *Erica arborea*, *Myrica faya*, *Arbutus canariensis* or *Visnea mocanera*, occurring naturally in the most wind-exposed and the driest stations within the 'monte verde' of the Canary Island cloud belt; they also occur extensively as degradation stages of the *Laurus* woodland G2.3 or as secondary colonists.

Small-stature woodland variously dominated by arborescent ericoids, laurels (*Laurus* spp.), strawberry tree (*Arbutus unedo*) and Canarian holly (*Ilex canariensis*) in situations that range from cold and hyper-humid slopes and exposed fog-bound outcrops to sub-humid and dry foothills of Madeira and the Canaries.

## **G3.1a Temperate mountain *Picea* woodland**

Original description of G3.1 *Abies* and *Picea* woodland: Woodland dominated by *Abies* or *Picea*.

Evergreen coniferous woodland 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.

## **G3.1b Temperate mountain *Abies* woodland**

Original description of G3.1 *Abies* and *Picea* woodland: Woodland dominated by *Abies* or *Picea*.

Woodlands 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.

### **G3.1c Mediterranean mountain *Abies* woodland**

Original description of G3.1 *Abies* and *Picea* woodland: Woodland dominated by *Abies* or *Picea*.

Evergreen coniferous woodlands 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*).

### **G3.2 Temperate subalpine *Larix*-*Pinus* woodland**

Original description: Forests of the subalpine and sometimes montane levels of the Alps and the Carpathians, dominated by *Larix decidua* or *Pinus cembra*; the two species may form either pure or mixed stands, and may be associated with *Picea abies* or, in the western Alps, *Pinus uncinata*.

Coniferous, in part deciduous, woodland 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.

### **G3.3 *Pinus uncinata* woodland**

Original description: Mostly subalpine forests of the Alps, the Jura, the Pyrenees and the Iberian Range, dominated by *Pinus uncinata*, usually open and with a very developed shrubby understory.

Coniferous woodland dominated by *Pinus uncinata* with a shrubby *Rhododendron*-rich understorey at the sub-alpine level of the western Alps, Jura, Pyrenees and Iberian mountains.

### **G3.4/5a Temperate Continental *Pinus sylvestris* woodland**

Original description of G3.4 *Pinus sylvestris* woodland south of the taiga: Forests of *Pinus sylvestris* ssp. *sylvestris* and *Pinus sylvestris* ssp. *hamata* of the Nemoral and Mediterranean zones and of their transitions to the Steppe zone. Included are, in particular, the forests of Scotland, of the Alpine system, of the Mediterranean peninsulas, of the lowlands of Central Europe, of the East European Nemoral zone and its adjacent wooded steppes, formed by *Pinus sylvestris* ssp. *sylvestris*, as well as those of Anatolia, of the Caucasus and of Crimea, formed by *Pinus sylvestris* ssp. *hamata*. Excluded are the formations situated within the range of natural lowland occurrence of *Picea abies*.

Original description of G3.5 *Pinus nigra* woodland: Forests dominated by pines of the *Pinus nigra* group.

Woodlands 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.

#### **G3.4/5b Temperate and submediterranean montane *Pinus sylvestris-nigra* woodland**

Original description of G3.4 *Pinus sylvestris* woodland south of the taiga: Forests of *Pinus sylvestris* ssp. *sylvestris* and *Pinus sylvestris* ssp. *hamata* of the Nemoral and Mediterranean zones and of their transitions to the Steppe zone. Included are, in particular, the forests of Scotland, of the Alpine system, of the Mediterranean peninsulas, of the lowlands of Central Europe, of the East European Nemoral zone and its adjacent wooded steppes, formed by *Pinus sylvestris* ssp. *sylvestris*, as well as those of Anatolia, of the Caucasus and of Crimea, formed by *Pinus sylvestris* ssp. *hamata*. Excluded are the formations situated within the range of natural lowland occurrence of *Picea abies*.

Original description of G3.5 *Pinus nigra* woodland: Forests dominated by pines of the *Pinus nigra* group

Evergreen coniferous woodlands, 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.

#### **G3.4/5c Mediterranean montane *Pinus sylvestris-nigra* woodland**

Original description of G3.4 *Pinus sylvestris* woodland south of the taiga: Forests of *Pinus sylvestris* ssp. *sylvestris* and *Pinus sylvestris* ssp. *hamata* of the Nemoral and Mediterranean zones and of their transitions to the Steppe zone. Included are, in particular, the forests of Scotland, of the Alpine system,

of the Mediterranean peninsulas, of the lowlands of Central Europe, of the East European Nemoral zone and its adjacent wooded steppes, formed by *Pinus sylvestris* ssp. *sylvestris*, as well as those of Anatolia, of the Caucasus and of Crimea, formed by *Pinus sylvestris* ssp. *hamata*. Excluded are the formations situated within the range of natural lowland occurrence of *Picea abies*.

Original description of G3.5 *Pinus nigra* woodland: Forests dominated by pines of the *Pinus nigra* group

Evergreen coniferous woodland 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 Scots pine (*Pinus sylvestris*), both trees often occurring as vicariant forms in different localities.

### **G3.6 Mediterranean and Balkan subalpine *Pinus heldreichii*-*peuce* woodland**

Original description: Woods of *Pinus heldreichii*, *Pinus leucodermis* or *Pinus peuce*.

Evergreen coniferous woodland of timberlines in the mountains of the Balkans and southern Italy, dominated by Bosnian pine (*Pinus heldreichii*) on base-rich soils in more sunny and drought-prone situations or by Macedonian pine (*P. peuce*) on siliceous soils.

### **G3.7 Mediterranean lowland to submontane *Pinus* woodland**

Original description: Mediterranean and thermo-Atlantic forests of thermophilous pines, mostly appearing as successional stages or plagioclimax replacements of Mediterranean evergreen broadleaved woodland G2.1 or G2.4. Long-established plantations of these pines, within their natural area of occurrence, and with an undergrowth basically similar to that of G2.1 and G2.4, are included.

Evergreen coniferous woodland dominated by various thermophilous pines: Maritime pine (*Pinus pinaster* in eastern 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 on Aegean islands), the first three often favouring unstable substrates or pre-climax situations.

### **G3.8 *Pinus canariensis* woodland**

Original description: Forests of endemic *Pinus canariensis*, of the dry montane level at around 800 to 2000 m (locally down to 500 and up to 2500 m) in

Tenerife, La Palma, Gran Canaria and Hierro, with *Chamaecytisus proliferus*, *Adenocarpus foliolosus*, *Cistus symphytifolius*, *Lotus campylocladus*, *Lotus hillebrandii*, *Lotus spartioides*, *Daphne gnidium*, *Juniperus cedrus*, *Micromeria* spp.; these forests, of which well-preserved examples have become rare, are the only habitat of *Fringilla teydea*, *Dendrocopos major canariensis* and *Dendrocopos major thanneri*.

Woodland of endemic Canarian pine (*Pinus canariensis*) occurring mostly at high altitudes in dry sunny situations above the fog belt, locally on foothill rock outcrops and old lava flows, in the western Canary Islands.

### **G3.9a *Taxus baccata* woodland**

Original description of Coniferous woodland dominated by Cupressaceae or Taxaceae: Woods dominated by *Cupressus sempervirens*, *Juniperus* spp. or *Taxus baccata* of the nemoral and Mediterranean mountains and hills.

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.

### **G3.9b Mediterranean Cupressaceae woodland**

Original description of Coniferous woodland dominated by Cupressaceae or Taxaceae: Woods dominated by *Cupressus sempervirens*, *Juniperus* spp. or *Taxus baccata* of the nemoral and Mediterranean mountains and hills.

Evergreen woodlands of cypress (*Cupressus sempervirens*), junipers (*Juniperus excelsa*, *J. foetidissima*, *J. drupacea*, *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.

### **G3.9c Macaronesian *Juniperus* woodland**

Original description of Coniferous woodland dominated by Cupressaceae or Taxaceae: Woods dominated by *Cupressus sempervirens*, *Juniperus* spp. or *Taxus baccata* of the nemoral and Mediterranean mountains and hills.

Evergreen woodlands of endemic macaronesian junipers (*Juniperus turbinata* ssp. *canariensis*, *J. cedrus* ssp. *cedrus* and ssp. *maderensis*, *J. brevifolia*) in diverse habitats as sometimes very small isolated populations, each with distinctive associated floras.

### **G3.A *Picea* taiga woodland of relatively rich and moist soils**



Original description: Boreal spruce or spruce-pine forests of Fennoscandia, northeastern Poland, the Baltic States, Belarus and European Russia, with G3.B constituting the westernmost section of the continuous Eurasian northern taiga belt.

Woodland naturally dominated by spruce but frequently with an admixture of some Scot's pine (*Pinus sylvestris*) and birch (*Betula pendula* and *B. pubescens*) on more mesic soils through the north-eastern continental and boreal regions, often with a subordinate deciduous broadleaf component in the canopy and understorey and rich and varied field-layer, mosses and lichens.

### **G3.B *Pinus sylvestris* taiga woodland**

Original description: Boreal pine forests of Fennoscandia, northeastern Poland, the Baltic States, Belarus and European Russia, with G3.A constituting the westernmost section of the continuous Eurasian northern taiga belt.

Woodland naturally dominated by Scot's pine (*Pinus sylvestris*) but often with some birch (*Betula pendula* and *B. pubescens*) and spruce (*Picea abies* and *P. obovata*) on lithomorphic and podsolized soils of dry and barren situations through the north-eastern continental and boreal regions with a generally heathy field layer but, when on eskers, a specialised herb flora.

### **G3.C *Larix* taiga woodland**

Original description: Boreal larch, forests of Fennoscandia, the Baltic States, Belarus and European Russia, occurring in limited, edaphic pockets within the area dominated by G3.A and G3.B.

Deciduous coniferous woodland of Siberian larch (*Larix sibirica*) which extends west from its extensive realm in European Russia as small stands with an open, low-stature canopy on patches of moist, nutrient-poor sandy soils among spruce and pine taiga in the Boreal zone

### **G3.D Boreal bog conifer woodland**

Original description: Woods of *Pinus* spp. or *Picea* spp., sometimes mixed with *Betula pubescens*, colonizing bogs and fens in the boreal and boreonemoral zones.

Evergreen coniferous woodland, often open and low-growing, dominated by spruce (*Picea abies*, especially to the north) or Scot's pine (*Pinus sylvestris*, more to the south) and sometimes forming extensive stands on peaty soils on or around bogs or in depressions kept moist by high ground water table, through the Boreal zone.

### **G3.E Temperate bog conifer woodland**

Original description: Woods of *Pinus* spp. or *Picea* spp., sometimes mixed with *Betula pubescens*, colonizing bogs and fens in the nemoral zone. Conifer-dominated bog woodland occurs mainly in the boreal and boreonemoral zones, but extends into the nemoral, wooded steppe and steppe zones.

Evergreen coniferous woodland, often open and low-growing, dominated by Scot's pine (*Pinus sylvestris*) or spruce (*Picea abies*) on often drier but sometimes extensive peats, on bog margins or in depressions kept moist by high ground water table, through the nemoral zone.

## Appendix F: Distribution and suitability maps of revised EUNIS forest habitat types

### EUNIS classes and number of representing relevés

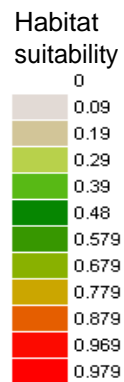
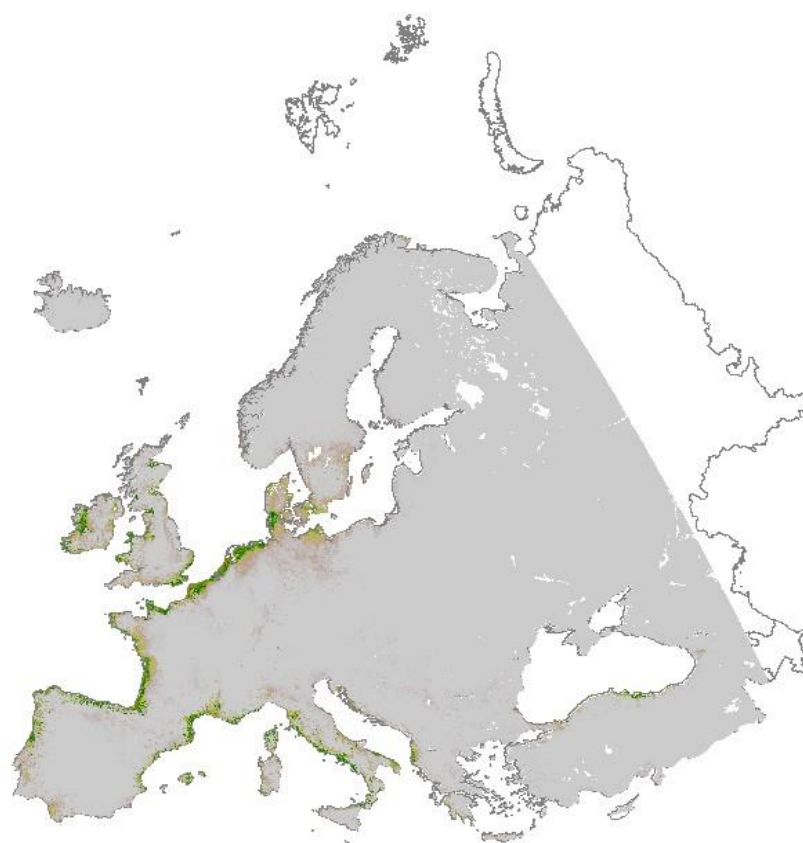
Type Subtype	Name	Number of locations	Background	
			Forest	Random
B1.7	Coastal dune woodland* [Coastal dune woods]	550		1
G1.1	Temperate and boreal softwood riparian woodland* [Riparian and gallery woodland, with dominant [Alnus], [Betula], [Populus] or [Salix]]	3219	1	
G1.2	Temperate and boreal hardwood riparian woodland* [Mixed riparian floodplain and gallery woodland]	5393	1	
			1	
G1.3	Mediterranean and Macaronesian riparian woodland* [Mediterranean riparian woodland]	1377	1	
G1.4	Broadleaved swamp woodland on non-acid peat* [Broadleaved swamp woodland not on acid peat]	3828	1	
G1.5	Broadleaved swamp woodland on acid peat* [Broadleaved swamp woodland on acid peat]	1956		
G1.6	[Fagus] woodland could be divided into two types, because of the high variation within the overall type and the possibility to make a clear division:			
G1.6a	Fagus woodland on non-acid soils	21695		1
G1.6b	Fagus woodland on acid soils	12981		1
G1.7	Thermophilous deciduous woodland	15196	1	
G1.8	Acidophilous Quercus woodland* [Acidophilous [Quercus]-dominated woodland]	9410		1
G1.9	Non-riverine woodland with [Betula], [Populus tremula] or [Sorbus aucuparia] has to be divided into two types:			
G1.9a	Mountain Betula and Populus tremula woodlands on mineral soils	162	1	
G1.9b	Lowland continental Betula and Populus tremula woodlands on mineral soil	No data		
G1.A	Mesotrophic and eutrophic deciduous woodland, not dominated by Fagus* [Meso- and eutrophic [Quercus], [Carpinus], [Fraxinus], [Acer], [Tilia], [Ulmus] and related woodland]	19668	1	
G1.B	Non-riverine Alnus woodland on mineral soil* [Non-riverine [Alnus] woodland]	No data		
G1.C	Broadleaved deciduous plantations of non site-native trees* [Highly artificial broadleaved deciduous forestry plantations]	No data		
G1.D	<i>Fruit and nut tree orchards is not a woodland and should be removed (it could go into EUNIS group I)</i>	No data		
G2.1	Mediterranean evergreen Quercus woodland* [Mediterranean evergreen [Quercus] woodland]	6493	1	
G2.2	Mainland lauriphyllous woodland* [Eurasian continental sclerophyllous woodland]	39		0
G2.3	Macaronesian lauriphyllous woodland* [Macaronesian [Laurus] woodland]	No data		
G2.4	Olea oleaster-Ceratonia siliqua woodland* [Olea europaea] - [Ceratonia siliqua] woodland]	856		1
G2.5	Phoenix groves* [[Phoenix] groves]	10		0
G2.6	Ilex aquifolium woodland* [[Ilex aquifolium] woods]	313		1
G2.7	<i>Macaronesian heathy woodland* [Canary Island heath woodland]</i>	No data		

G2.8	Broadleaved evergreen plantations of non site-native trees* [Highly artificial broadleaved evergreen forestry plantations]	No data		
G2.9	Evergreen orchards and groves	No data		
G3.1	[Abies] and [Picea] woodland has to be divided into three types (according to dominant species and geographic distribution):			
G3.1a	Temperate mountain Picea woodland	12596		1
G3.1b	Temperate mountain Abies woodland	6994		1
G3.1c	Mediterranean mountain Abies woodland	64		0
G3.2	Temperate subalpine Larix-Pinus woodland* [Alpine [Larix] - [Pinus cembra] woodland]	2487		1
G3.3	[Pinus uncinata] woodland should be merged into G3.2 [Alpine [Larix] - [Pinus cembra] woodland] (this category corresponds to the same phytosociological units, with Pinus species as the usual dominant))	No data		
G3.4	[Pinus sylvestris] woodland south of the taiga has to be divided into three types:			
G3.4a	Temperate continental Pinus sylvestris woodland	9387	1	
G3.4b	Temperate and submediterranean montane Pinus sylvestris-nigra woodland	3530		1
G3.4c	Mediterranean montane Pinus sylvestris-nigra woodland	24		0
G3.5	[Pinus nigra] woodland should to be merged into the G3.4a and G3.4c types	No data		
G3.6	Mediterranean and Balkan subalpine Pinus heldreichii-peucis woodland* [balpine mediterranean [Pinus] woodland]	211		0
G3.7	Mediterranean lowland to submontane Pinus woodland* [Lowland to montane mediterranean [Pinus] woodland (excluding [Pinus nigra])]	2065		1
G3.8	Pinus canariensis woodland* [Canary Island [Pinus canariensis] woodland]	No data		
G3.9	Coniferous woodland dominated by [Cupressaceae] or [Taxaceae] should be divided into two types: Taxus baccata woodland and Juniperus-Cupressus woodland and further into mainland and Macaronesia.			
G3.9a	Taxus baccata woodland	317		1
G3.9b	Mediterranean Cupressaceae woodland	1621	1	
G3.9c	Macaronesian Juniperus woodland	No data		
G3.A	Picea taiga woodland* [{Picea] taiga woodland]	164	0	
G3.B	Pinus sylvestris taiga woodland* [[Pinus] taiga woodland]	2		0
G3.C	Larix taiga woodland* [[Larix] taiga woodland]	No data		
G3.D	Boreal bog conifer woodland* [Boreal bog conifer woodland]	No data		
G3.E	Temperate bog conifer woodland* [Nemoral bog conifer woodland]	1047		1
G3.F	Conifer plantations of non site-native trees* [Highly artificial coniferous plantations]	No data		

### B1.7 - Coastal dune woodland\* [Coastal dune woods]



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the study area*

<b>AUC training (0-1)</b>	0.987
<b>AUC test (0-1)</b>	0.9904
<b>Contribution variables to the Maxent model (%)</b>	
Temperature Seasonality (stdev * 100)	39.5222
Solar radiation	31.5583
Mean Temperature of Wettest Quarter	15.8472
Precipitation Seasonality (coef. of var.)	8.5057
Precipitation of Warmest Quarter	1.2786
Annual Precipitation	1.018
Potential Evapotranspiration	0.9996
Distance to water	0.947
Soil pH	0.3234

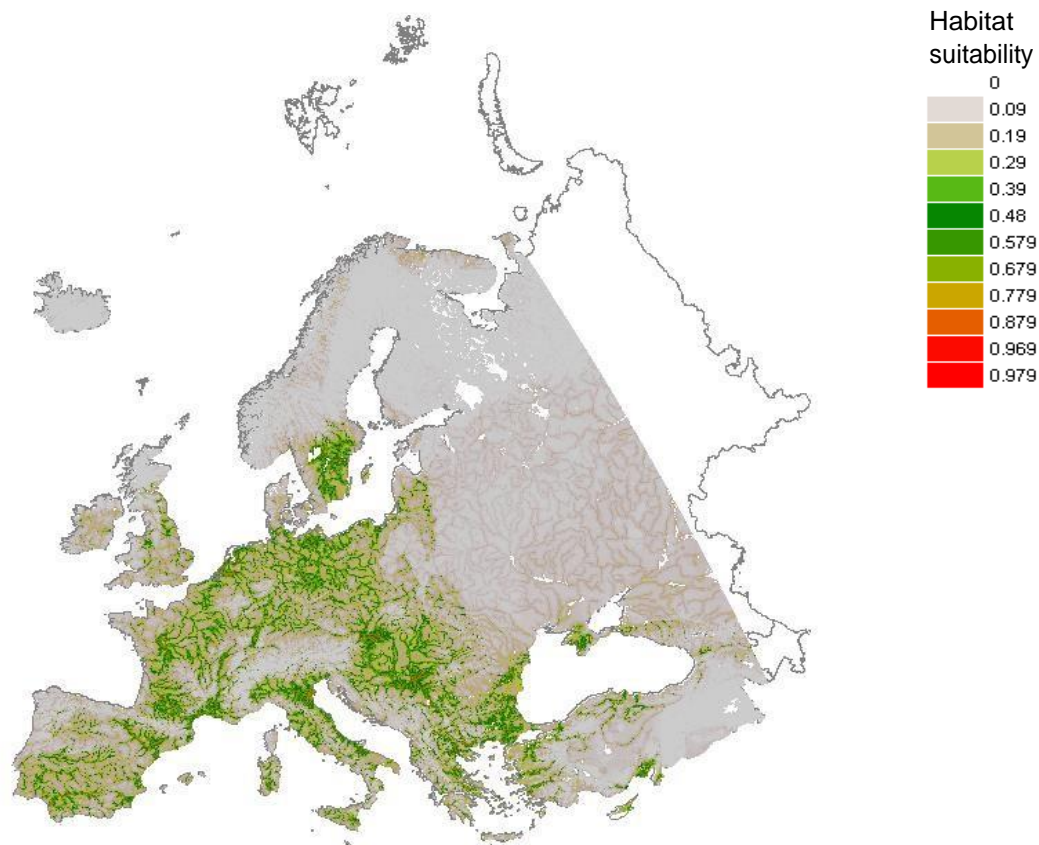
#### **Comment**

Suitable areas in the coastline of temperate and mediterranean climates. Inland predictions reflect climatic similarity but they must be masked to coastal habitats.

**G1.1 - Temperate and boreal softwood riparian woodland\* [Riparian and gallery woodland, with dominant [Alnus], [Betula], [Populus] or [Salix]]**



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the complete forest data set*

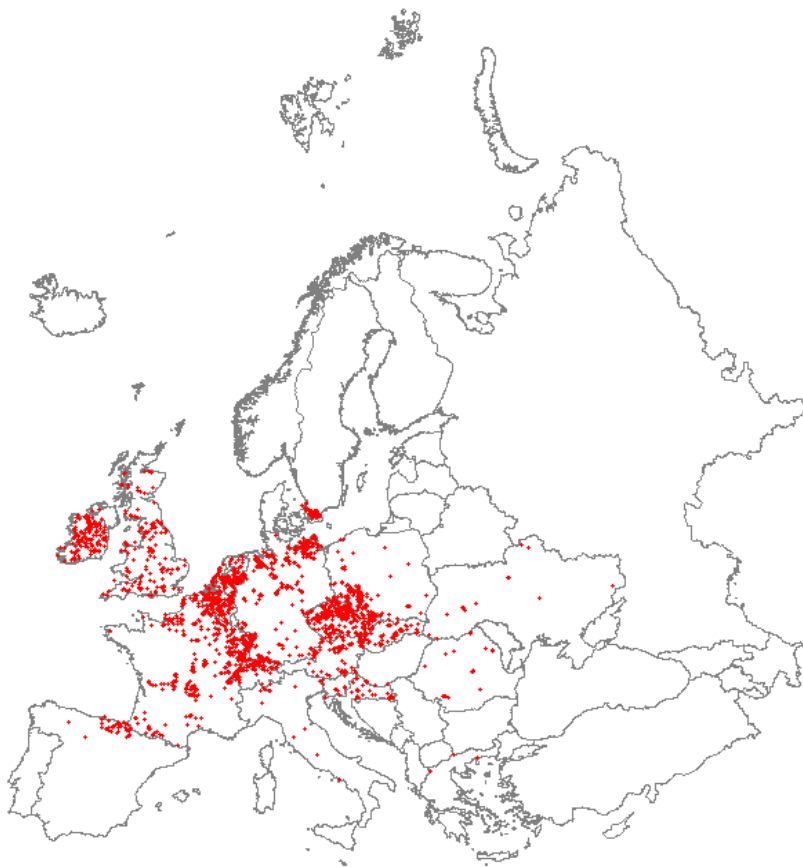
<b>AUC training (0-1)</b>	0.8625
<b>AUC test (0-1)</b>	0.8529
<b>Contribution variables to the Maxent model (%)</b>	
Distance to water	40.9207
Solar radiation	26.2171
Annual Precipitation	11.4437
Soil pH	10.1855
Temperature Seasonality (stdev * 100)	4.7345
Precipitation of Warmest Quarter	2.8407
Potential Evapotranspiration	1.6611
Precipitation Seasonality (coef. of var.)	1.3648
Mean Temperature of Wettest Quarter	0.6319

#### **Comment**

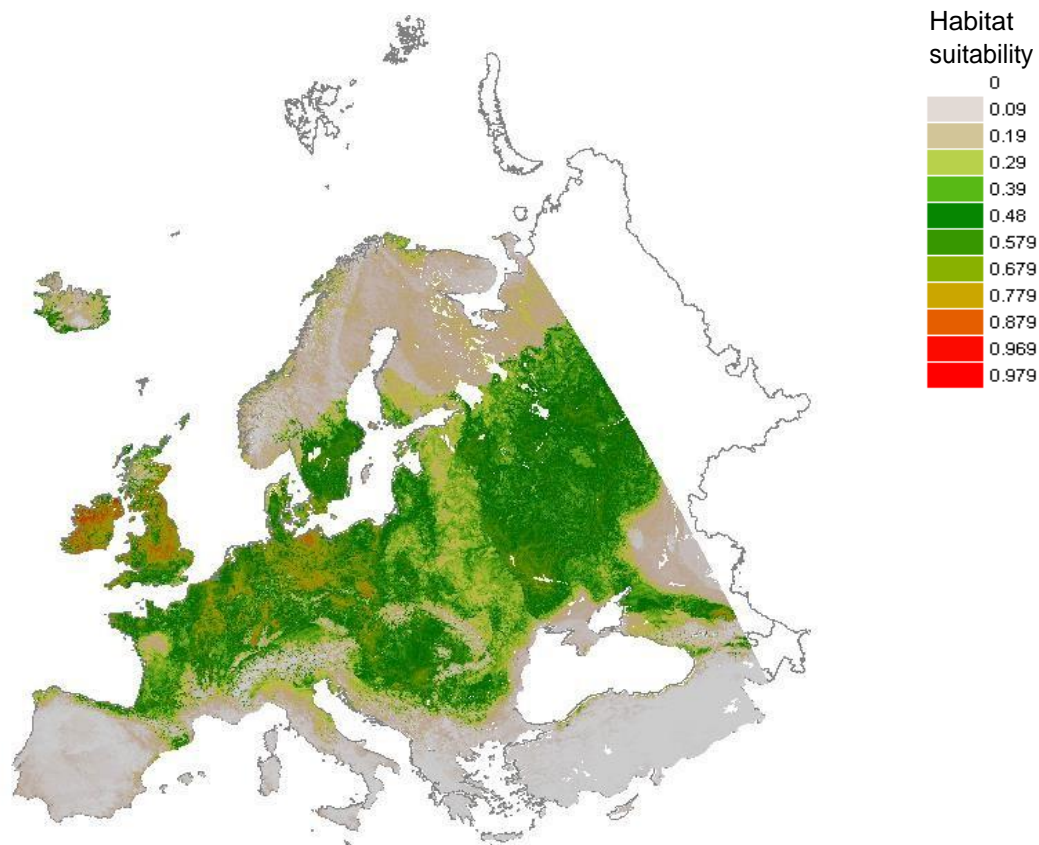
Suitable areas mainly distributed along the river basins. Potential underprediction for Eastern Europe and the Boreal zone because of the lack of data for these regions.



**G1.2 - Temperate and boreal hardwood riparian woodland\* [Mixed riparian floodplain and gallery woodland]**



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the complete forest data set*

<b>AUC training (0-1)</b>	0.7676
<b>AUC test (0-1)</b>	0.7524
<b>Contribution variables to the Maxent model (%)</b>	
Solar radiation	44.5248
Precipitation of Warmest Quarter	31.0573
Temperature Seasonality (stdev * 100)	5.8461
Mean Temperature of Wettest Quarter	5.4082
Potential Evapotranspiration	5.0005
Annual Precipitation	4.4875
Soil pH	1.7308
Precipitation Seasonality (coef. of var.)	1.0157
Distance to water	0.929

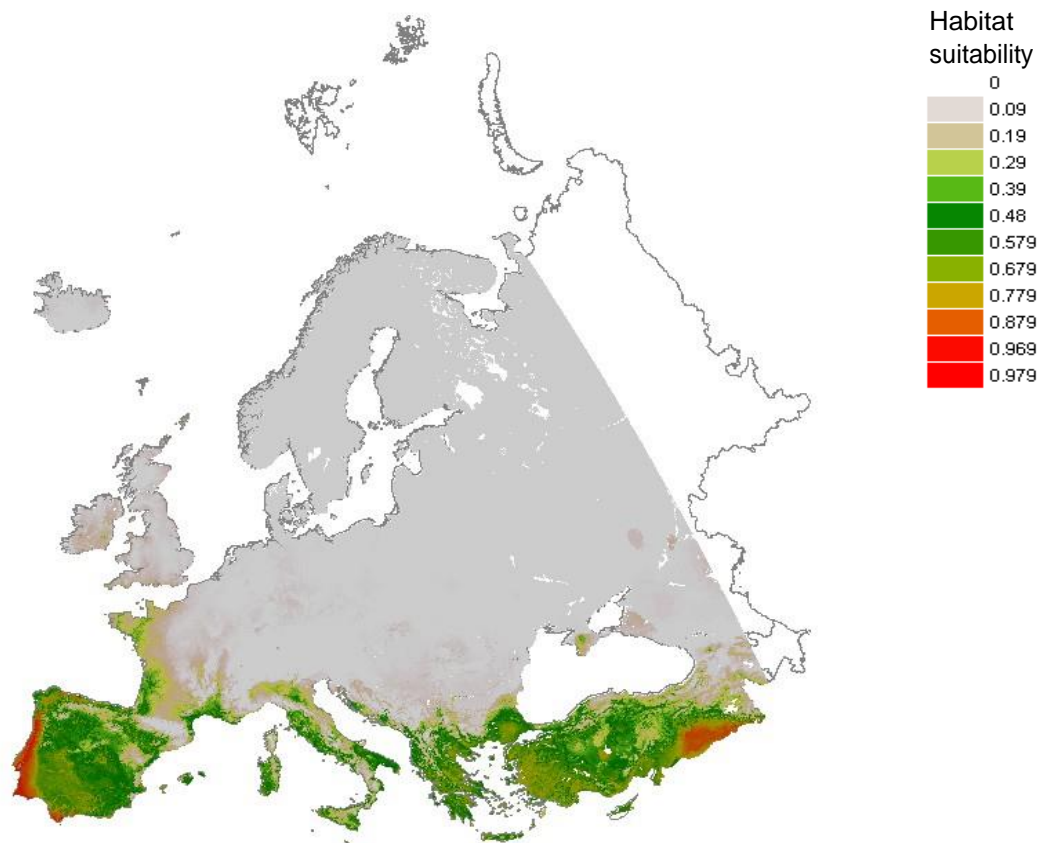
#### **Comment**

Suitable areas mainly confined to the Temperate biome, with a possible underprediction in the Boreal zone. The lack of soil moisture variables expands the predictions to non-riparian habitats.

### G1.3 - Mediterranean and Macaronesian riparian woodland\* [Mediterranean riparian woodland]



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the complete forest data set*

<b>AUC training (0-1)</b>	0.9318
<b>AUC test (0-1)</b>	0.9149
<b>Contribution variables to the Maxent model (%)</b>	
Potential Evapotranspiration	53.4946
Precipitation of Warmest Quarter	28.0611
Temperature Seasonality (stdev * 100)	9.4465
Mean Temperature of Wettest Quarter	3.8968
Precipitation Seasonality (coef. of var.)	2.2413
Solar radiation	1.5617
Soil pH	0.4755
Distance to water	0.4626
Annual Precipitation	0.3599

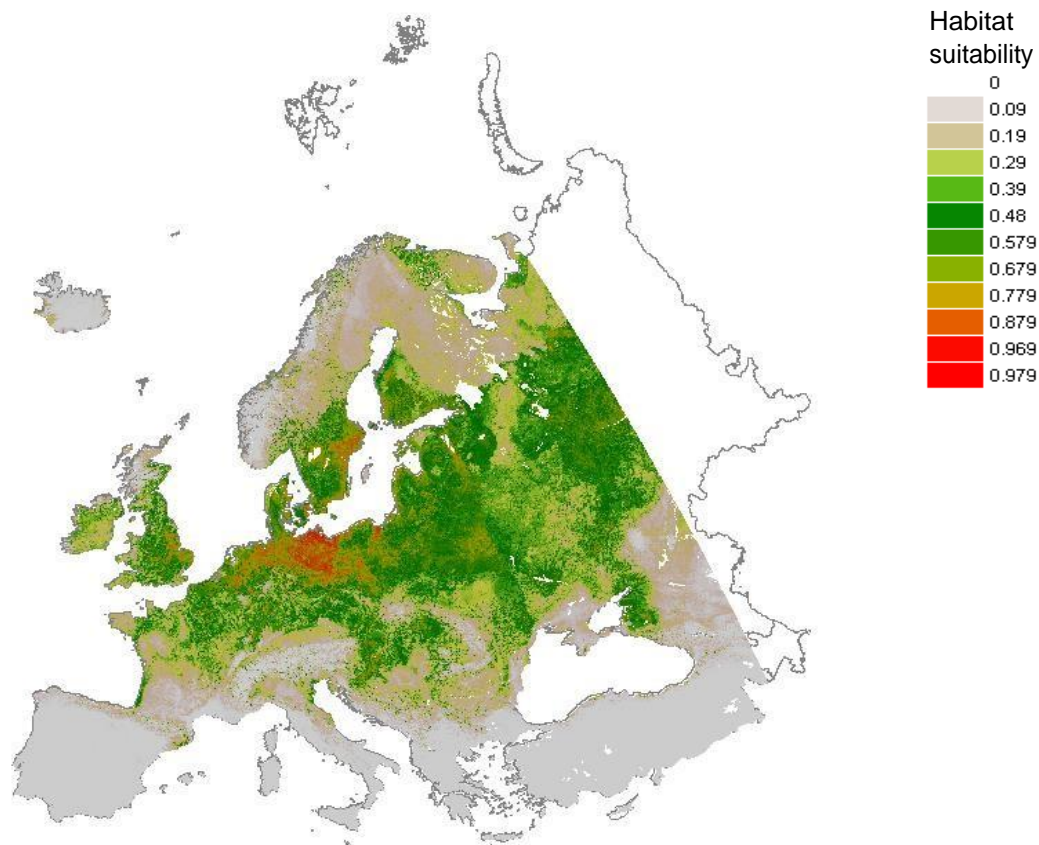
#### **Comment**

Suitable areas mainly confined to the Mediterranean biome. The lack of soil moisture variables expands the predictions to non-riparian habitats.

**G1.4 - Broadleaved swamp woodland on non-acid peat\* [Broadleaved swamp woodland not on acid peat]**



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the complete forest data set*

<b>AUC training (0-1)</b>	0.8424
<b>AUC test (0-1)</b>	0.8173
<b>Contribution variables to the Maxent model (%)</b>	
Solar radiation	35.2926
Precipitation of Warmest Quarter	18.6273
Mean Temperature of Wettest Quarter	16.2205
Annual Precipitation	12.3519
Potential Evapotranspiration	9.4265
Soil pH	4.6459
Temperature Seasonality (stdev * 100)	2.535
Precipitation Seasonality (coef. of var.)	0.8557
Distance to water	0.0447

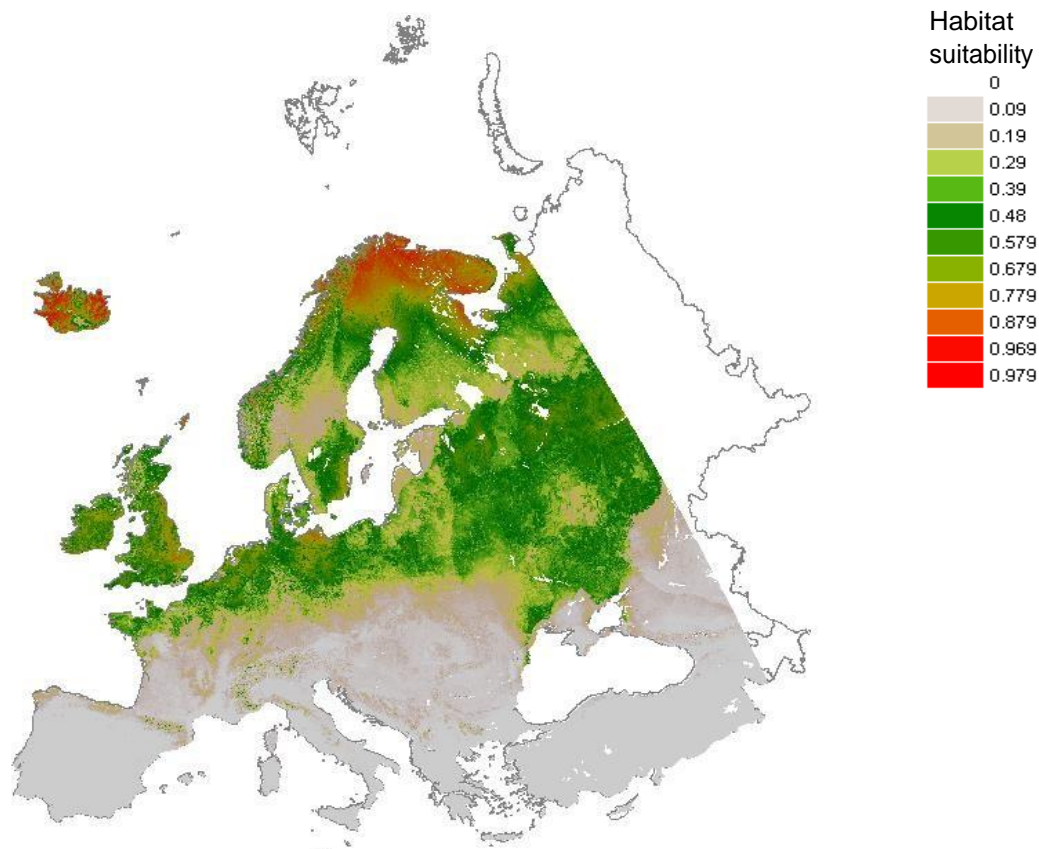
#### **Comment**

Suitable areas in the Temperate and Boreal zones, reflecting low solar radiation and high precipitation. The lack of soil moisture variables expands the predictions to non-swamp habitats.

**G1.5 - Broadleaved swamp woodland on acid peat\* [Broadleaved swamp woodland on acid peat]**



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the complete forest data set*

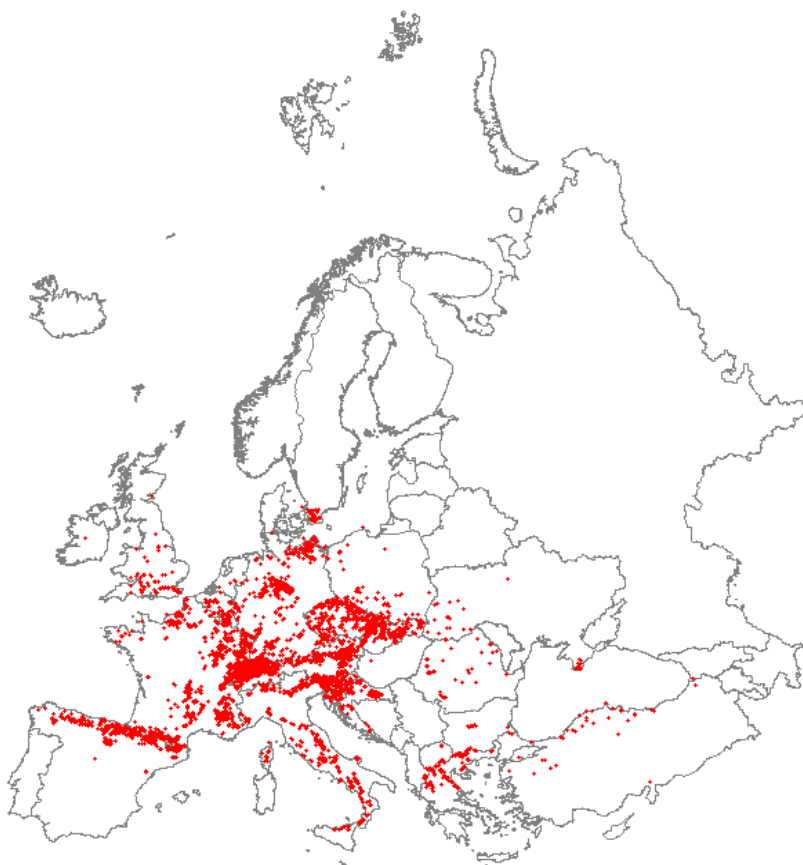
<b>AUC training (0-1)</b>	0.8759
<b>AUC test (0-1)</b>	0.855
<b>Contribution variables to the Maxent model (%)</b>	
Potential Evapotranspiration	48.1552
Solar radiation	20.9292
Precipitation of Warmest Quarter	11.3991
Precipitation Seasonality (coef. of var.)	5.7861
Soil pH	4.7057
Temperature Seasonality (stdev * 100)	4.0095
Annual Precipitation	2.9986
Mean Temperature of Wettest Quarter	1.4044
Distance to water	0.6122

#### **Comment**

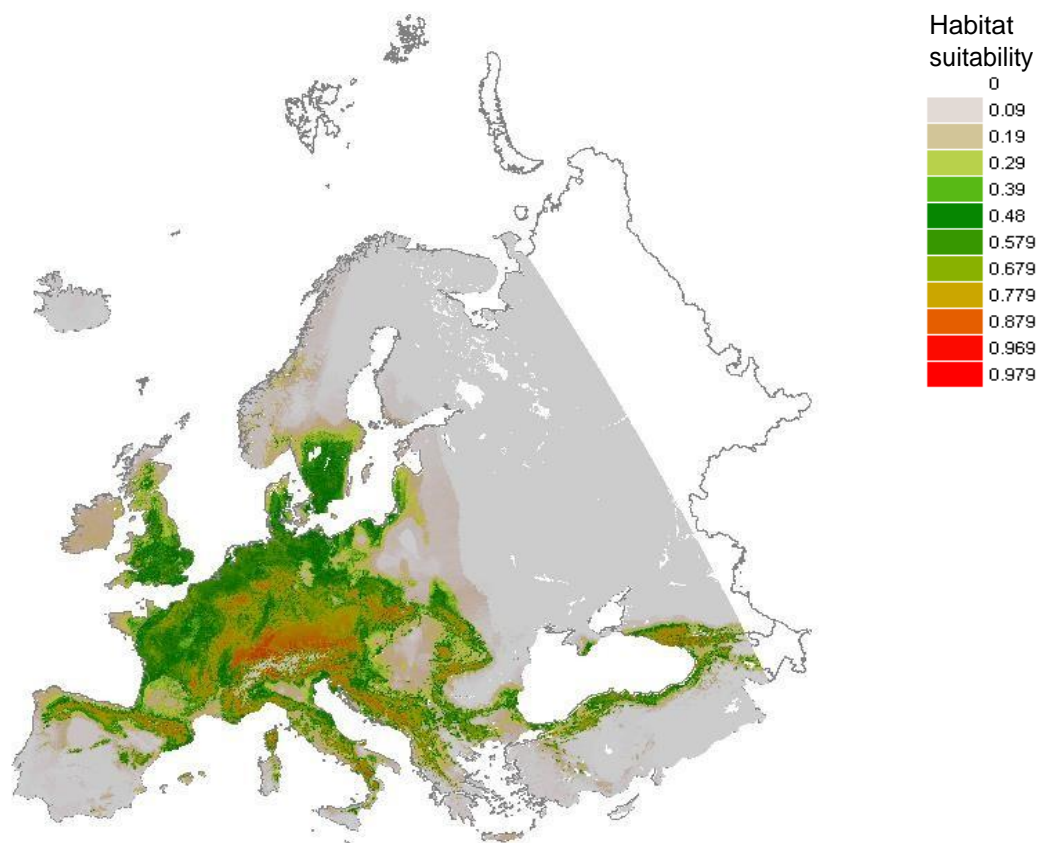
Suitable areas in the Boreal and North-Temperate zones, reflecting low potential evapotranspiration and low solar radiation. The lack of soil moisture variables expands the predictions to non-swamp habitats.



### G1.6a - *Fagus* woodland on non-acid soils



*Distribution based on vegetation relevés*



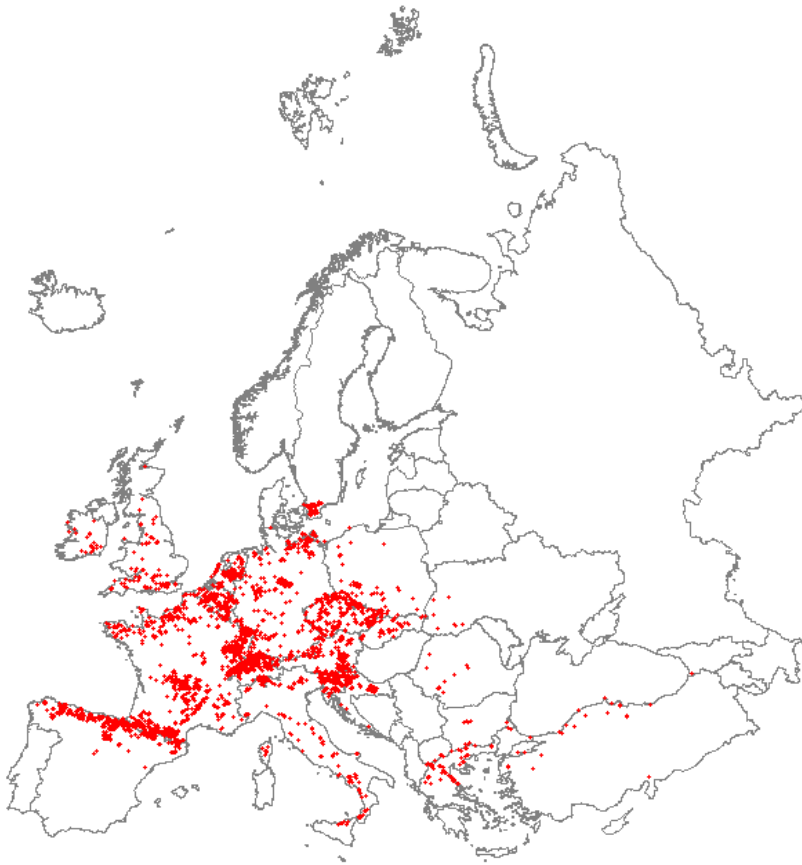
*Model prediction. Background data randomly selected from the study area*

<b>AUC training (0-1)</b>	0.8144
<b>AUC test (0-1)</b>	0.8091
<b>Contribution variables to the Maxent model (%)</b>	
Temperature Seasonality (stdev * 100)	57.2887
Potential Evapotranspiration	25.3307
Annual Precipitation	7.2249
Precipitation of Warmest Quarter	5.0275
Solar radiation	3.3526
Precipitation Seasonality (coef. of var.)	1.3313
Soil pH	0.2365
Mean Temperature of Wettest Quarter	0.1087
Distance to water	0.099

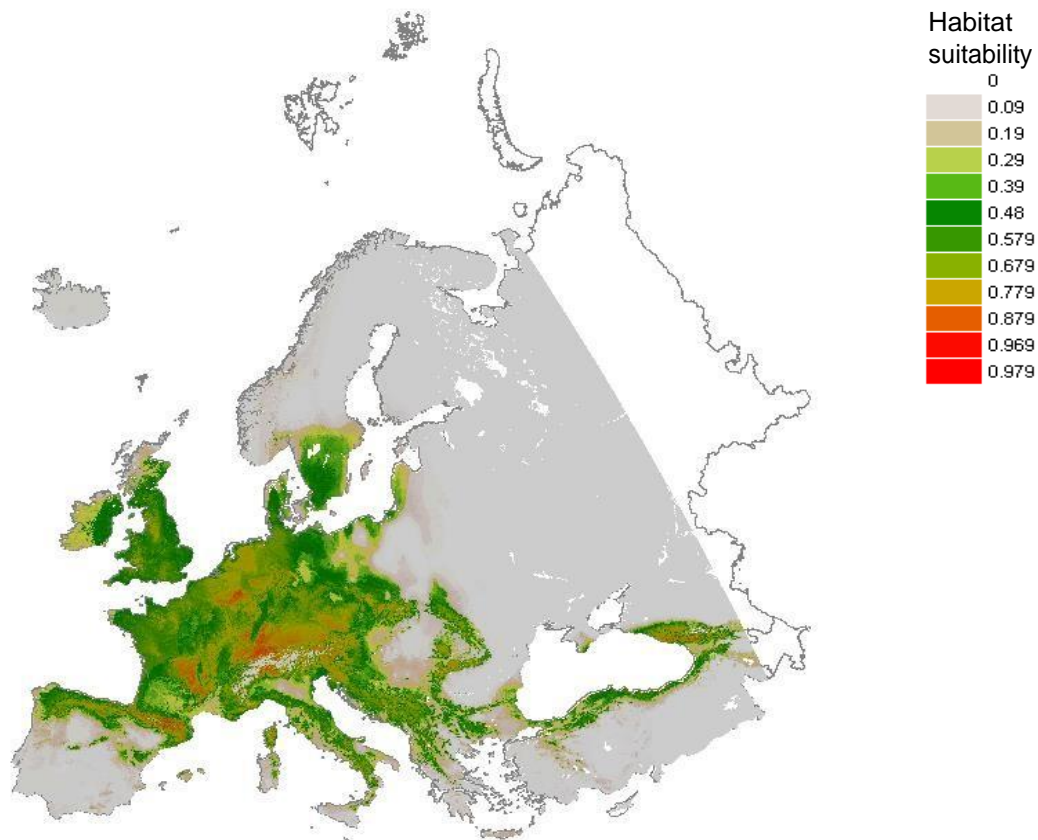
#### **Comment**

Suitable areas match the current distribution of Fagus forests in Europe. More accurate predictions for different soil conditions are limited by the lack of fine-resolution explanatory variables

### G1.6b - Fagus woodland on acid soils



*Distribution based on vegetation relevés*



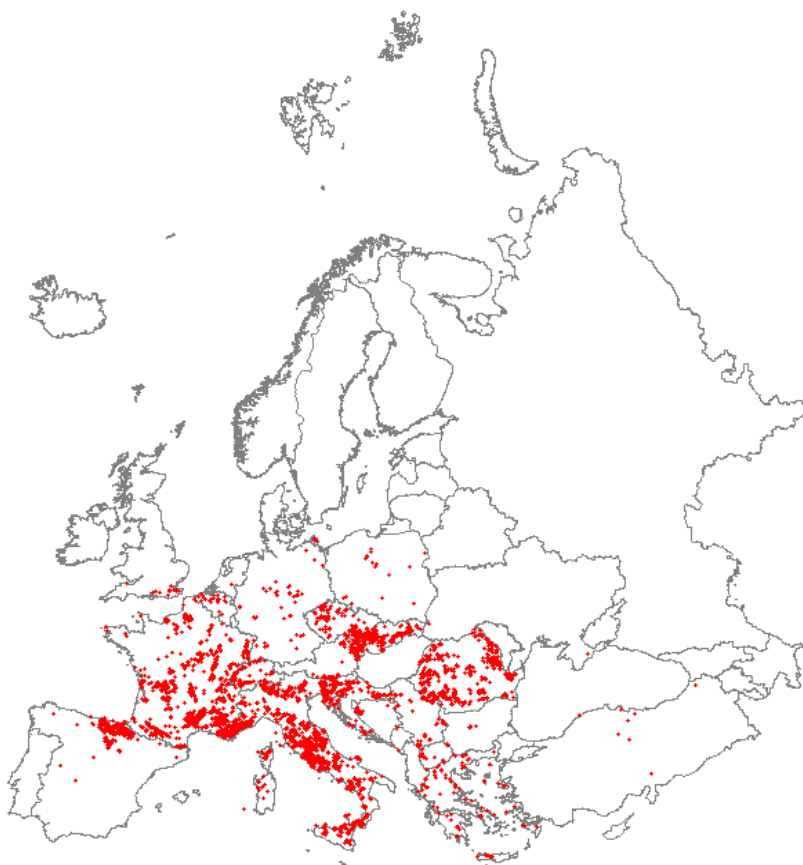
*Model prediction. Background data randomly selected from the study area*

<b>AUC training (0-1)</b>	0.8336
<b>AUC test (0-1)</b>	0.8312
<b>Contribution variables to the Maxent model (%)</b>	
Temperature Seasonality (stdev * 100)	58.7703
Potential Evapotranspiration	22.2968
Annual Precipitation	8.8968
Precipitation of Warmest Quarter	7.0438
Solar radiation	1.4606
Precipitation Seasonality (coef. of var.)	1.1614
Soil pH	0.224
Mean Temperature of Wettest Quarter	0.0876
Distance to water	0.0586

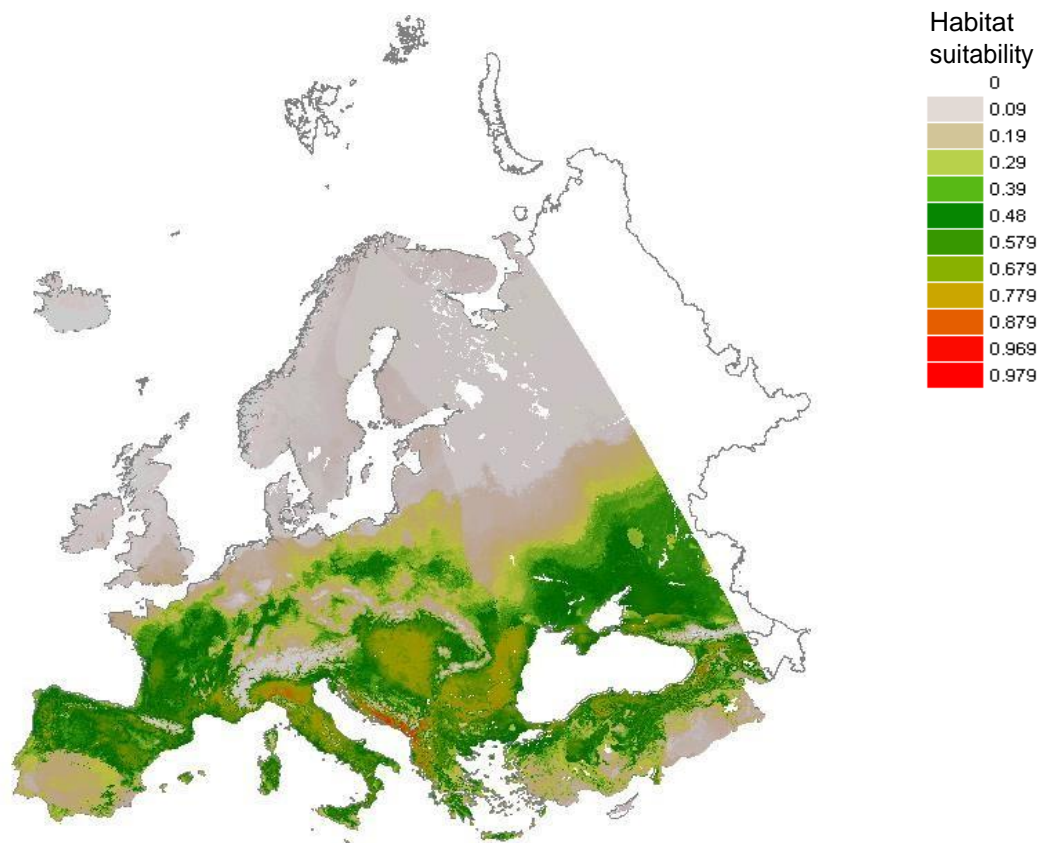
#### **Comment**

Suitable areas match the current distribution of Fagus forests in Europe. More accurate predictions for different soil conditions are limited by the lack of fine-resolution explanatory variables

## G1.7 - Thermophilous deciduous woodland



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the complete forest data set*

<b>AUC training (0-1)</b>	0.7726
<b>AUC test (0-1)</b>	0.768
<b>Contribution variables to the Maxent model (%)</b>	
Potential Evapotranspiration	75.8512
Precipitation of Warmest Quarter	10.3186
Temperature Seasonality (stdev * 100)	3.8745
Mean Temperature of Wettest Quarter	3.3564
Precipitation Seasonality (coef. of var.)	2.2401
Soil pH	1.5313
Annual Precipitation	1.5267
Solar radiation	0.8308
Distance to water	0.4704

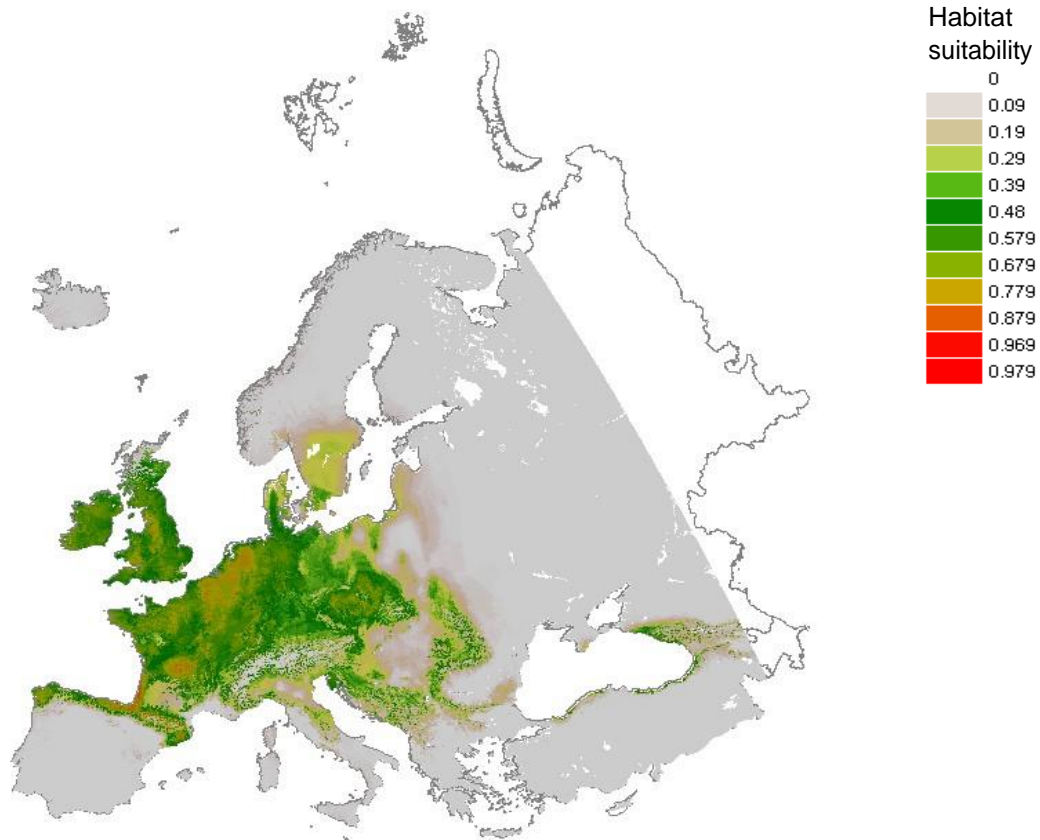
#### **Comment**

Suitable areas represented in the southern-Temperate zone, reflecting relatively warm conditions and excluding mountain regions.

**G1.8 - Acidophilous Quercus woodland\* [Acidophilous [Quercus]-dominated woodland]**



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the study area*

<b>AUC training (0-1)</b>	0.8628
<b>AUC test (0-1)</b>	0.863
<b>Contribution variables to the Maxent model (%)</b>	
Temperature Seasonality (stdev * 100)	58.255
Precipitation of Warmest Quarter	21.5749
Potential Evapotranspiration	14.6326
Solar radiation	2.9419
Precipitation Seasonality (coef. of var.)	1.4857
Soil pH	0.7197
Mean Temperature of Wettest Quarter	0.2729
Annual Precipitation	0.1128
Distance to water	0.0045

#### **Comment**

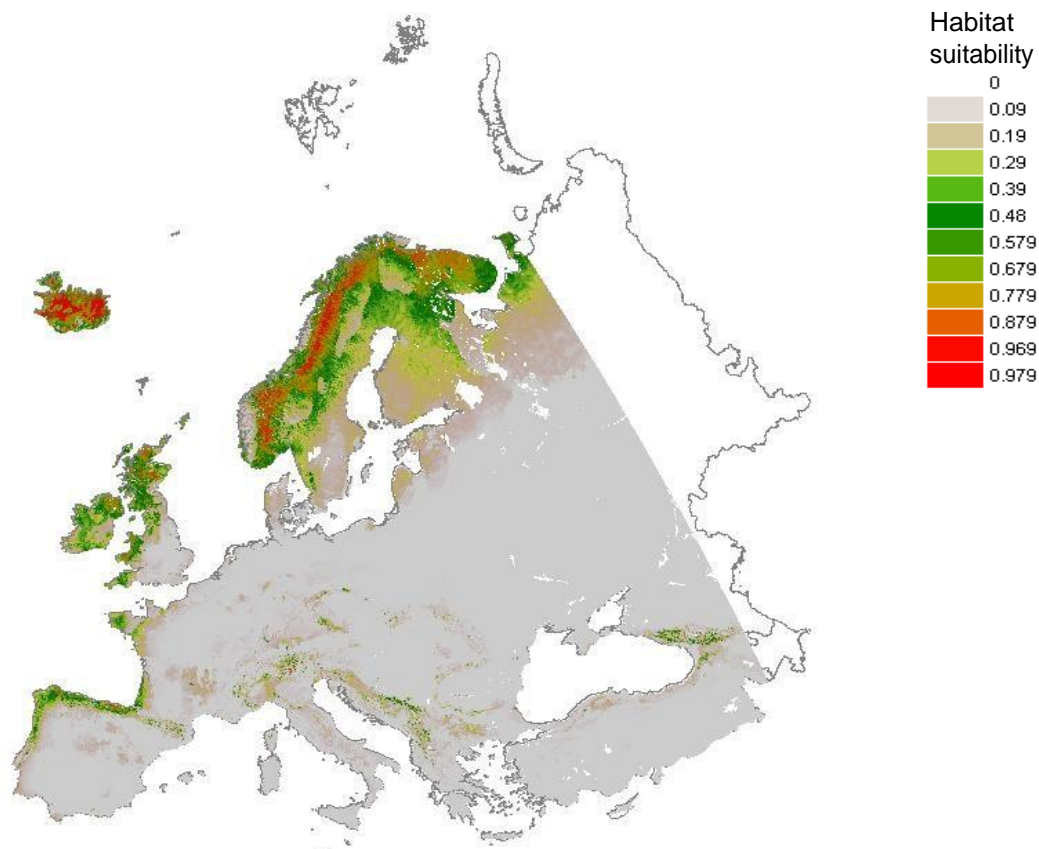
Suitable areas in warm Temperate regions of Western and Central Europe. Possible underprediction for Eastern Europe because of the lack of occurrence data.



### G1.9a - Mountain *Betula* and *Populus tremula* woodlands on mineral soils



*Distribution based on vegetation relevés*



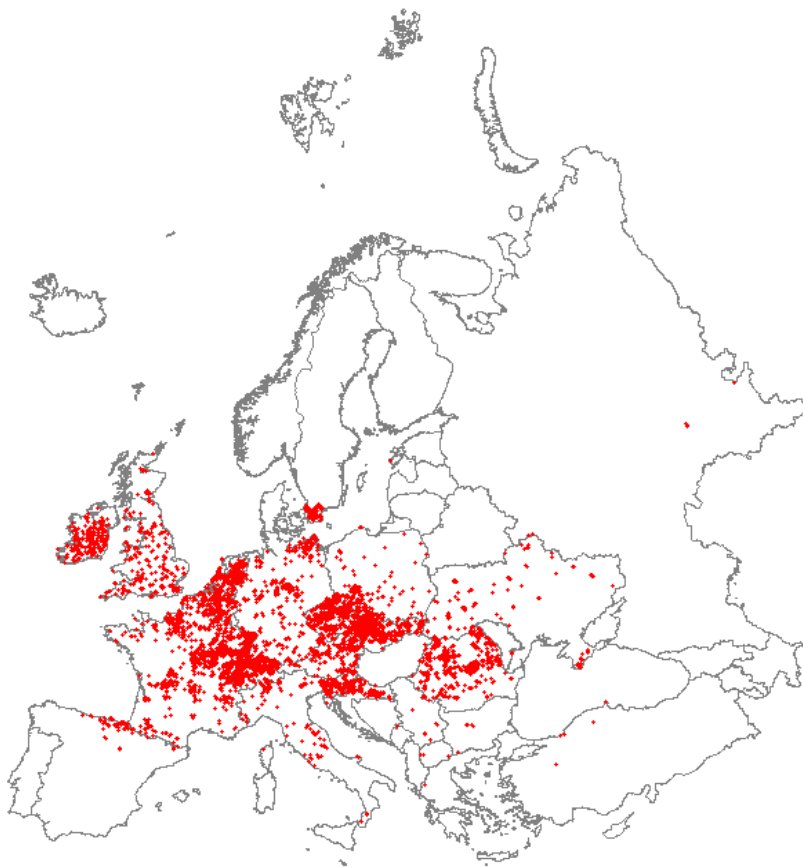
*Model prediction. Background data randomly selected from the complete forest data set*

<b>AUC training (0-1)</b>	0.9694
<b>AUC test (0-1)</b>	0.9146
<b>Contribution variables to the Maxent model (%)</b>	
Potential Evapotranspiration	25.3501
Temperature Seasonality (stdev * 100)	21.1121
Mean Temperature of Wettest Quarter	15.3974
Precipitation Seasonality (coef. of var.)	9.189
Soil pH	8.7273
Annual Precipitation	8.5167
Precipitation of Warmest Quarter	7.8623
Solar radiation	3.1554
Distance to water	0.6898

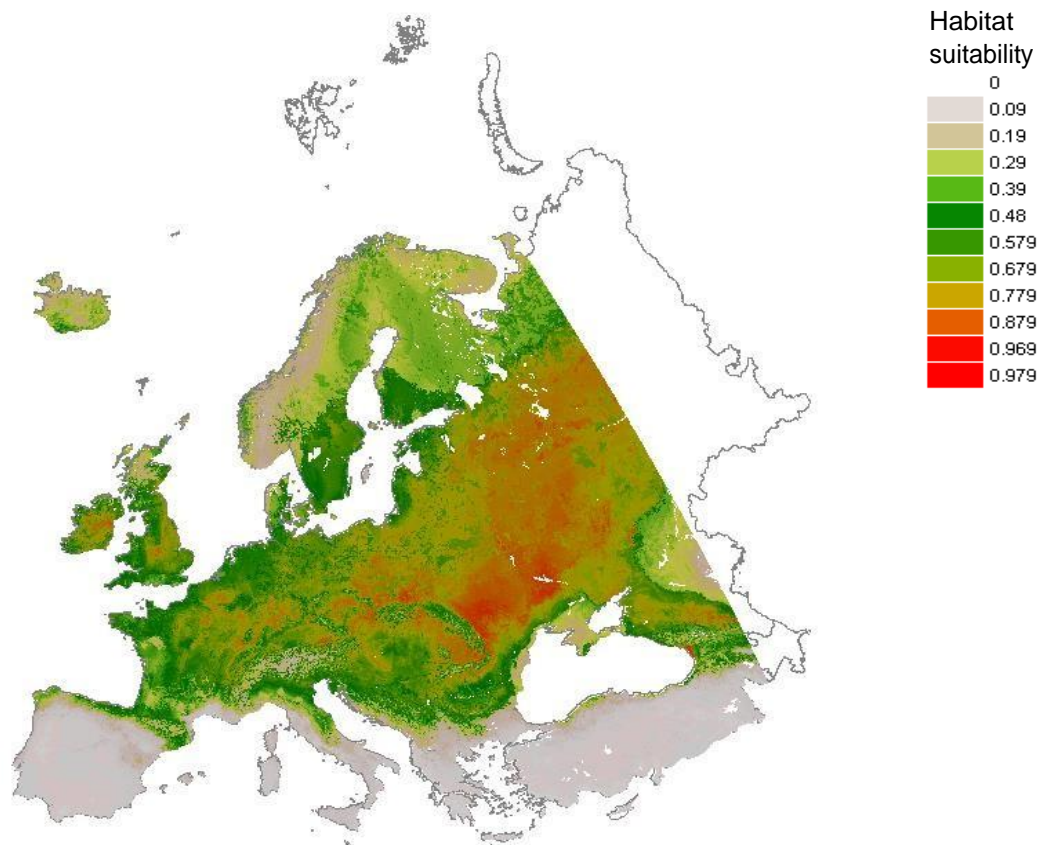
#### **Comment**

Suitable areas mainly distributed in North-Atlantic regions with low Potential Evapotranspiration and also with low seasonality. Although predictions seem realistic, the low number of occurrences makes necessary to interpret this model with caution.

**G1.A - Mesotrophic and eutrophic deciduous woodland, not dominated by *Fagus*\* [Meso- and eutrophic [*Quercus*], [*Carpinus*], [*Fraxinus*], [*Acer*], [*Tilia*], [*Ulmus*] and related**



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the complete forest data set*

<b>AUC training (0-1)</b>	0.6966
<b>AUC test (0-1)</b>	0.6903
<b>Contribution variables to the Maxent model (%)</b>	
Precipitation of Warmest Quarter	48.869
Solar radiation	13.4084
Mean Temperature of Wettest Quarter	11.6554
Potential Evapotranspiration	7.685
Annual Precipitation	6.7515
Temperature Seasonality (stdev * 100)	6.2496
Precipitation Seasonality (coef. of var.)	2.7453
Soil pH	2.5529
Distance to water	0.0829

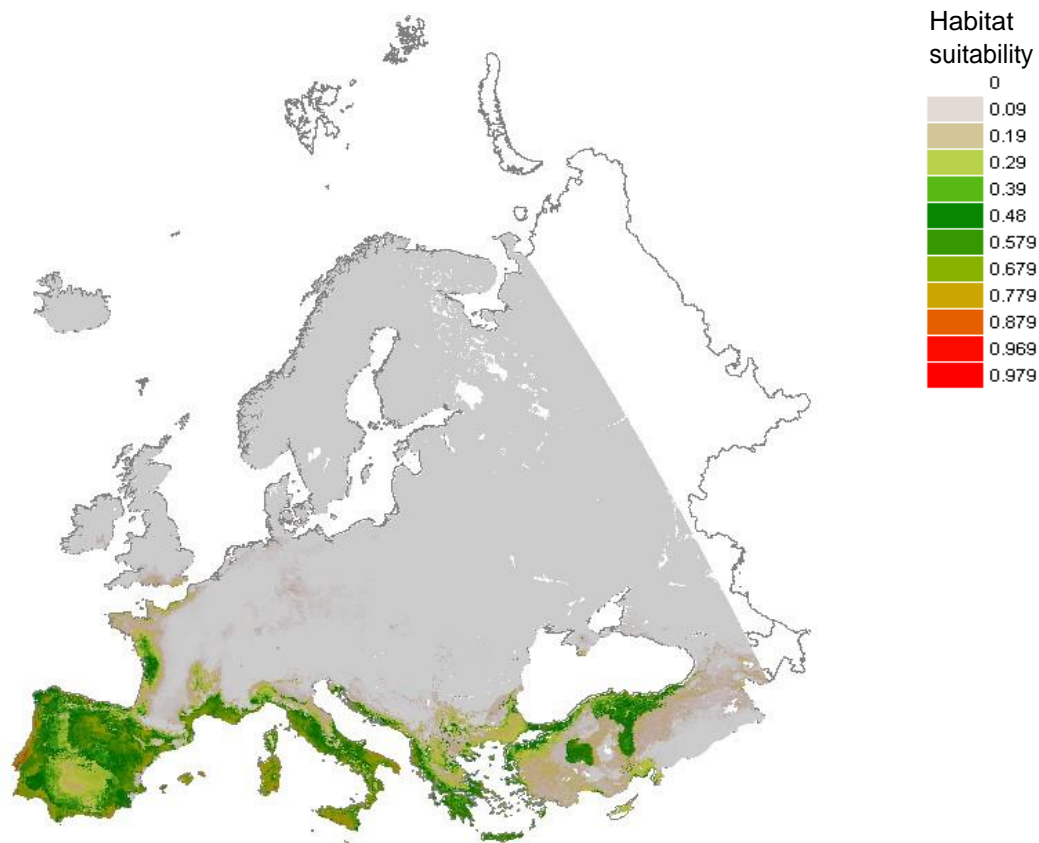
#### **Comment**

Suitable areas in the Temperate zone and especially in Central and Eastern Europe, reflecting relatively warm climates with high summer precipitation, thus excluding the Mediterranean region.

**G2.1 - Mediterranean evergreen Quercus woodland\* [Mediterranean evergreen [Quercus] woodland]**



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the complete forest data set*

<b>AUC training (0-1)</b>	0.9184
<b>AUC test (0-1)</b>	0.9068
<b>Contribution variables to the Maxent model (%)</b>	
Precipitation of Warmest Quarter	58.7016
Potential Evapotranspiration	17.7312
Precipitation Seasonality (coef. of var.)	7.9341
Temperature Seasonality (stdev * 100)	7.5346
Mean Temperature of Wettest Quarter	7.2427
Soil pH	0.4114
Annual Precipitation	0.2254
Distance to water	0.1675
Solar radiation	0.0516

#### **Comment**

Suitable areas match with the Mediterranean region by reflecting the decrease in summer precipitation. Predictions for France and Turkey fit well with the known distribution of evergreen Quercus species in submediterranean climates.

## G2.2 - Mainland lauriphyllous woodland\* [Eurasian continental sclerophyllous woodland]



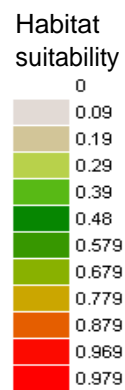
### Comment

Not enough data to create a reliable model.

**G2.4 - Olea oleaster-Ceratonia siliqua woodland\* [Olea europaea] - [Ceratonia siliqua] woodland]**



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the study area*



<b>AUC training (0-1)</b>	0.9854
<b>AUC test (0-1)</b>	0.983
<b>Contribution variables to the Maxent model (%)</b>	
Temperature Seasonality (stdev * 100)	38.9364
Precipitation of Warmest Quarter	29.1226
Precipitation Seasonality (coef. of var.)	13.7568
Mean Temperature of Wettest Quarter	8.5614
Potential Evapotranspiration	3.6343
Distance to water	3.2349
Solar radiation	2.3759
Soil pH	0.2087
Annual Precipitation	0.1689

#### **Comment**

Suitable areas mainly predicted in coastal Mediterranean areas. Predictions for inland regions of Southern Spain and Italy fit well with the known distribution of the habitat.

## G2.5 - Phoenix groves\* [[Phoenix] groves]



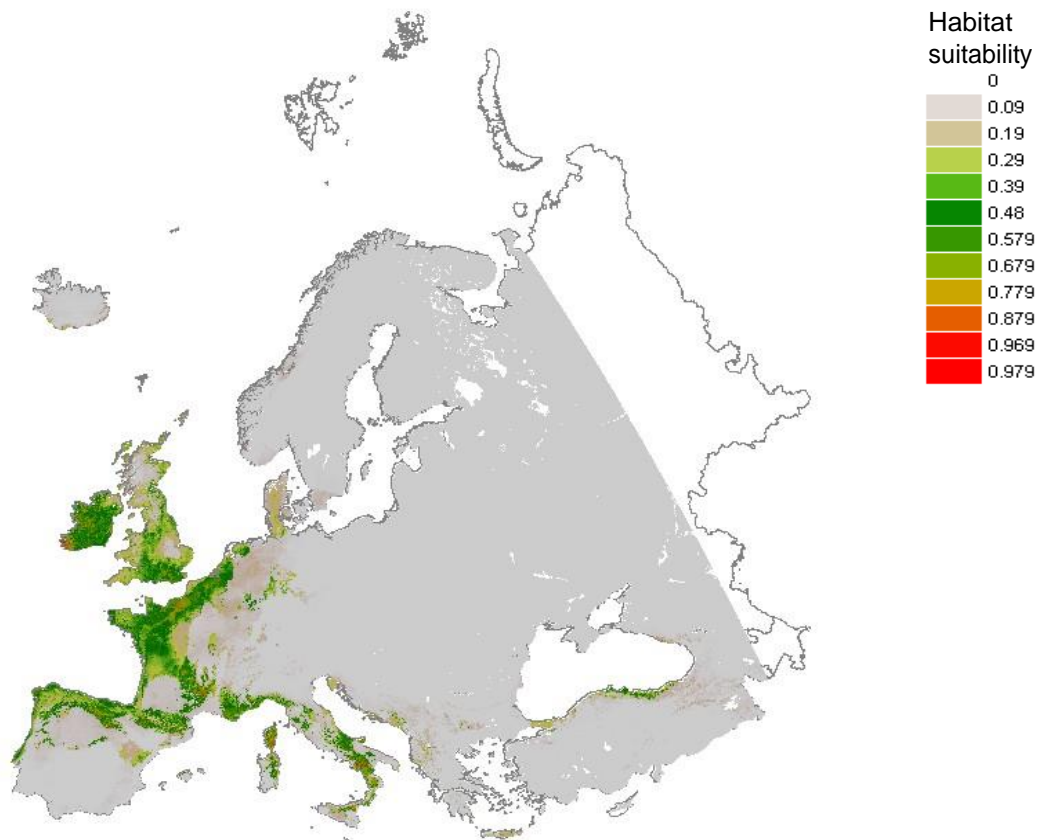
### Comment

Not enough data to create a reliable model.

## G2.6 - Ilex aquifolium woodland\* [[Ilex aquifolium] woods]



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the study area*

<b>AUC training (0-1)</b>	0.975
<b>AUC test (0-1)</b>	0.9567
<b>Contribution variables to the Maxent model (%)</b>	
Temperature Seasonality (stdev * 100)	57.3421
Potential Evapotranspiration	19.9521
Mean Temperature of Wettest Quarter	14.5124
Precipitation of Warmest Quarter	3.1735
Solar radiation	1.5147
Precipitation Seasonality (coef. of var.)	1.5128
Annual Precipitation	1.481
Soil pH	0.3936
Distance to water	0.1179

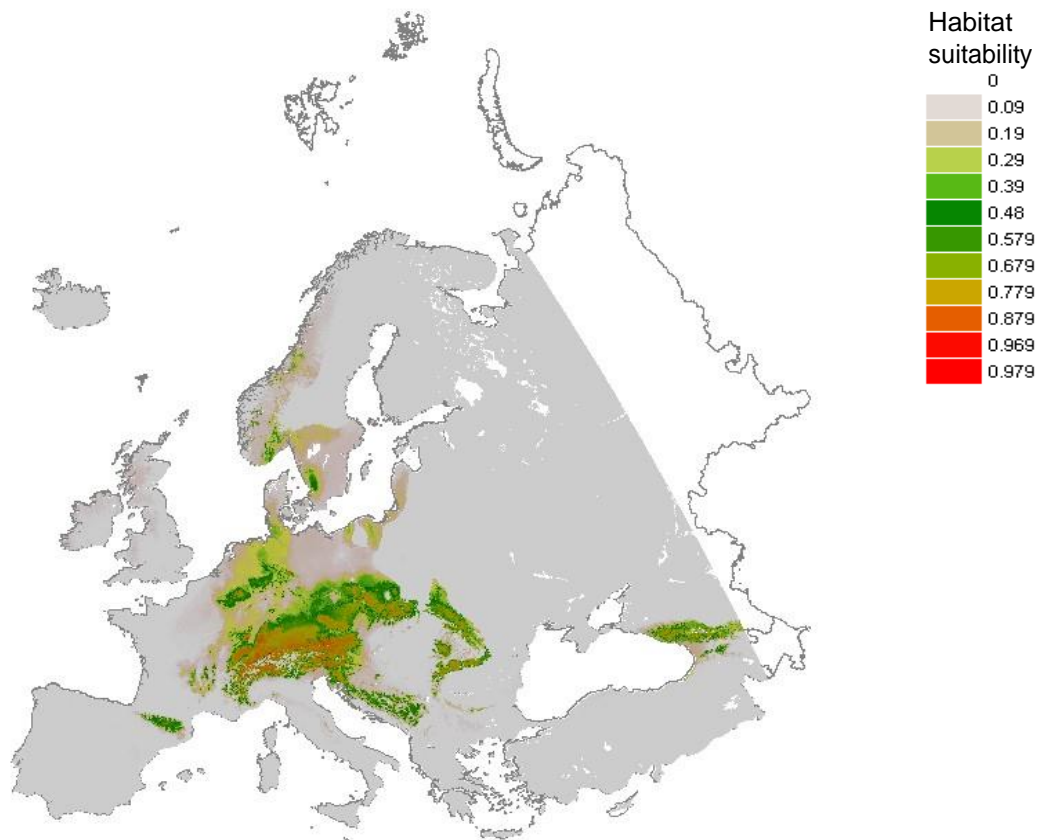
#### **Comment**

Suitable areas in relatively warm and humid regions without pronounced seasonality. Predictions seem to indicate optimal refugial zones for *Ilex aquifolium* in Europe.

### G3.1a - Temperate mountain *Picea* woodland



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the study area*

<b>AUC training (0-1)</b>	0.9085
<b>AUC test (0-1)</b>	0.9115
<b>Contribution variables to the Maxent model (%)</b>	
Precipitation of Warmest Quarter	69.6796
Temperature Seasonality (stdev * 100)	19.2195
Potential Evapotranspiration	10.1659
Precipitation Seasonality (coef. of var.)	0.4403
Annual Precipitation	0.2503
Solar radiation	0.1241
Mean Temperature of Wettest Quarter	0.0561
Distance to water	0.0463
Soil pH	0.018

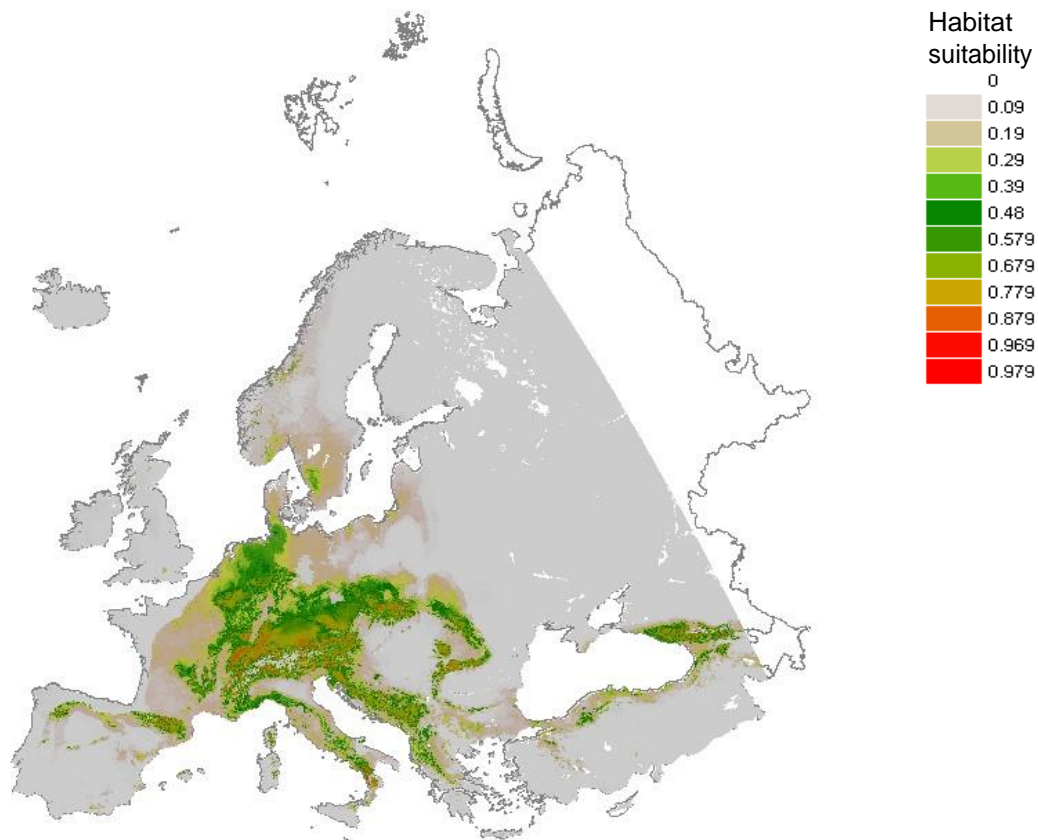
#### **Comment**

Suitable areas mainly distributed in continental regions of Central Europe with high summer precipitation. Natural distribution is overestimated in the Pyrenees and Central France due to occurrence data from plantations, but in any case these regions are climatically suitable.

### G3.1b - Temperate mountain *Abies* woodland



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the study area*

<b>AUC training (0-1)</b>	0.9028
<b>AUC test (0-1)</b>	0.9051
<b>Contribution variables to the Maxent model (%)</b>	
Temperature Seasonality (stdev * 100)	34.5811
Precipitation of Warmest Quarter	31.3979
Potential Evapotranspiration	15.594
Annual Precipitation	14.8453
Solar radiation	2.0337
Precipitation Seasonality (coef. of var.)	1.027
Mean Temperature of Wettest Quarter	0.3405
Distance to water	0.1393
Soil pH	0.0413

#### **Comment**

Suitable areas mainly distributed in the European Mountain System and lowlands of Central Europe, reflecting relatively continental climates with high summer precipitation.



### G3.1c - Mediterranean mountain *Abies* woodland



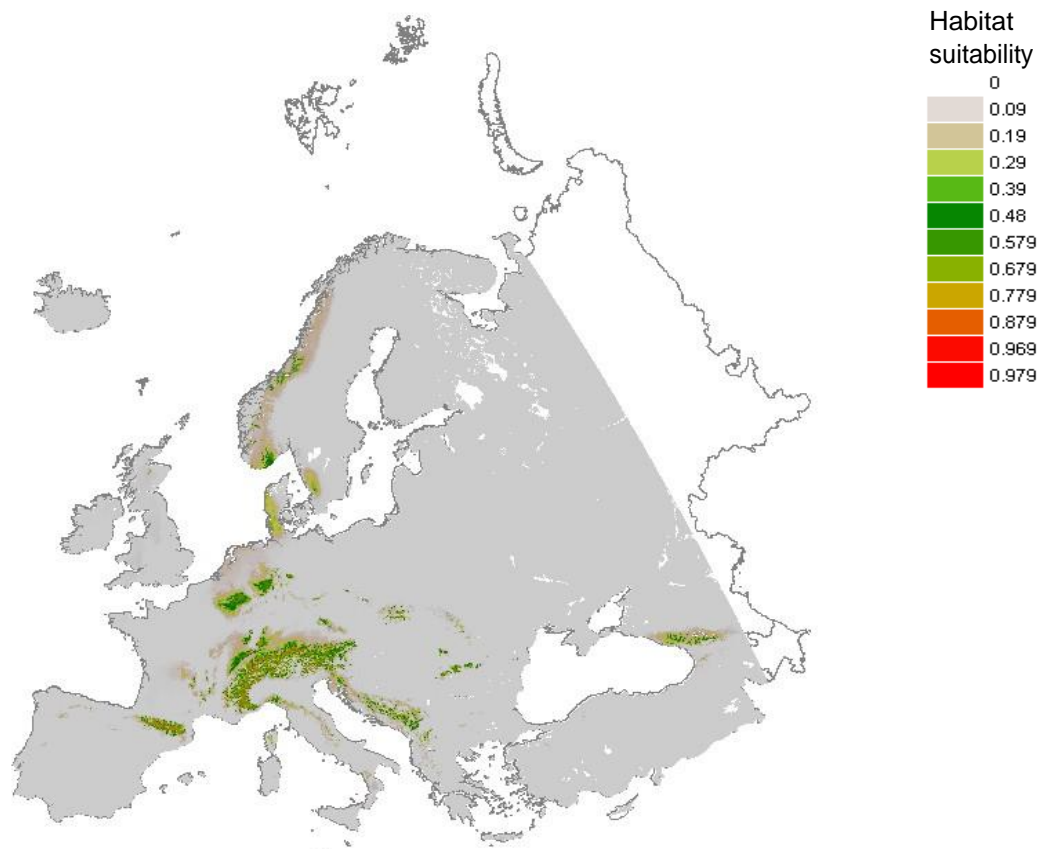
#### **Comment**

Not enough data to create a reliable model.

**G3.2 - Temperate subalpine Larix-Pinus woodland\* [Alpine [Larix] - [Pinus cembra] woodland]**



*Distribution based on vegetation relevés*



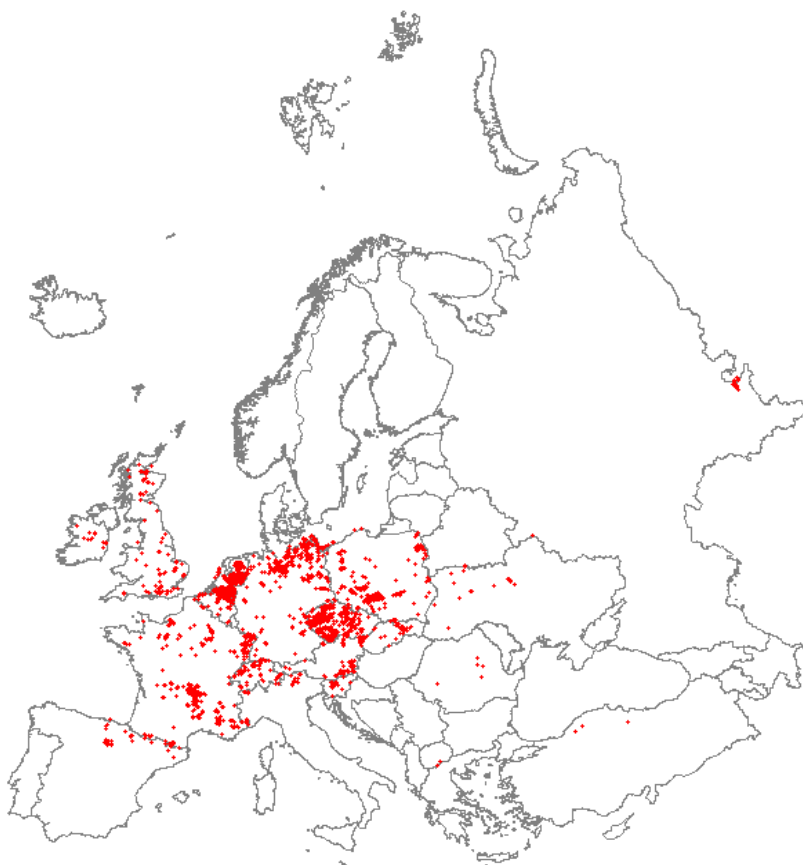
*Model prediction. Background data randomly selected from the study area*

<b>AUC training (0-1)</b>	0.9679
<b>AUC test (0-1)</b>	0.9613
<b>Contribution variables to the Maxent model (%)</b>	
Annual Precipitation	58.0386
Temperature Seasonality (stdev * 100)	18.8005
Potential Evapotranspiration	15.6623
Precipitation of Warmest Quarter	5.9122
Precipitation Seasonality (coef. of var.)	0.6514
Distance to water	0.4643
Solar radiation	0.2095
Soil pH	0.1338
Mean Temperature of Wettest Quarter	0.1274

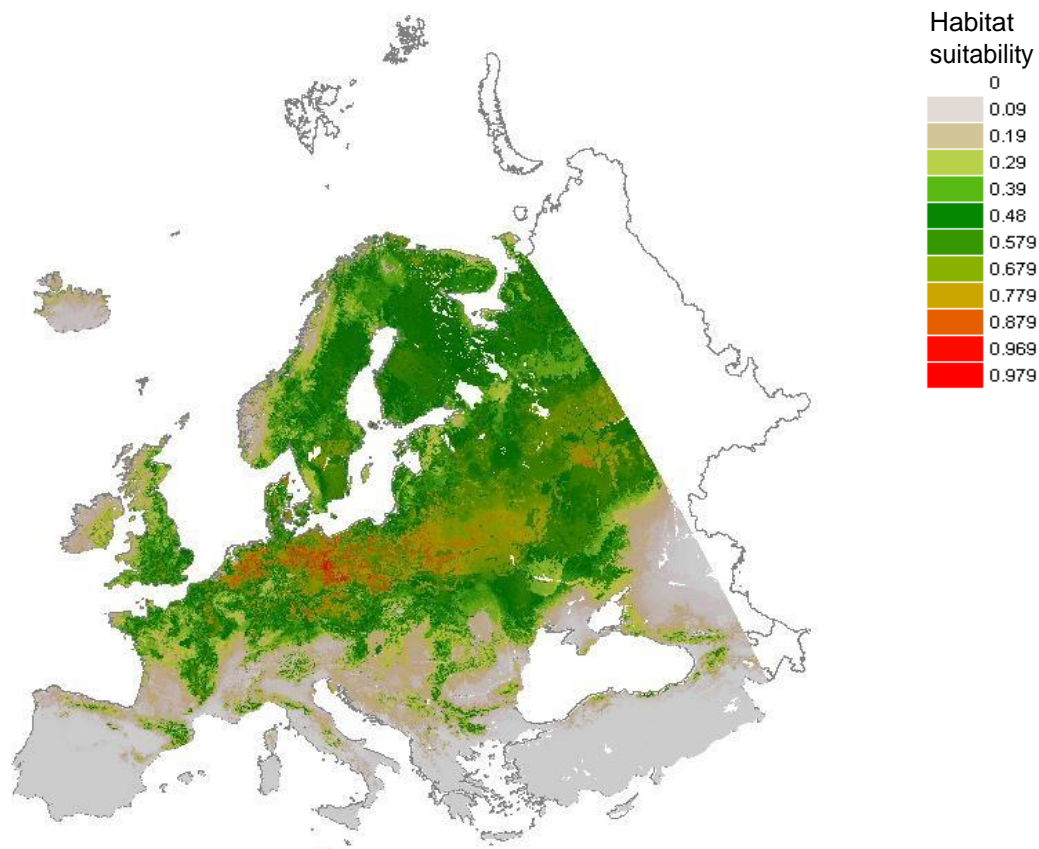
#### **Comment**

Suitable areas mainly represented in the highest altitudes of the Alps and nearby mountains. Overpredictions in the Pyrenees and Scandinavia (where this particular habitat does not occur) reflect climatic similarities rather than present distribution.

### G3.4a - Temperate continental *Pinus sylvestris* woodland



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the complete forest data set*

<b>AUC training (0-1)</b>	0.8068
<b>AUC test (0-1)</b>	0.7929
<b>Contribution variables to the Maxent model (%)</b>	
Potential Evapotranspiration	23.9712
Annual Precipitation	21.6615
Soil pH	16.9529
Mean Temperature of Wettest Quarter	15.5528
Precipitation of Warmest Quarter	13.583
Temperature Seasonality (stdev * 100)	4.9024
Precipitation Seasonality (coef. of var.)	1.8676
Solar radiation	1.3987
Distance to water	0.11

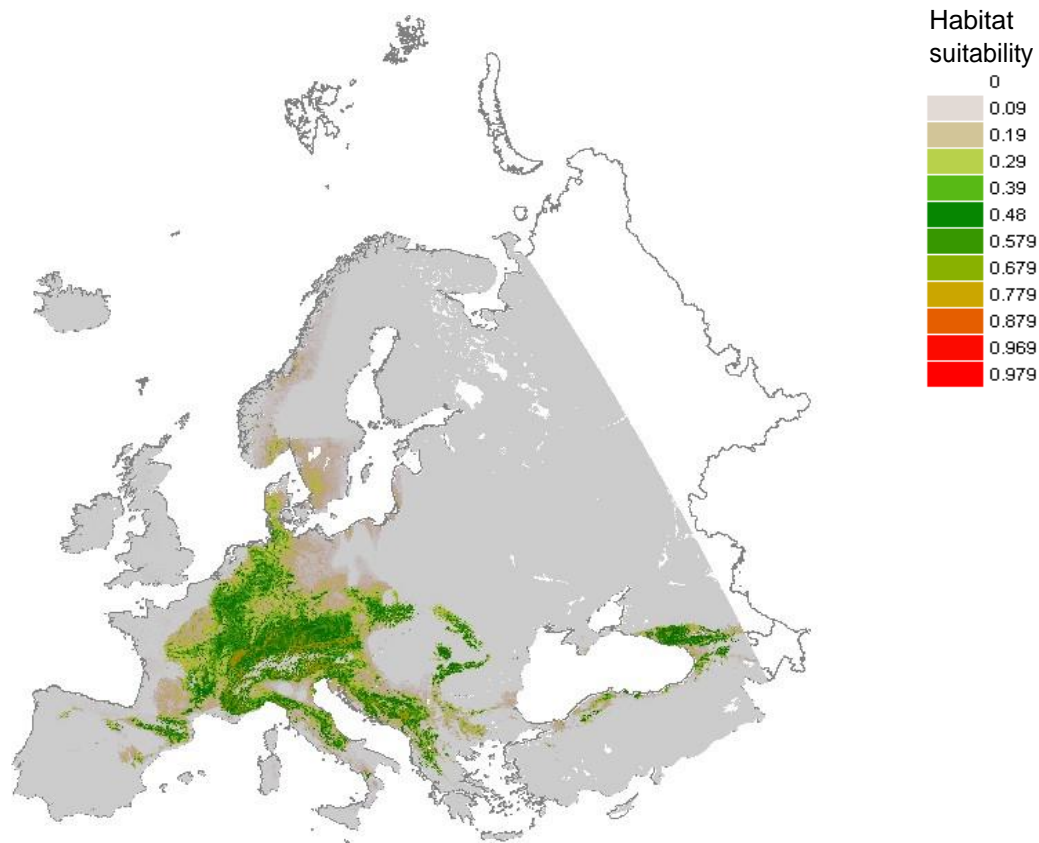
#### **Comment**

Most suitable areas are represented in the transition between temperate and boreal regions, matching with the known distribution of *Pinus sylvestris*. Predictions for southern Europe and Scandinavia are realistic in terms of climatic conditions but they are probably overestimating the current distribution of this particular habitat.

### G3.4b - Temperate and submediterranean montane *Pinus sylvestris-nigra* woodland



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the study area*

<b>AUC training (0-1)</b>	0.9407
<b>AUC test (0-1)</b>	0.9227
<b>Contribution variables to the Maxent model (%)</b>	
Temperature Seasonality (stdev * 100)	43.4162
Annual Precipitation	22.076
Precipitation of Warmest Quarter	12.9617
Potential Evapotranspiration	11.6566
Soil pH	5.7035
Distance to water	2.2883
Solar radiation	1.2367
Precipitation Seasonality (coef. of var.)	0.5145
Mean Temperature of Wettest Quarter	0.1465

#### **Comment**

Suitable areas mainly representing the European Mountain System and nearby regions of Central Europe. Best predictions are expected for those regions with a submediterranean influence.

#### G3.4c - Mediterranean montane *Pinus sylvestris-nigra* woodland



#### Comment

Not enough data to create a reliable model.



**G3.6 - Mediterranean and Balkan subalpine *Pinus heldreichii*-*peucis* woodland\* [balpine**



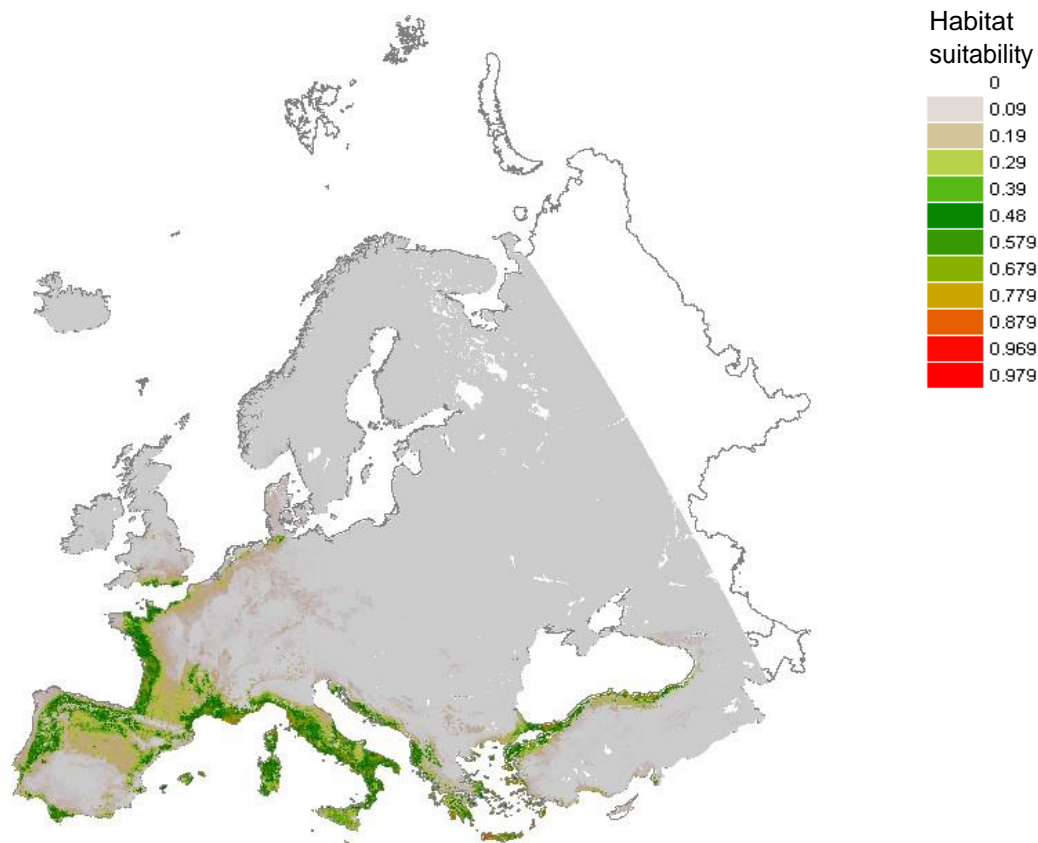
**Comment**

Not enough data to create a reliable model.

**G3.7 - Mediterranean lowland to submontane Pinus woodland\* [Lowland to montane mediterranean [Pinus] woodland (excluding [Pinus nigra])]**



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the study area*

<b>AUC training (0-1)</b>	0.9617
<b>AUC test (0-1)</b>	0.957
<b>Contribution variables to the Maxent model (%)</b>	
Temperature Seasonality (stdev * 100)	50.976
Potential Evapotranspiration	17.4106
Mean Temperature of Wettest Quarter	12.802
Precipitation of Warmest Quarter	5.8938
Precipitation Seasonality (coef. of var.)	4.7735
Annual Precipitation	3.8205
Distance to water	2.7684
Solar radiation	0.9681
Soil pH	0.5871

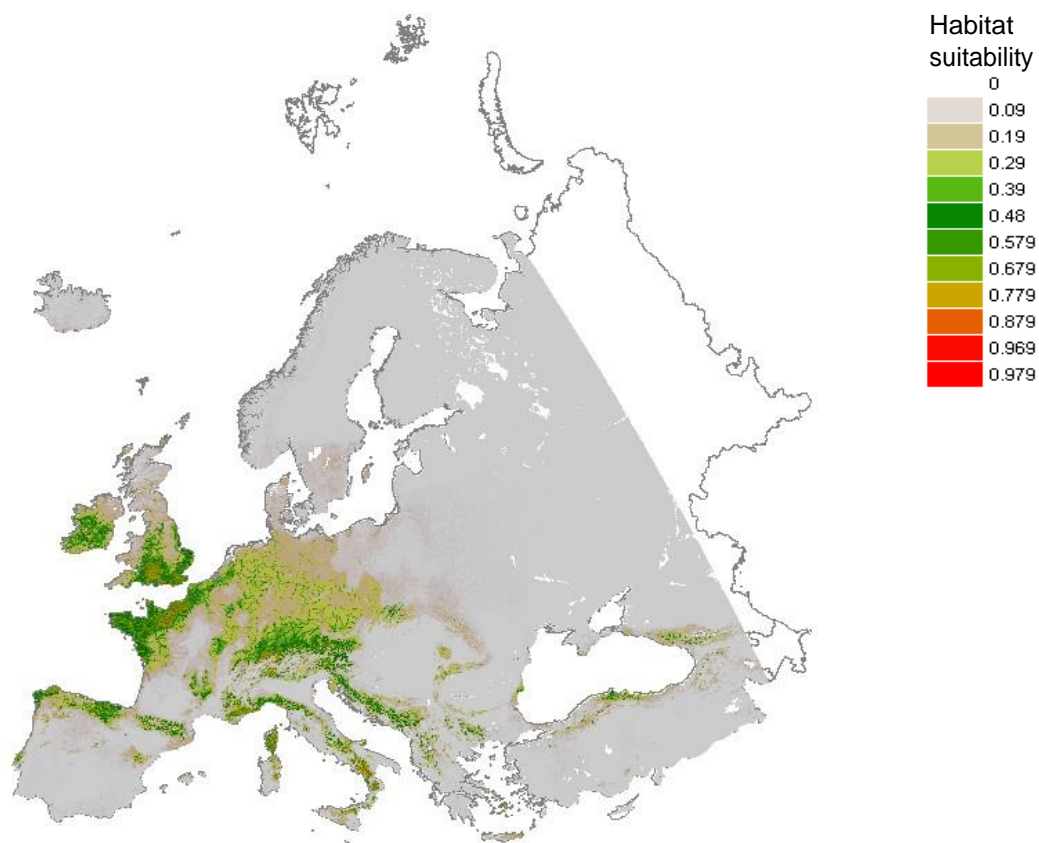
#### **Comment**

Suitable areas mainly represented in warm regions with low seasonality of the Mediterranean basin. More accurate predictions within the suitable areas would require high-resolution layers to reflect soil conditions.

### G3.9a - *Taxus baccata* woodland



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the study area*

<b>AUC training (0-1)</b>	0.9576
<b>AUC test (0-1)</b>	0.964
<b>Contribution variables to the Maxent model (%)</b>	
Temperature Seasonality (stdev * 100)	43.4382
Potential Evapotranspiration	34.4928
Precipitation of Warmest Quarter	6.4517
Mean Temperature of Wettest Quarter	4.5974
Distance to water	3.3867
Precipitation Seasonality (coef. of var.)	2.9875
Solar radiation	2.5543
Soil pH	1.1712
Annual Precipitation	0.9202

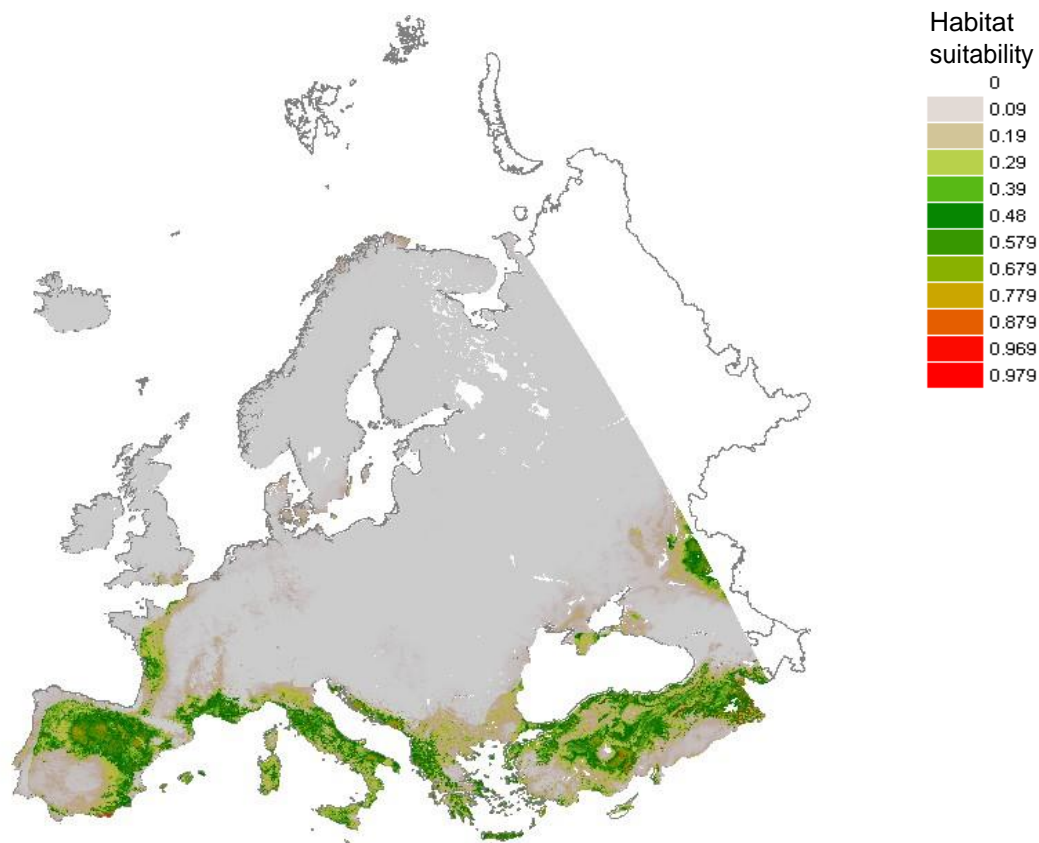
#### **Comment**

Suitable areas are mainly represented in the Southern mountains and the Atlantic region. Given the complex historical biogeography of *Taxus baccata*, predictions are probably reflecting refugial areas together with climatic optima.

### G3.9b - Mediterranean Cupressaceae woodland



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the complete forest data set*

<b>AUC training (0-1)</b>	0.938
<b>AUC test (0-1)</b>	0.9235
<b>Contribution variables to the Maxent model (%)</b>	
Precipitation of Warmest Quarter	59.8598
Potential Evapotranspiration	12.6501
Mean Temperature of Wettest Quarter	6.6394
Soil pH	4.9473
Distance to water	4.6239
Precipitation Seasonality (coef. of var.)	4.5698
Temperature Seasonality (stdev * 100)	3.0765
Solar radiation	1.9085
Annual Precipitation	1.7246

#### **Comment**

Suitable areas restricted to Mediterranean regions with dry and continental climates, reflecting well the distribution of the habitat. Within each region, occurrence is related to specific species and soil factors not considered here.

### G3.A - Picea taiga woodland\* [[Picea] taiga woodland]



#### Comment

Not enough data to create a reliable model.



**G3.B - *Pinus sylvestris* taiga woodland\* [[Pinus] taiga woodland]**



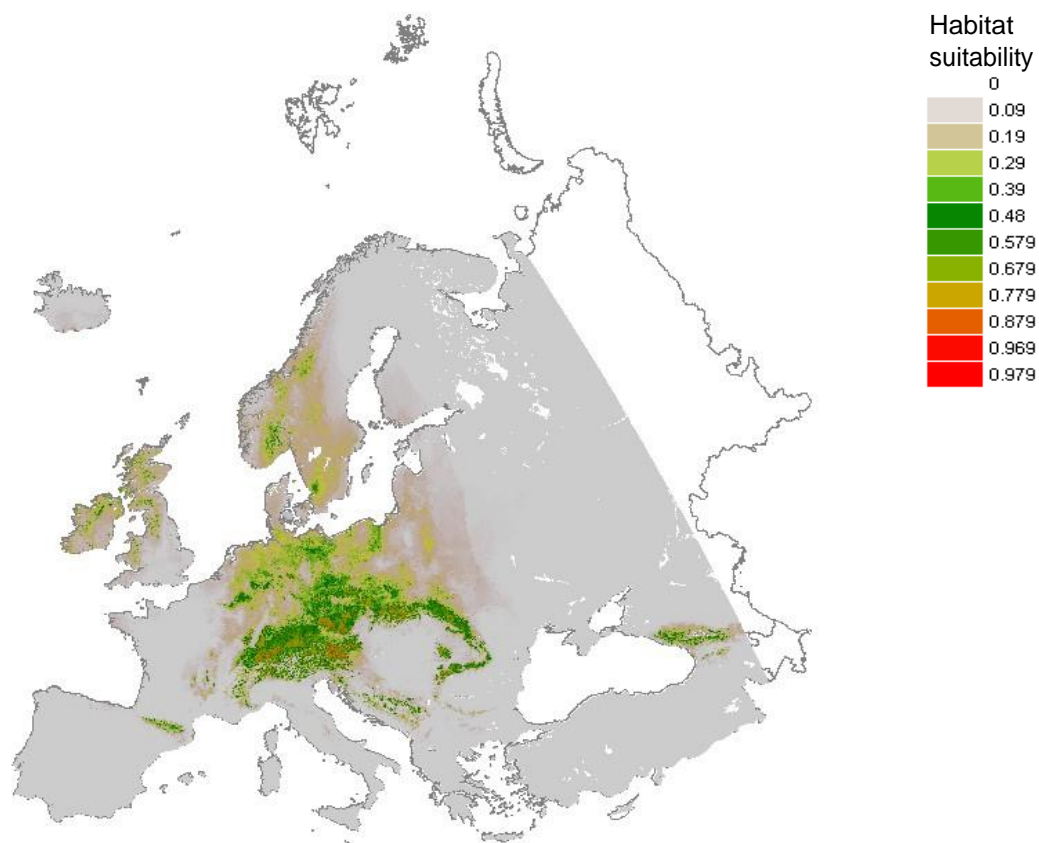
**Comment**

Not enough data to create a reliable model.

**G3.E - Temperate bog conifer woodland\* [Nemoral bog conifer woodland]**



*Distribution based on vegetation relevés*



*Model prediction. Background data randomly selected from the study area*

<b>AUC training (0-1)</b>	0.952
<b>AUC test (0-1)</b>	0.9356
<b>Contribution variables to the Maxent model (%)</b>	
Precipitation of Warmest Quarter	54.2453
Temperature Seasonality (stdev * 100)	17.9736
Potential Evapotranspiration	15.7111
Mean Temperature of Wettest Quarter	6.9313
Solar radiation	1.915
Soil pH	1.4725
Precipitation Seasonality (coef. of var.)	0.9937
Annual Precipitation	0.6425
Distance to water	0.1149

#### **Comment**

Suitable areas are distributed in Central European regions with high summer precipitation, reflecting well the known distribution of the habitat. Local distribution is probably limited to soil conditions not considered here.