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Assessment and Prospects for the Impact of Invasive Fish on Native European Amphibians

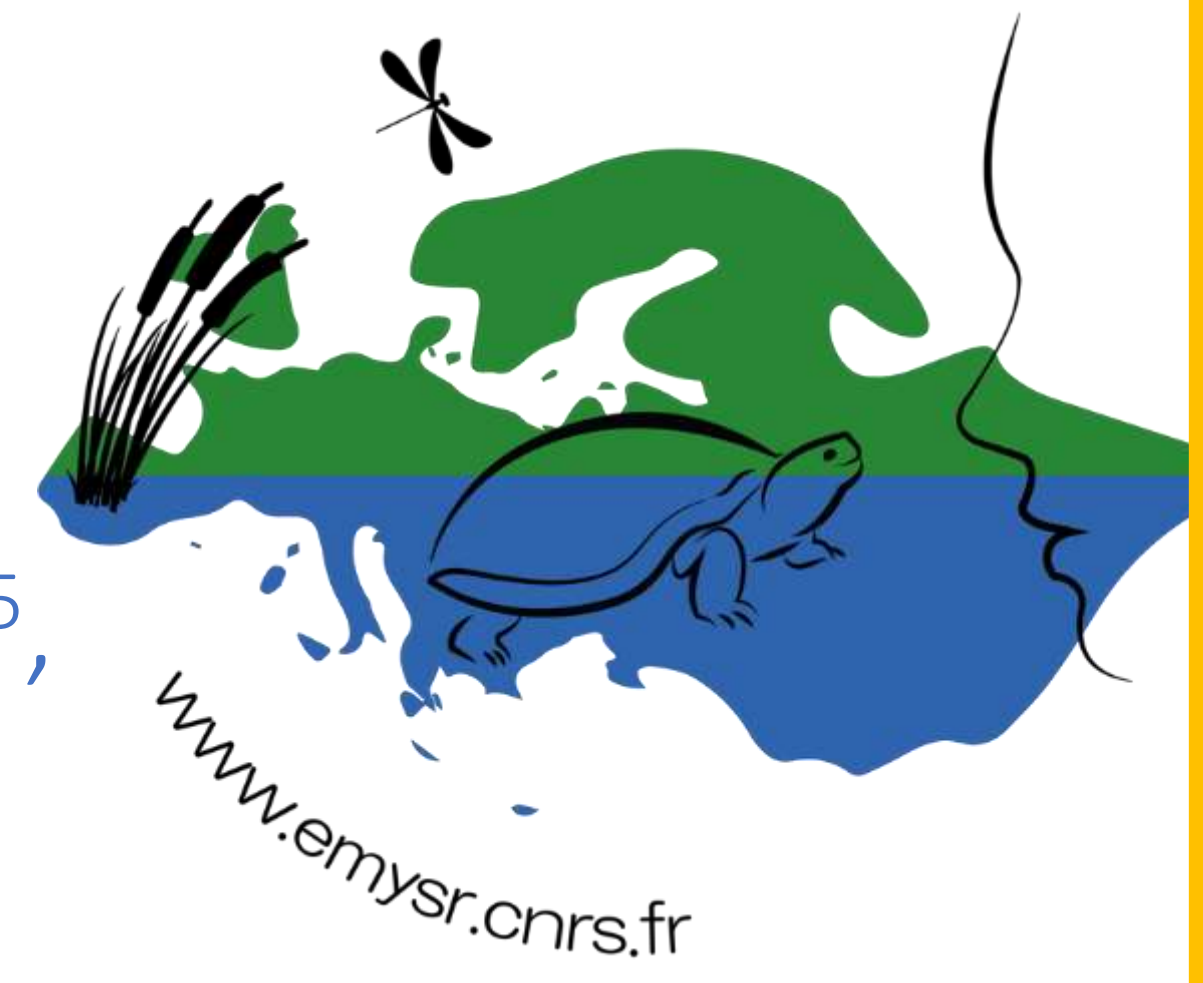
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INTRODUCTION

Recently, a decrease in the numbers of amphibians in Eastern Europe was reported multiple times. Suitable habitats that are important for amphibians at certain stages of their lives shrink and degrade due to climate change, anthropogenic impact and the animals suffer from pollution and appearance of alien invasive species. Alien invasive species often appear and adapt in new places far from their natural range for example as a result of uncontrolled release into the wild from the terrariums or being accidentally transported as a result of developing aquaculture. Particularly concerning is the transcontinental spread of invasive predatory fish species like Chinese sleeper *Percottus glenii* and pumpkinseed *Lepomis gibbosus* into European wetlands, local freshwater biodiversity.



MATERIALS & METHODS

To assess the potential impacts by 2050 and 2090 of these predatory fish on European amphibians, we conducted GIS modeling based on Species Distribution Models (SDMs). To assess the potential impacts by 2050 and 2090 of these predatory fish on European amphibians, we conducted GIS modeling based on Species Distribution Models (SDMs).

We used the 'ntbox' package in R to avoid errors due to spatial autocorrelation. Ecological niche modeling and species distribution modelling (SDM) methods have been used to determine the potential home range of invasive species in new environments (MaxEnt with 25 replicates, DivaGis (Bioclim)). We used 35 bioclimatic variables from the CliMond dataset. Of 35 bioclimatic variables, highly correlated (>0.7) predictors were removed using the 'virtualespecies' package in R, resulting in a selection of 18 for 1975 (1970-2000), 2050 (2061-2090).

The area under the receiver operating characteristic (ROC) curve (AUC) was used for assessing the discriminatory capacity of the models: AUC>0.85 is considered excellent. We carried out separate modelling for each set of factors and for each species. Logistic output format was used to describe the relative probability of presence, which is a continuous habitat suitability (HS) range between 0 (unsuitable) and 1 (the most suitable).

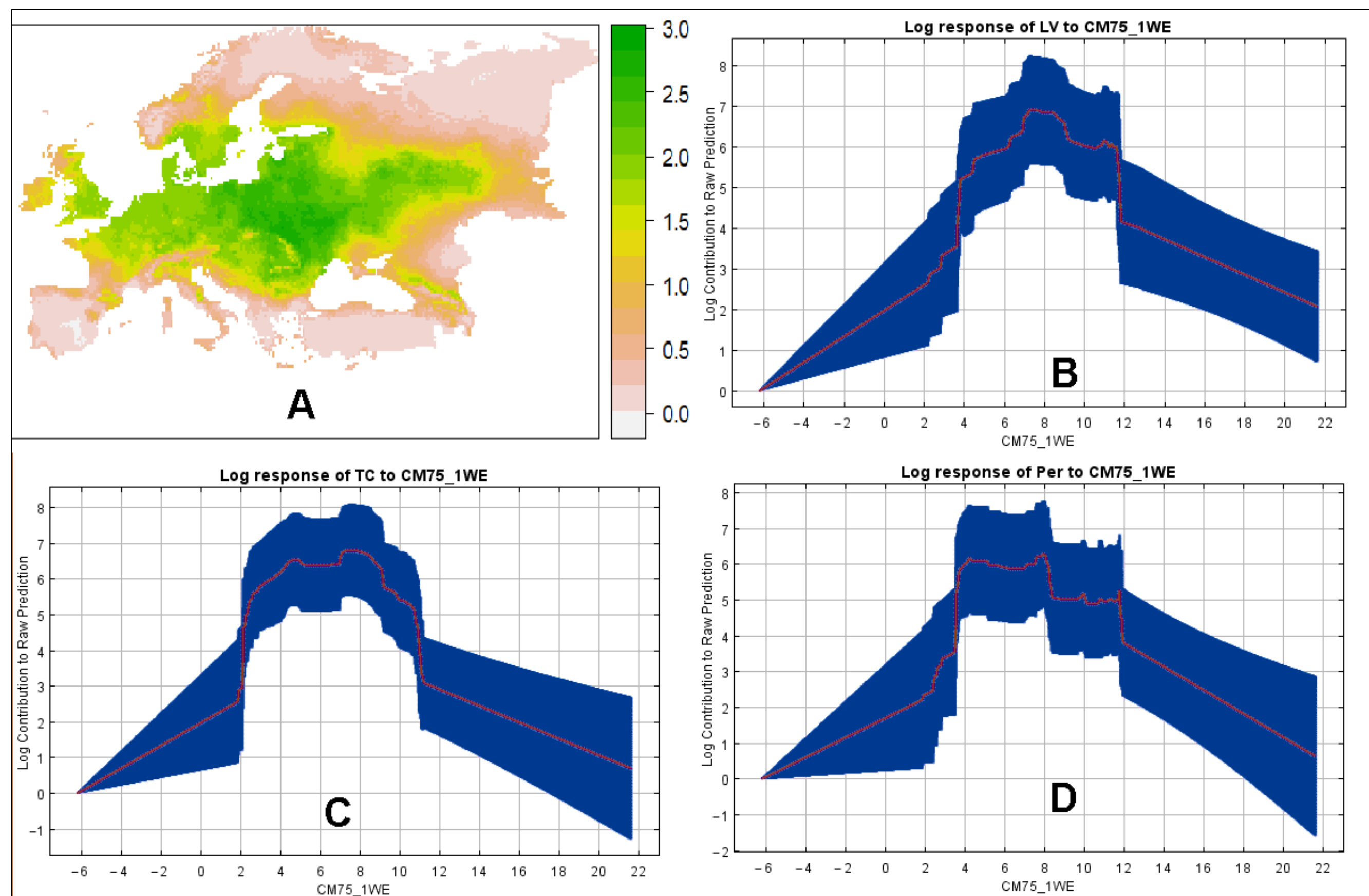


Figure 1. Map Maxent model: (A) – Map of cohabitation of 3 species (SSDM) in Europe; and the plots of response curves of Maxent model using only the variable - Annual mean temperature (°C, CliMond) from: (B) – *L. vulgaris*; (C) – *T. cristatus*; (D) – *P. glenii*.

Conclusions

Our models forecast:

- 1) an increase in the range of the thermophilic invasive fish species;
- 2) significant declines in most native amphibians' natural ranges by 2090;
- 3) native European amphibians will face increased pressure from invasive fish as breeding habitat loss intensifies.

Creating Geographically Isolated Wetlands (GIW) is crucial for amphibian conservation, as they harbor greater diversity and abundance while preventing predatory fish expansion. Urgent action is needed to protect amphibians, particularly newts, through reconstruction of GIW and simultaneous control of invasive predators.

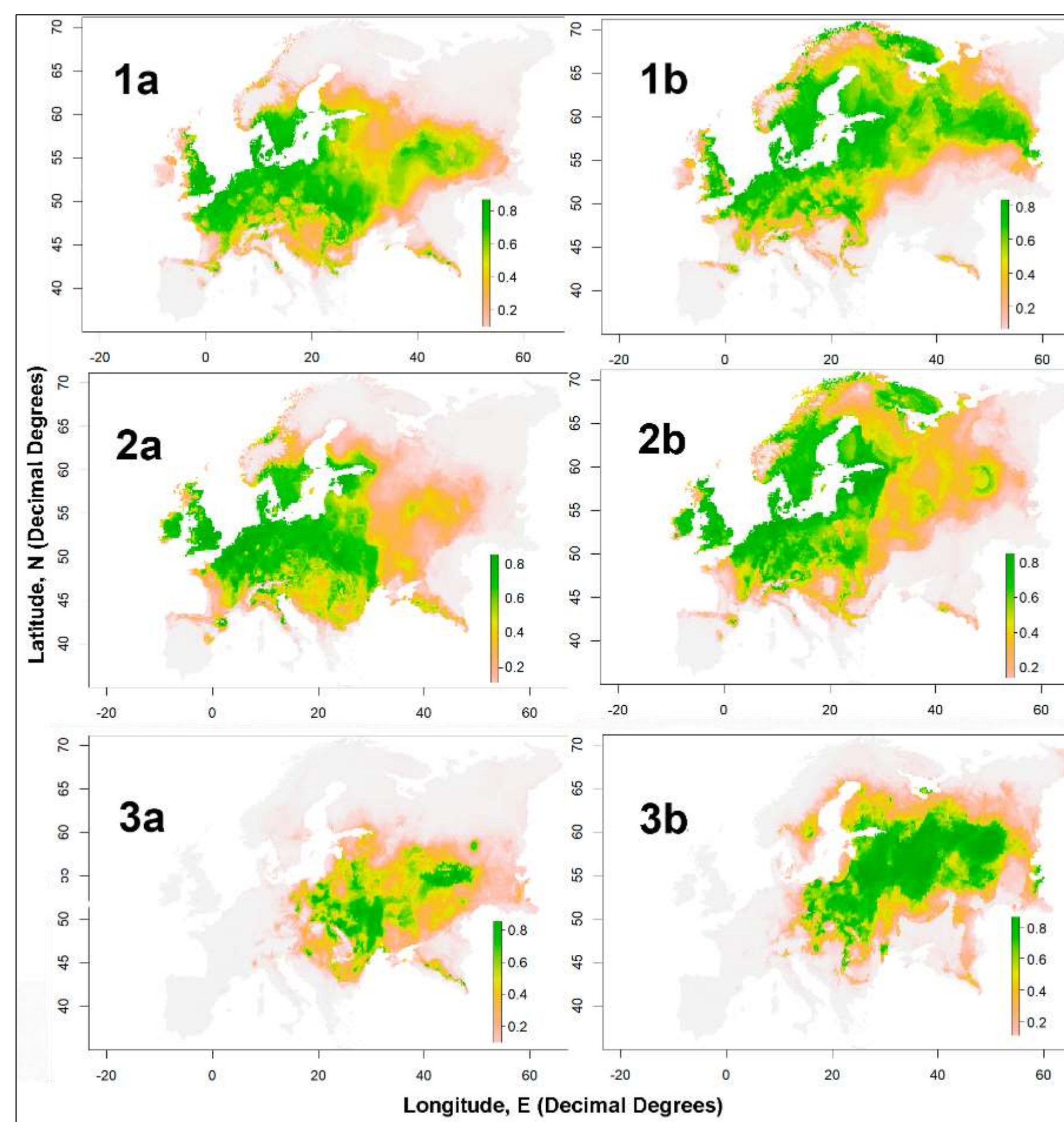


Figure 2. Result of the analysis of Binomial tests (5 bioclimatic CliMond covariates): 1 - *T. cristatus*; 2 - *L. vulgaris*; 3 - *P. glenii*; a – 2000, b – 2090.

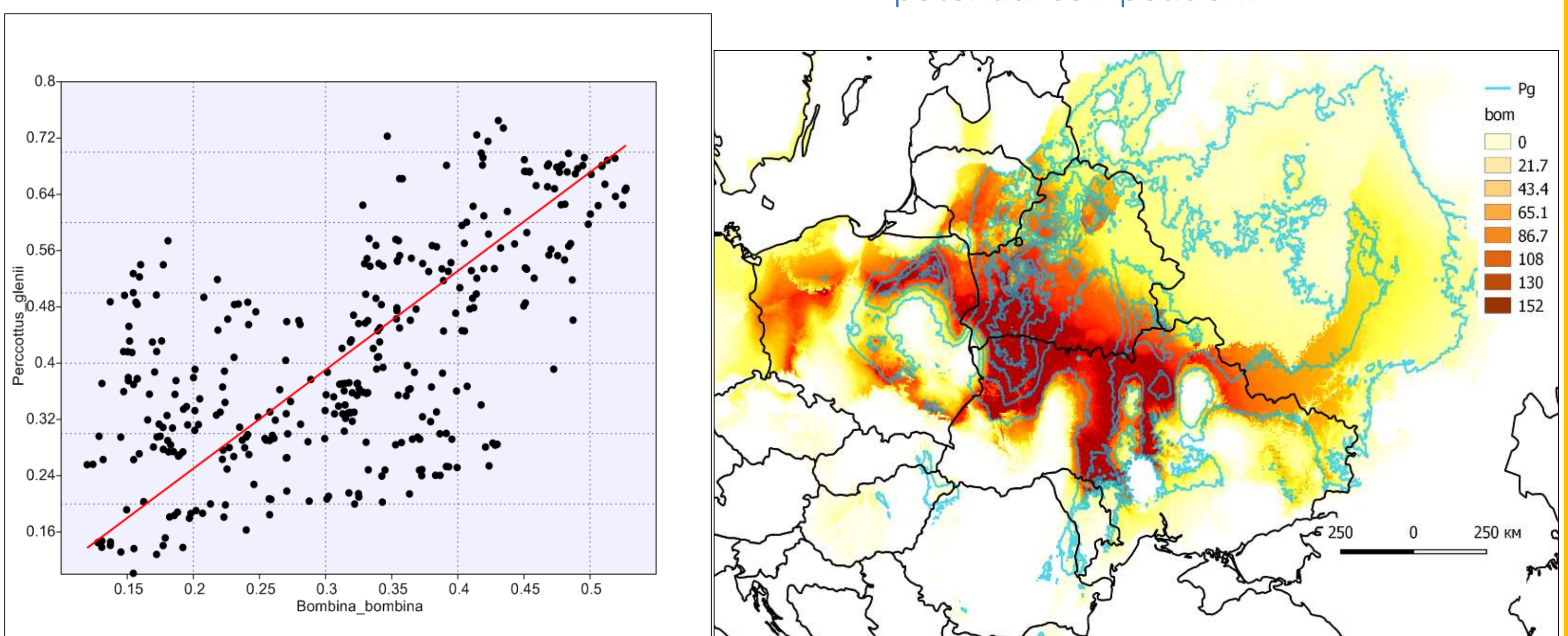


Figure 3. Graph of Pearson correlation between grids of 0.166667° resolution representing predicted bioclimatic habitat suitability for *P. glenii* & *B. bombina* in Latvia. Figure 4. Visualization of potential distribution of *P. glenii* & *B. bombina* using the programs DIVA-GIS, QGIS.



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