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# Distribution and habitat suitability maps of revised EUNIS vegetated man-made habitats

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# 1 Introduction

Under the Framework Contract EEA/NSS/17/002/Lot 1 Schaminée et al. (2019) delivered expert rules to classify the EUNIS habitat types belonging to the group V, Vegetated man-made habitats. The work resulted in an improved classification that was used to assign a large part of the European Vegetation Archive (EVA) to EUNIS habitat types. This work was the starting point for the current study for ETC/BD, Task 1.7.5.1 to deliver distribution and suitability maps for the EUNIS habitat types belonging to group V.

Of all the EUNIS habitats, belonging to the group V, only V1 (Arable land and market gardens) and V3 (Grasslands) have been taken into account, because only of these types the floristic composition could be defined (Schaminée et al. 2020). Excluded from the analysis are therefore V2 (Cultivated areas of gardens and parks), V4 (Hedgerows), V5 (Shrub plantation) and V6 (Orchards and small planted woodlands). In the current reporting the focus is therefore only on rural areas, urban areas are excluded.

## 2 Habitat suitability modelling

### 2.1 Introduction

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

The Maxent modelling procedure considers presence data (known observations of a given entity) and the so-called background data. Background data comprise a set of points used to describe the environmental variation of the study area according to the available environmental layers. It is assumed that these layers represent well the most important ecological gradients on a European scale. The layers were selected from meaningful environmental predictors commonly used for modelling non-tropical plant and vegetation diversity, and are not mutually strongly correlated. In addition to what was selected as predictors in 2016 and 2017 (Hennekens 2016, 2017), also so-called RS-EBV's (Remote Sensed Essential Biodiversity Variables; predictors based on remote sensing data), such as Land Use Land Cover, Phenology, Inundation, Vegetation height have now also been applied<sup>2</sup>. It is assumed that by using additional meaningful predictors such as the RS-EBV's, the modelling will result in more realistic suitability maps with less outliers (prediction in areas where the habitat is not expected to be present).

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<sup>1</sup> Maxent version 3.4.1 was used. [http://biodiversityinformatics.amnh.org/open\\_source/maxent/](http://biodiversityinformatics.amnh.org/open_source/maxent/)

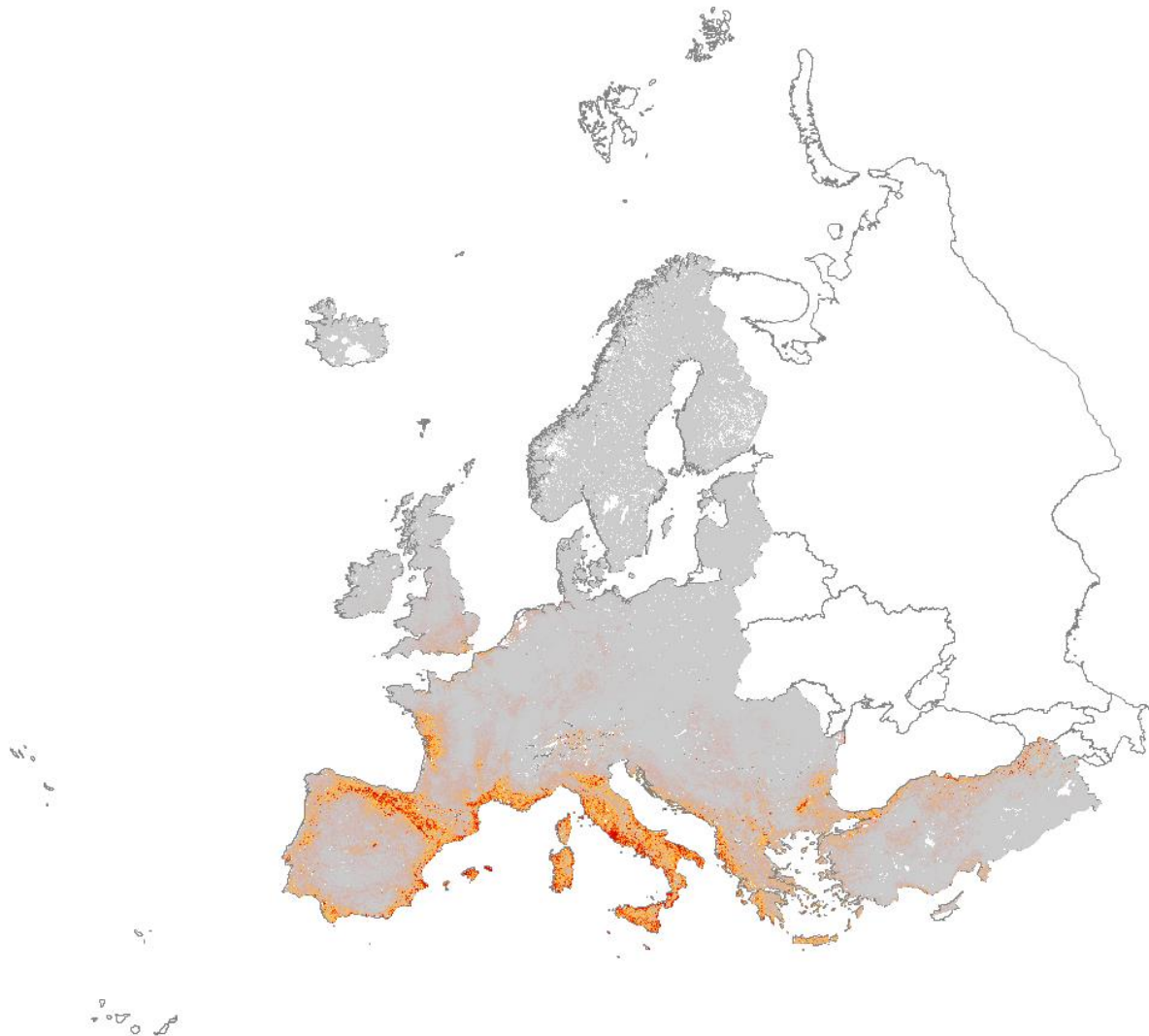
<sup>2</sup> Unfortunately LAI predictor maps had to be excluded, as they have gaps due to presence of clouds in parts of Europe. Due to these gaps the modelling process will ignore these areas and eventually results in an incomplete suitability map.

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

For the current study on vegetated man-made habitats population density has been added to the list of predictors. It is expected that this predictor will have a significant contribution in the modelling of made-made habitats.

In paragraph 2.2 the complete list of predictors and their sources is presented.

**Figure 1** Example of a suitability map (V33) indicating the geographic area with grey colour that has been taken into account for this study



## 2.2 Predictors

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

### Climate

- Temperature Seasonality (standard deviation \*100)  
<https://www.worldclim.org/bioclimate>
- Mean Temperature of Wettest Quarter  
<https://www.worldclim.org/bioclimate>
- Annual Precipitation  
<https://www.worldclim.org/bioclimate>
- Precipitation Seasonality (Coefficient of Variation)  
<https://www.worldclim.org/bioclimate>
- Precipitation of Warmest Quarter  
<https://www.worldclim.org/bioclimate>
- Solar radiation ( $\times 365/8$  kWh m<sup>-2</sup>)  
[www.worldgrids.org](http://www.worldgrids.org)
- Potential Evapotranspiration (mm yr<sup>-1</sup>)  
<https://cgiarcsi.community/data/global-aridity-and-pet-database/>

### Topography

- Distance to water (rivers, lakes, sea)  
derived from the shapefile 'Inland\_Waters.shp'
- Digital Elevation Map (DEM)

### Soil

- Bulk density of the soil (kg/m<sup>3</sup>)  
Hengl et al. 2014  
<https://soilgrids.org/>
- Cation Exchange Capacity of the soil  
Hengl et al. 2014  
<https://soilgrids.org/>
- Weight in % of clay particles (<0.0002 mm)  
Hengl et al. 2014  
<https://soilgrids.org/>
- Volume % of coarse fragments (> 2 mm)  
Hengl et al. 2014  
<https://soilgrids.org/>
- Soil organic carbon content (‰)  
Hengl et al. 2014  
<https://soilgrids.org/>
- Soil pH (water)  
Hengl et al. 2014  
[https://soilgrids.org](https://soilgrids.org/)

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

#### **RS-EBV's**

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

#### **Anthropogenic**

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

More information on predictors and particularly on RS-EBS's can be found here:  
[https://www.synbiosys.alterra.nl/nextgeoss/docs/Description\\_Abiotic\\_and\\_RSEBVs.pdf](https://www.synbiosys.alterra.nl/nextgeoss/docs/Description_Abiotic_and_RSEBVs.pdf)

## 2.3 Modelling

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

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

The two modelling approaches (background data selected from the EVA database or selected by Maxent) were evaluated for each of the EUNIS habitat types in order to estimate which assumption is more likely. As it was the case with many other evaluated EUNIS habitats (Hennekens 2018) the current study also showed, that all maps using background data that was randomly selected by Maxent, were far more better (by visual inspection) than the maps produced using background randomly derived from the EVA database. Therefore, and in contrast what is recommended by Elith et al. (2011) only suitability maps based on random selected background data by Maxent are taken into account in this report (Annex 2).

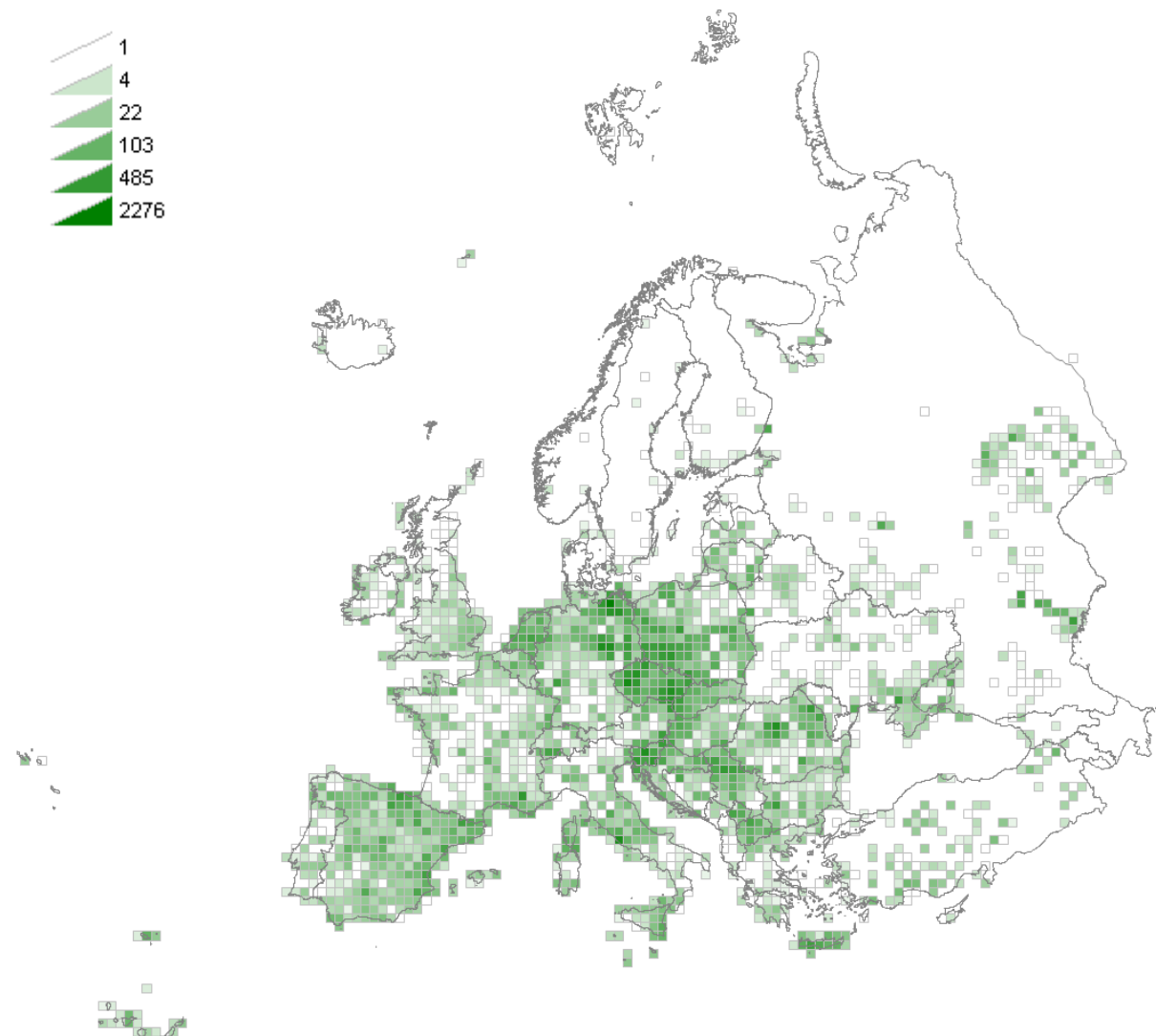


### 3 Results

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

For a number of habitat types no maps have been provided, because these types cannot be defined on a floristic basis and are therefore excluded from the modelling process.

**Figure 2 Overall distribution of plot observations assigned to Vegetated man-made habitats (79,069 plot observations)**



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

- A distribution map showing the location of the relevés that have been assigned to the EUNIS type concerned and therefore used as observation data. As background for the observations the inventory effort regarding Vegetated man-made habitats is presented.
- A habitat suitability map with colours varying from grey, through orange to red, indicating increasingly favourable ecological conditions for the type (expressing the logistic output of the model between 0 and 1).
- A binary map based on the 10 percentile training presence. The 10 percentile training presence is a threshold which omits all regions with habitat suitability lower than the suitability values for the lowest 10% of occurrence records. It assumes that the 10% of occurrence records in the least suitable habitat aren't occurring in regions that are representative of the species overall habitat, and thus should be omitted.
- Statistics from the Maxent modelling:
  - AUC, or the Area Under the Curve, as a general estimate of model performance. This is the likeliness that the classifier correctly orders two points (a random positive example and a random negative example). In general, AUC values in the range 0.5-0.7 were considered low, 0.7-0.9 were moderate and > 0.9 were high, suggesting poor, good and very good model performances, respectively. We provide two estimates of the AUC as calculated by Maxent. 'AUC training' reflects the internal fit between observed and predicted occurrences in the computed model. 'AUC test' provides the mean AUC obtained from a 10-fold cross-validation procedure in which ten different models were computed with a random selection of 90% of data (calibration data set) and 10% for testing the model (validation data set).
  - The 10 percentile training presence, as threshold for drawing the binary map.
  - Contribution in percentage of the predictors to the Maxent model. It indicates to what extent the environmental variables contribute to the model. A higher contribution value means a higher prediction value.

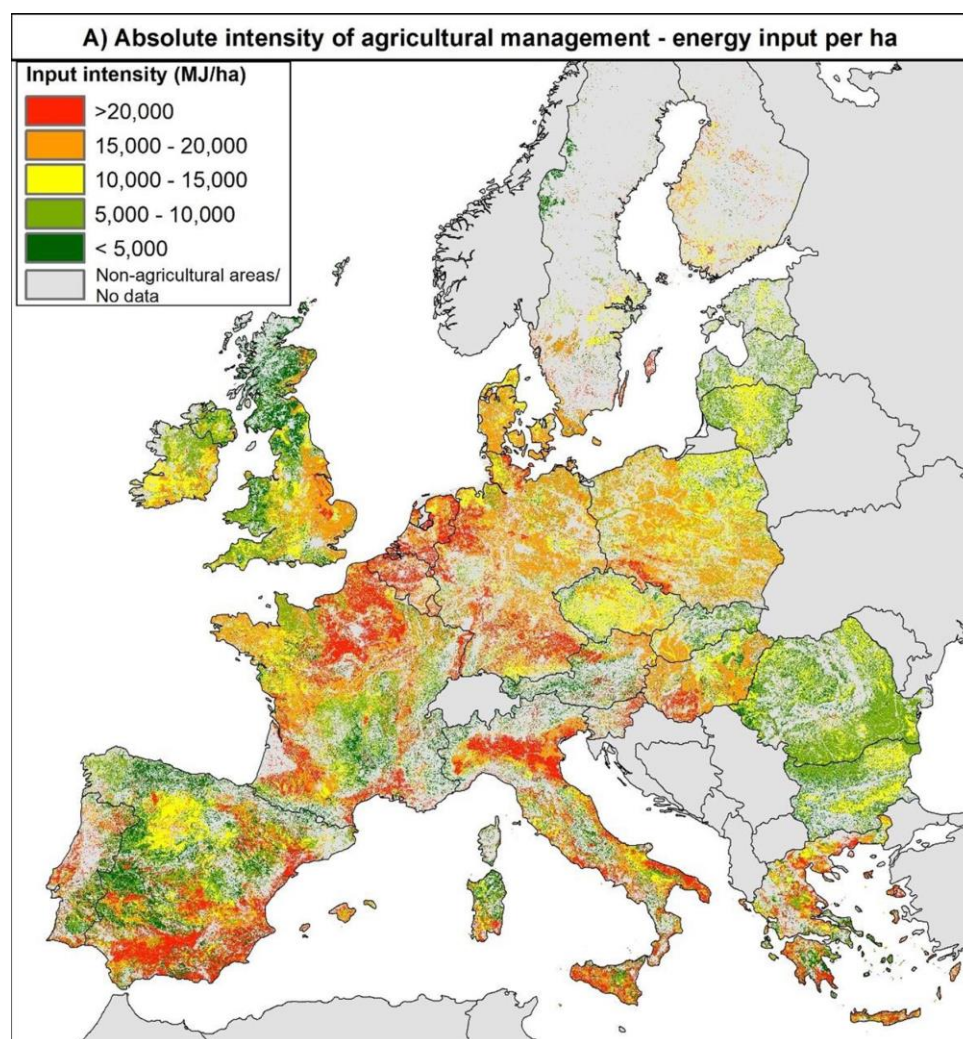
## 4 Discussion

In general the range of the **suitability** maps is very much in line with the range of the **distribution** maps, which is in contrast to earlier reports on the suitability maps of EUNIS habitats (Hennekens 2016, 2017). From 2018 RS-EBV's, like phenology, have been introduced in the modelling process, resulting in the exclusion of the most eastern part of Europe, an area that is underrepresented in the EVA database.

Even though the number of plot observations, assigned to V habitats, seems high (79,069), Figure 2 shows that there are regions in Europe that are underrepresented, like parts of Ireland, Britain, Germany, France, Portugal, Northern Italy and especially Eastern Europe. Scandinavia is also hardly represented by plot data, but this is probably due to the fact there is very little agricultural activities anyway. This assumption is underpinned by Figure 3, that clearly shows that, at least large parts of Sweden and Finland are classified as Non-agricultural areas.

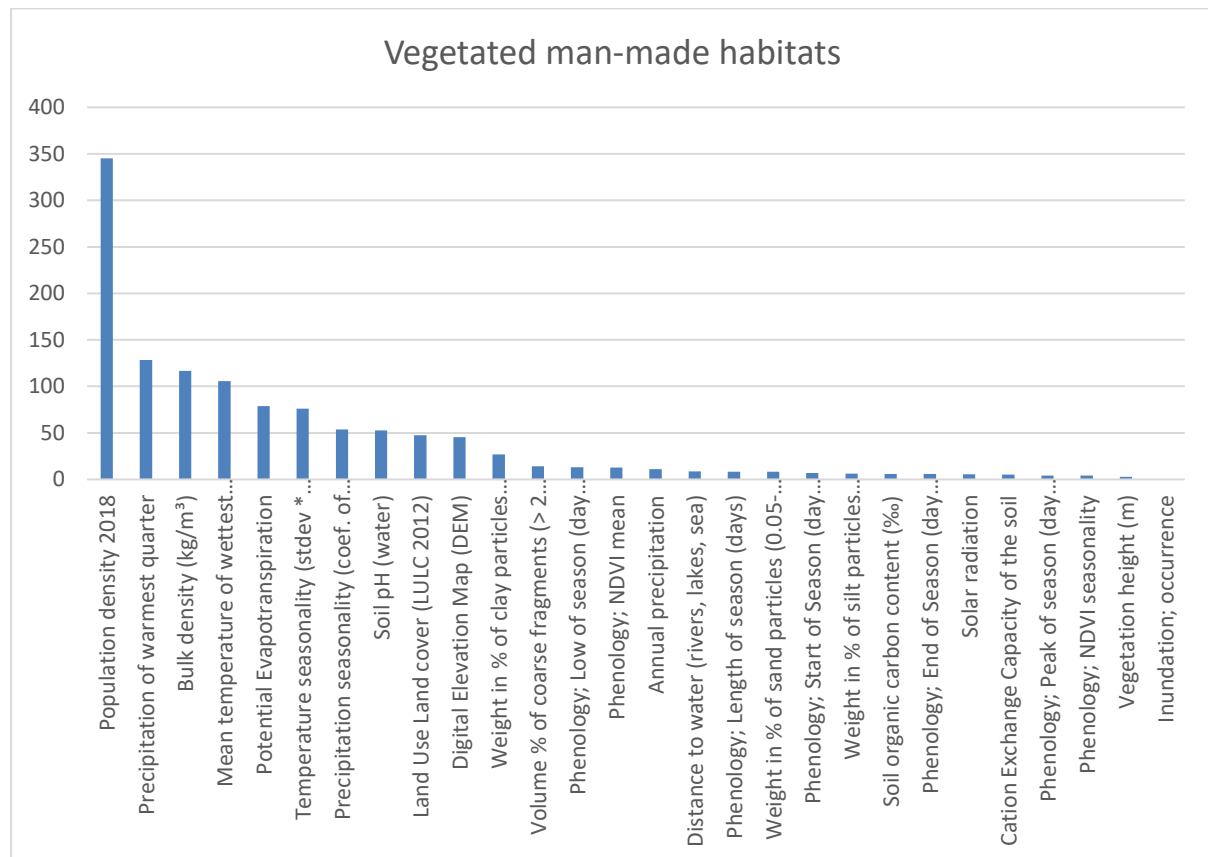
The lack of observation data in various parts of Europe has a clear effect on the range of suitability maps as demonstrated in for example V11 and V12, habitat types one may expect to occur all over Europe. However, the suitability maps of these types show large gaps in Britain, Ireland, France, Spain and Italy.

**Figure 3** Absolute intensity of agricultural management (Rega et al. 2020)



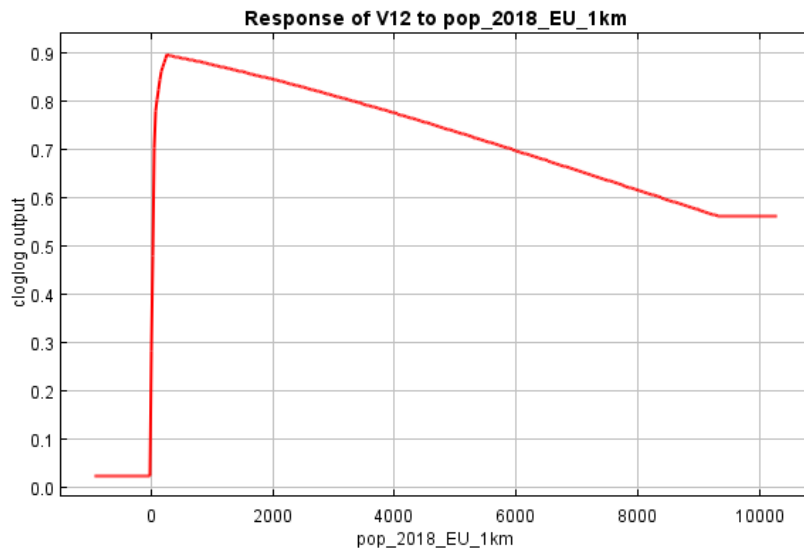
To what extent the suitability maps (Appendix 2) represent a realistic range of the types modelled is hard to say. Compared with other EUNIS habitats (Hennekens 2017, 2018, 2019) the suitability maps of Man-made vegetated habitats are, with a few exceptions, less determined by climate and soil predictors, but much more by population density, which is not surprising. This is demonstrated in Figure 4, where the sum of the contributions of population density is much larger than that of all other predictors.

**Figure 4** Sum of the contributions of all suitability models for group V



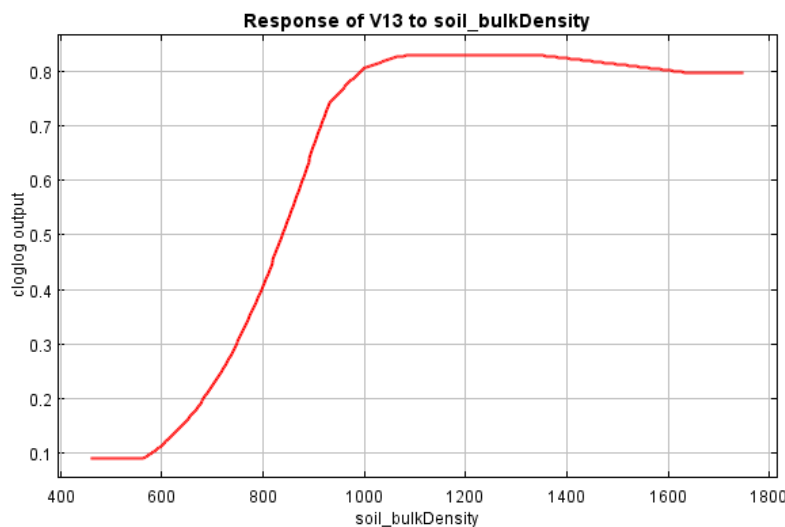
The response curve in Figure 5 shows that even with the smallest population density the chance of occurrence of a V-habitat is very high, which one might of course expect. Human settlements in rural areas always induce agricultural activities. The response curve also shows that with increasing population density the chance of occurrence of the habitats slightly decrease. This can be explained by the fact the agricultural activities are higher in rural areas, compared to urban areas.

**Figure 5** Relation between population density (x-axis) and suitability (y-axis) of habitat type V12



Another predictor which is strongly related to Vegetated man-made habitats is bulk density of the soil (Figure 6). Agricultural activities, like ploughing increases the bulk density of the soil, which is clearly shown in figure 5.

**Figure 6** Relation between bulk density of the soil (x-axis) and suitability (y-axis) of habitat type V13

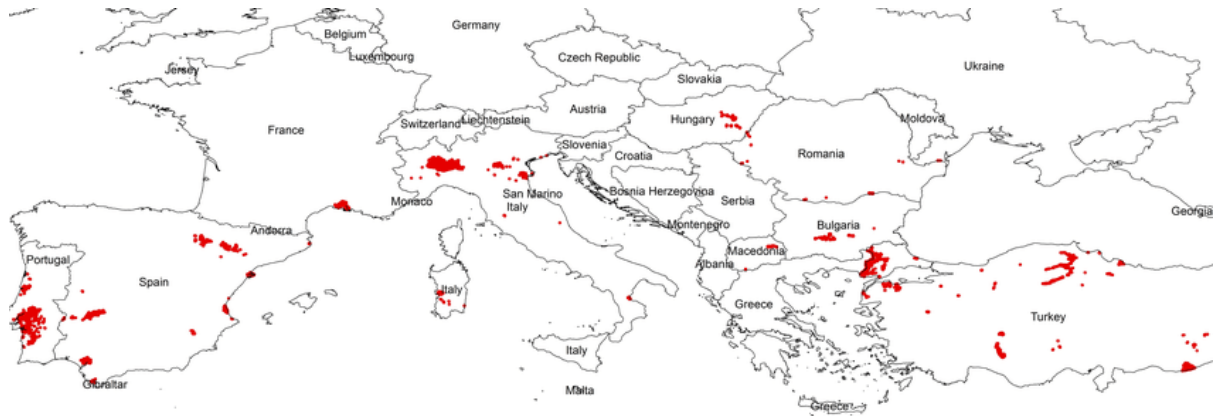


The predictors population density and bulk density of the soil play a less important role in the modelling process of the Mediterranean located types V32 (Mediterranean subnitrophilous annual grassland) and V33 (Dry mediterranean lands with unpalatable non-vernal herbaceous vegetation). Here climatic conditions dominate the modelling.

There are a few exceptions where climate and soil predictors overrule population density. These are the habitat types V32 (Mediterranean subnitrophilous annual grassland) and V33 (Dry mediterranean lands with unpalatable non-vernal herbaceous vegetation), both restricted to the Mediterranean, and V14 (Inundated or inundatable cropland, including rice fields), which has a very limited distribution.

Based on relatively few plot observations (136) the suitability map for V14 lacks many potential areas when compared with the distribution maps of rice fields in Europe (Figure 7). Nevertheless, it is remarkable that V14 is predicted for Hungary, even though no plot observations from that area are available. According to the Figure 7 rice fields occur in Hungary.

**Figure 7** Distribution of rice fields in Europe (Bogliani & Della Rocca 2015)



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

- The assignment of a plot observation to a EUNIS habitat type is based on expert rules. These rules may need further refinement, which could lead to different results.
- The number of plot observations may be too small to deliver an accountable model (V14).
- The degree of detail in the predictor maps could be too limited, in other words the maps with a grid size of 1x1 km could be too coarse. Plants, that form the basis of a habitat type operate on a much smaller scale than 1x1 km. And in the field micro climate and soil parameter may differ significantly over short distances.

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# Annex 1 List of EUNIS habitat types (group V) with indication of availability of distribution and suitability maps

New code	EUNIS 2012 code	Habitat name	Distribution map	Suitability map	No of plots
V		Vegetated man-made habitats			
V1	I1	Arable land and market gardens			
V11	I1.1	Intensive unmixed crops	x	X	7260
V12	I1.2	Mixed crops of market gardens and horticulture	x	X	433
V13	I1.3	Arable land with unmixed crops grown by low-intensity agricultural methods	x	X	3379
V14	I1.4	Inundated or inundatable cropland, including rice fields	x	X	136
V15	I1.5	Bare tilled, fallow or recently abandoned arable land	x	X	24128
V2	I2	Cultivated areas of gardens and parks			
V21	I2.1	Large-scale ornamental garden areas			
V22	I2.2	Small-scale ornamental and domestic garden areas			
V23	I2.3	Recently abandoned garden areas			
V3		Grasslands			
V31	E2.6	Agriculturally-improved, re-seeded and heavily fertilised grassland, including sports fields and grass lawns			
V32	E1.6	Mediterranean subnitrophilous annual grassland	x	X	7896
V33	E1.C	Dry mediterranean lands with unpalatable non-vernal herbaceous vegetation	x	X	434
V34	E1.E	Trampled xeric grassland with annuals	x	X	1764
V35	E2.8	Trampled mesophilous grassland with annuals	x	X	4733
V36	E4.5	Alpine and subalpine enriched grassland			
V37	E5.1	Annual anthropogenic herbaceous vegetation	x	X	11491
V38		Dry perennial anthropogenic herbaceous vegetation	x	X	13856
V39		Mesic perennial anthropogenic herbaceous vegetation	x	X	3559
V4	FA	Hedgerows			
V41	FA.1	Hedgerows of non-native species			
V42	FA.2	Highly-managed hedgerows of native species			
V43	FA.3	Species-rich hedgerows of native species			
V44	FA.4	Species-poor hedgerows of native species			
V5	FB	Shrub plantation			
V51	FB.1	Shrub plantations for whole-plant harvesting			



V52	FB.2	Shrub plantations for leaf or branch harvest
V53	FB.3	Shrub plantations for ornamental purposes or for fruit, other than vineyards
V54	FB.4	Vineyards
V6		Orchards and small planted woodlands
V61	G1.D	Broadleaved fruit and nut tree orchards
V62	G2.9	Evergreen orchards and groves
V63	G5.1	Lines of planted trees
V64	G5.2	Small deciduous broadleaved planted other wooded land
V65	G5.3	Small evergreen broadleaved planted other wooded land
V66	G5.4	Small coniferous planted other wooded land

For a number of habitat types no maps have been provided, because these types cannot be defined on a floristic basis and are therefore excluded from the modelling process.

## **Annex 2 Distribution and suitability maps of the revised EUNIS habitat types (group V)**

See PDF file: Annex 2 - Distribution and suitability maps of the revised EUNIS habitat types (Group V)