Bioclimatic variables and their impact on the potential distribution of *Brenneria goodwinii* in Europe

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Brenneria goodwinii is one of the factors responsible for the phenomenon known as Acute Oak Decline (AOD). This phenomenon was first described in the UK, but this bacterium is increasingly being observed in other parts of Europe, suggesting a wider range of climatic requirements for this organism. The aim of the study is to investigate the influence of bioclimatic variables on the potential spread of the bacterium *Brenneria goodwinii* in Europe.

Materials and Methods

In the study, bioclimatic variables (Tab. 1) and the MAXENT model were used to assess the suitability of habitats for the development of *B. goodwinii* in different European countries. The study covered the entire area of the European continent between latitudes 72° N – 34° N and longitudes 14° E – 39° E. Nineteen bioclimatic variables available on the WorldClim portal for the years 1970–2000 were used to create the model. Data on the occurrence of *B. goodwinii* were collected from the scientific literature and public databases. To create a database on the occurrence of *B. goodwinii*, an autocorrelation analysis was performed using the QGIS 3.18.3 Zurich programme, which uses average nearest neighbour analysis. 56 points containing information on the occurrence of *B. goodwinii* on oaks were used for modelling.

Results

The Maxent model (Tab. 2) was developed to recognise the trend in the distribution of *B. goodwinii* in Europe. The model achieved a high prediction accuracy measured by parameters such as AUC and AUCdiff. It allows the determination of the most useful bioclimatic variables to assess the maximum entropy of the habitat in relation to the occurrence of *B. goodwinii*. These bioclimatic variables are the mean temperature of the coldest quarter, the mean temperature of the warmest quarter and the precipitation of the wettest month. The model identified areas in Europe where the adaptation probabilities for bacteria are >.7, including the UK, France, Belgium, the Netherlands, Germany, Denmark, Spain, Portugal and Italy (Fig. 1).

Table 2. The results of model fitting and the contribution of individual variables for all models made.

GCMs number	Test AUC	Contribution								
		BIO 1	BIO 10	BIO 11	BIO 13	BIO 14	BIO 18	BIO 8	BIO 9	BIO 19
brenneria_goodwinii (model)	0,835	0,00	15,75	56,14	19,29	1,51	1,57	2,95	3,13	0,00

Table 1. List of bioclimatic variables, type and unit of measure.

Code	Bioclimatic variables	Unit
BIO 1*	Annual Mean Temperature	°C
BIO 2	Mean Diurnal Range	°C
BIO 3	Isothermality	dimensionless
BIO 4	Temperature Seasonality	°C
BIO 5	Max Temperature of Warmest Month	°C
BIO 6	Min Temperature of Coldest Month	°C
BIO 7	Temperature Annual Range	°C
BIO 8*	Mean Temperature of Wettest Quarter	°C
BIO 9*	Mean Temperature of Driest Quarter	°C
BIO 10*	Mean Temperature of Warmest Quarter	°C
BIO 11*	Mean Temperature of Coldest Quarter	°C
BIO 12	Annual Precipitation	mm
BIO 13*	Precipitation of Wettest Month	mm
BIO 14*	Precipitation of Driest Month	mm
BIO 15	Precipitation Seasonality	fraction
BIO 16	Precipitation of Wettest Quarter	mm
BIO 17	Precipitation of Driest Quarter	mm
BIO 18*	Precipitation of Warmest Quarter	mm
BIO 19*	Precipitation of Coldest Quarter	mm

* Variables which, after preliminary analyses, were used to construct the model.

Conclusions

- The Maxent model was developed to detect the trend in the distribution of *B. goodwinii* in Europe, achieving a high prediction accuracy.

- The study emphasises the potential impact of climate change on the occurrence of *B. goodwinii* and the need for further research on this topic.

- The low number of records of *B. goodwinii* may be due to the limited knowledge and description of bacterial diseases in forest ecosystems, leading to a lack of information on the presence of bacteria associated with the phenomenon of Acute Oak Decline.
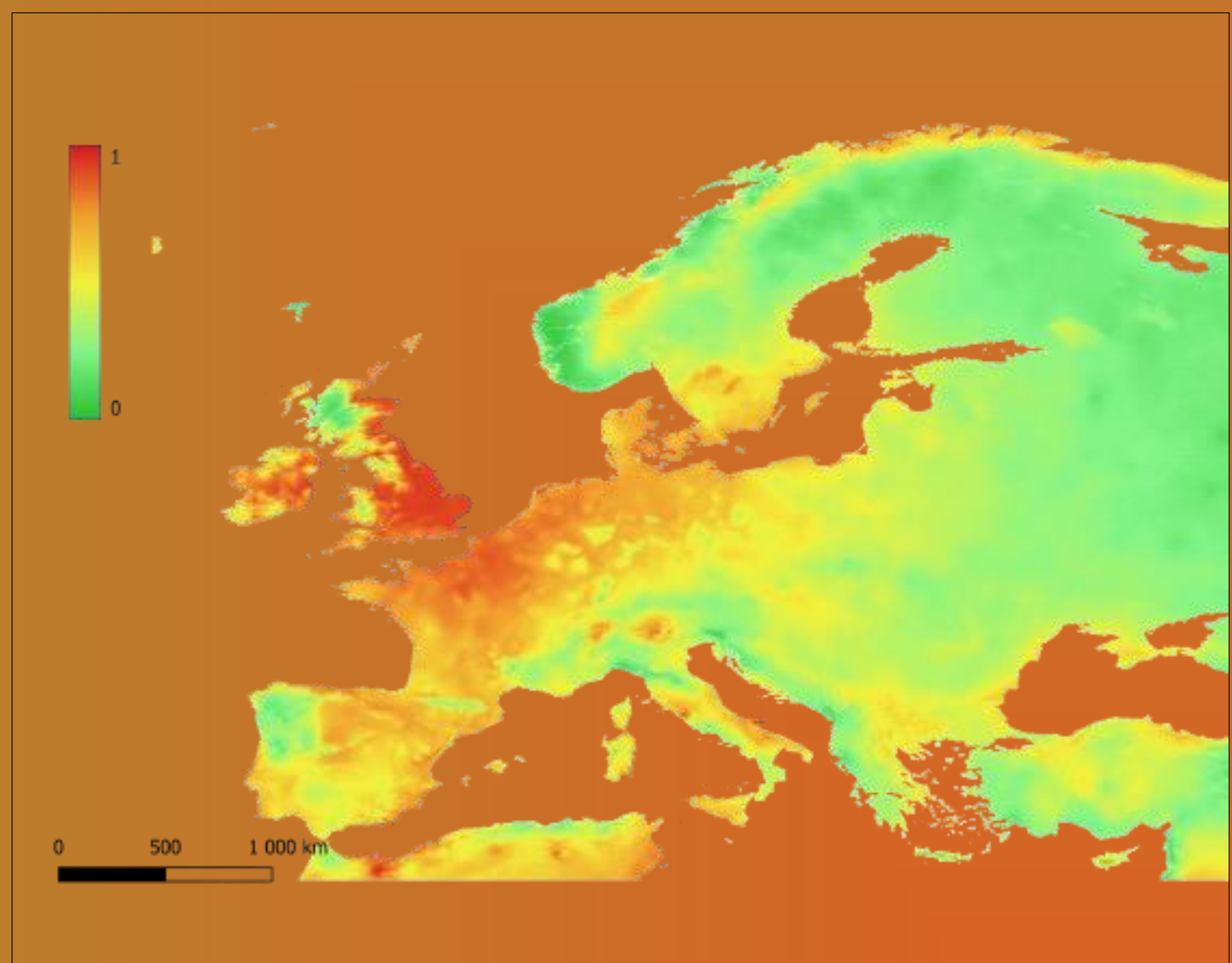

Fig. 1. Current species distribution models (SDMs) of *Brenneria goodwini*. The map shows the probability of presence ranging from 0 (green) to 1 (red).