



# Predicting the Effectiveness of Tagus International Nature Park in Protecting Vegetation Under Climate Change

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## Abstract

Climate change induces a redistribution of life on Earth that affects the effectiveness of protected areas. Species shift their ranges under climate change to track suitable climate, mainly shifting poleward and toward higher elevation. They often face degraded habitats in human-dominated landscapes and a higher extinction threat. Also, climate change may result in the loss of combinations of climatic conditions that are restricted to a given protected area. On the other hand, species with restricted occurrence might expand their distribution range as a result of climate change. In order to study the effectiveness of Tagus International Nature Park, located in the center-eastern part of Portugal, Maxent modeling approach was used to model the current distribution of three shrub species—*Pistacia terebinthus* L., *Juniperus oxycedrus* L., and *Rhamnus lycioides* L.—indicators of a typical Mediterranean vegetation with a regional distribution restricted to the Tagus International Natural Park, and project its future distribution considering different General Circulation Models, periods (2060 and 2080) and Representative Concentration Pathways (4.5 and 8.5). The variables most impacting the species distribution were the mean precipitation of the driest quarter, annual precipitation, mean annual temperature, and slope. The results

suggested some range expansion in the future for all three species in the studied scenarios. Those species and the vegetation where they occur will probably remain confined to center-eastern Portugal in the future, where they will continue to face relevant threats like human activity, reinforcing the need for its conservation.

## Keywords

Climate change • Environmental variables • Plant species • Protected area • Species modeling

## 1 Introduction

Habitat and biodiversity loss are global concerns related to climate change. Changes in climate will induce a fundamental redistribution of life on earth that could affect the effectiveness of protected areas as well as ecosystem functioning. Many studies have reported the poleward shift of species distribution as a biological sign of climate change (Aguirre-Gutiérrez et al., 2019; Thomas & Gillingham, 2015). The need for modeling climate change's impact on plant habitats is particularly evident for predictions of the stability of potentially most vulnerable species. The increase in temperature, longer periods of higher temperatures, and changes in precipitation are expected in the climate of southern Europe (Orlikowska et al., 2016).

Restricted-range species are particularly vulnerable to the effects of environmental change, which makes assessing likely climate change effects on geographic distributions of such species important to the development of integrated conservation strategies (Casazza et al., 2014), and ultimately may lead to local extinctions (Mawdsley et al., 2009; Urban, 2015).

We selected three species with a regional distribution restricted to the Tagus International Natural Park—*Pistacia terebinthus* L., *Juniperus oxycedrus* L., and *Rhamnus*

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*lycioides* L. to study the influence of climate change on the potential geographic distribution of those species as indicators of typical Mediterranean vegetation using an ecological niche model (ENM).

*J. oxycedrus* L. is a dominant or co-dominant species in the priority habitat in Europe, 9560—Endemic forests with *Juniperus* spp., and the habitat 5210—Arborescent matorral with *Juniperus* spp., included in the 92/43/CEE Directive. These habitats have a limited distribution in mainland Portugal, thus, it is important modeling their distribution face to climate change, once these results could be useful for its management.

## 2 Materials and Methods

The study area located in the central-eastern part of Portugal, includes the Tagus International Nature Park (PNTI) and the surrounding area belonging to the Tagus International Transboundary Biosphere Reserve, with an extent of 1692 km<sup>2</sup> (Fig. 1). It is an area of low altitude but with steep relief as a result of the embedding of the Tagus and its tributaries on the edge of the peneplain. Most of the vegetation is made up of sclerophyllous formations of holm oak and cork oak, as well as abundant patches of scrub, which alternate with cultivated areas and pastures.

Floristic relevés were performed based on the phytosociological method Braun-Blanquet modified by Géhu and Rivas-Martínez (1981), with Braun-Blanquet scale converted to the average percentage (Podani, 2006). Vegetation was sampled in a stratified random manner to obtain broadly

representative data. The sample areas were defined within these patterns randomly in 100 m<sup>2</sup>

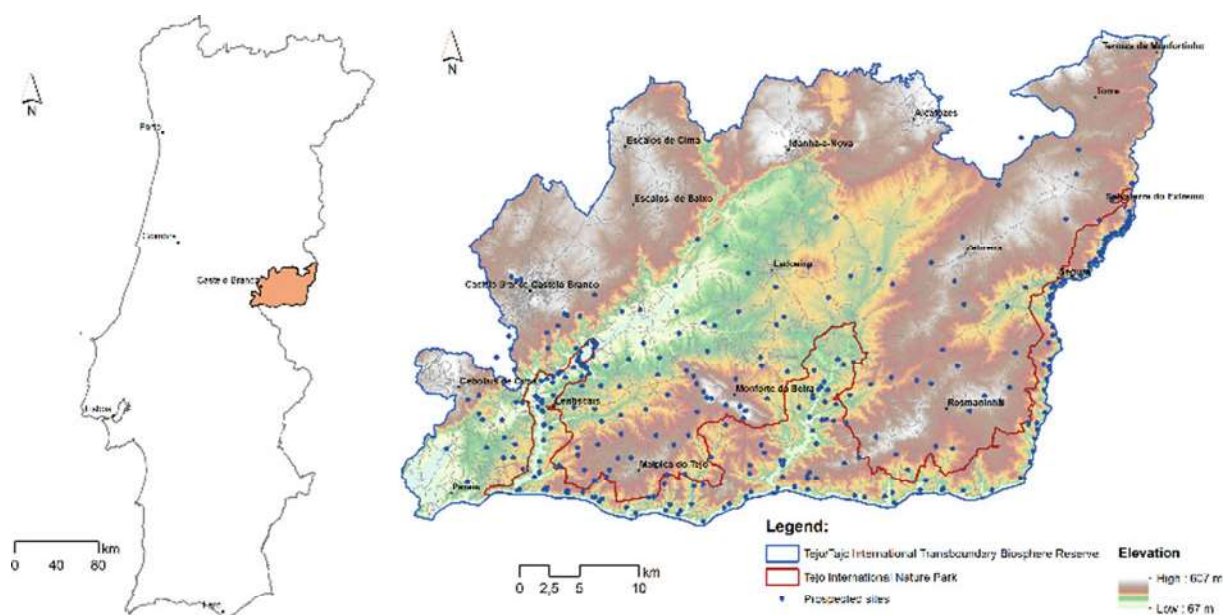
The ecological niche model (ENM) was computed employing the software Maxent v3.4.1 (2022). Known for generating robust presence-background models, even with low sample sizes (Thibaud et al., 2014).

A literature review was performed and different topographical, climatic, and soil data were selected to evaluate habitat suitability to model the selected species' habitat. To model the species distribution in future scenarios, we have considered two representative concentration pathways (RCPs) scenarios: RCP 4.5 and RCP 8.5, fitted for 2080, which is obtained from the WorldClim database (Fick & Hijmans, 2017). Emissions in RCP 4.5 (Intermediate scenario) peak around 2040, then decline, resulting in a global temperature rise between 1.1 and 2.6 °C by 2081–2100 (relative to 1986–2005). In RCP 8.5 (Worst-case climate change scenario) emissions continue to rise throughout the twenty-first century, resulting in a global temperature rise between 2.6 and 4.8 °C by 2081–2100.

## 3 Results and Discussion

The present distribution of the species is shown in Fig. 2 and the potential distribution of the species for the study area for future scenarios RCP 4.5 and RCP 8.5, fitted for 2080 are presented in Fig. 3, considering a spatial resolution of 500 m.

For *J. oxycedrus*, the increase in the potential area of occurrence will be the same in both scenarios (RCP 4.5 and



**Fig. 1** Location of the study area with the field samples used to identify the studied species

8.5). The trend for *P. terebinthus* and *R. lycioides* is also the increase in the species' range, with a slightly higher increase in the RCP 4.5 scenario. The variables most impacting on the species distribution were the mean precipitation of the driest quarter, annual precipitation, mean annual temperature, and slope. Those results are consistent with other studies on the ecology and distribution of Mediterranean and sub-Mediterranean evergreen sclerophyllous scrub species in the Iberian Peninsula (Araújo et al., 2022; Cano et al., 2019; Cano Ortiz et al., 2021).

The results suggested some range expansion in the future for all three species for the studied scenarios. This potential expansion of the studied species in the region is related to

the fact that warmer and drier conditions are projected to occur in the area under study in both climate scenarios. These conditions will be favorable to the occurrence of these species (Costa et al., 2017).

### 4 Conclusions

The studied species and the vegetation where they occur will probably remain confined to center-eastern Portugal in the future, where they will continue to face relevant threats like human activity, reinforcing the need for its conservation.

**Fig. 2** Present distribution of species: **a** *Juniperus oxycedrus*; **b** *Pistacia terebinthus*; **c** *Rhamnus lycioides*

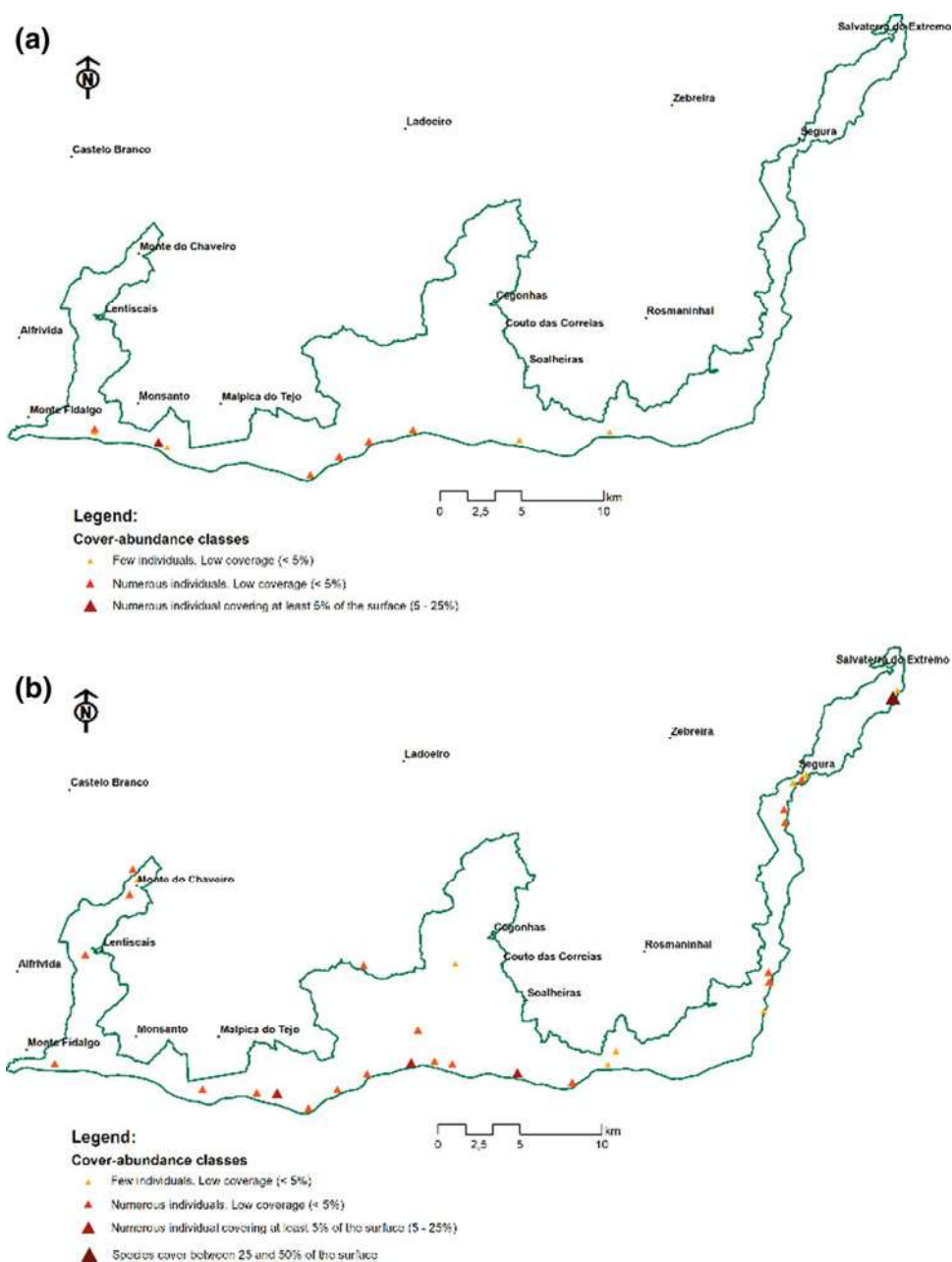


Fig. 2 (continued)

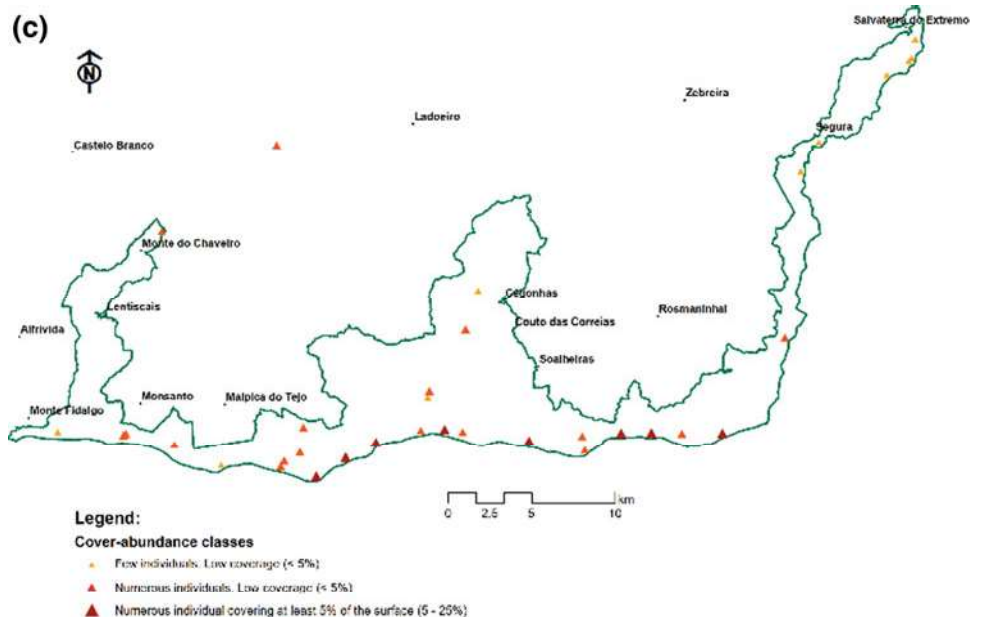
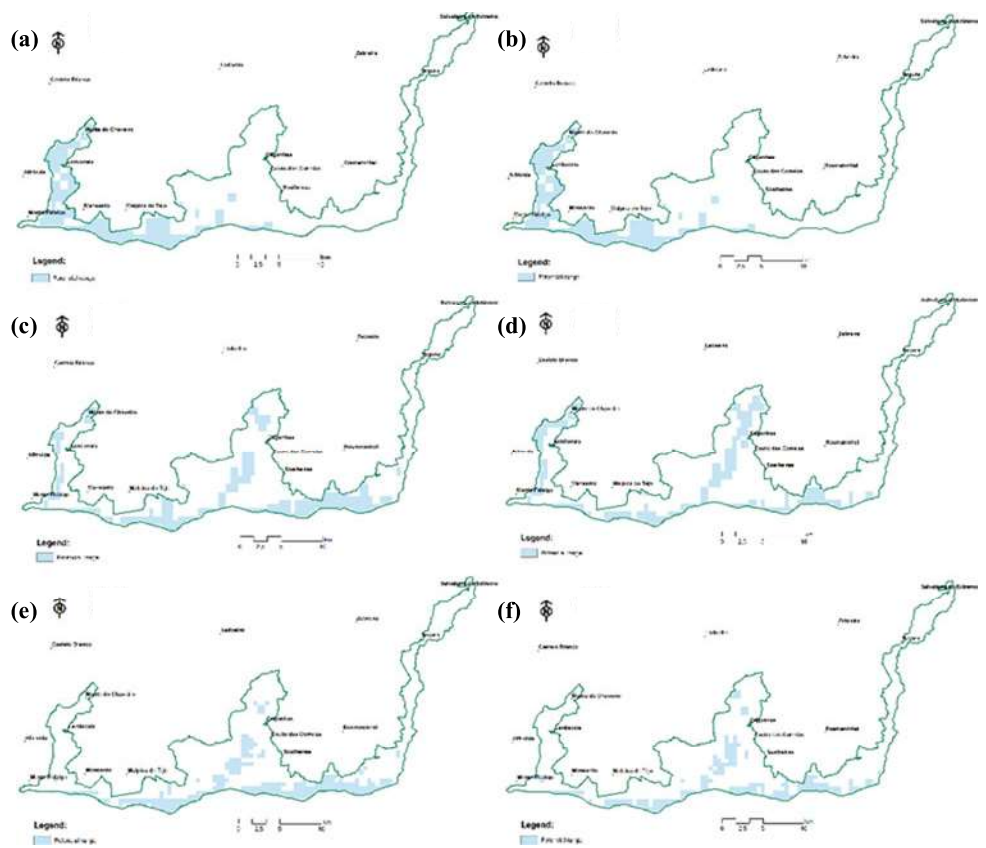


Fig. 3 Future distributions of species: **a** *Juniperus oxycedrus*—RCP 4.5; **b** *Juniperus oxycedrus*—RCP 8.5; **c** *Pistacia terebinthus*—RCP 4.5; **d** *Pistacia terebinthus*—RCP 8.5; **e** *Rhamnus lycioides*—RCP 4.5; **f** *Rhamnus lycioides*—RCP 8.5



The increase in potential area for *J. oxycedrus* is relevant to promote the conservation of the habitat 9560—Endemic forests of *Juniperus*, a priority for conservation at a European level. Also, maquis conservation, with *P. terebinthus* and *R. lycioides* as indicator species, is important at a local and regional level under the habitat 5330 of 92/43/CEE Directive.

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## References

- Aguirre-Gutiérrez, J., Van Treuren, R., Hoekstra, R., & Van Hintum, T. (2019). Crop wild relatives range shifts and conservation in Europe under climate change. *Diversity and Distributions*, 23(7), 739–750.
- Araújo, P. V., Porto, Clamote, F., Carapeto, A., Correia, M. J., Pereira, A. J., Amado, A., Aguiar, C. et al. (2022). *Pistacia terebinthus* L. - mapa de distribuição. Flora-On: Flora de Portugal Interactiva, Sociedade Portuguesa de Botânica. <http://www.flora-on.pt/#wPistacia+terebinthus>. Last accessed 9 June 2022.
- Cano, E., Musarella, C. M., Cano-Ortiz, A., Piñar Fuentes, J. C., Rodríguez Torres, A., Del Rio González, S., Pinto Gomes, C., Quinto-Canas, R., & Spampinato, G. (2019). Geobotanical study of the Microforests of *Juniperus oxycedrus* subsp. *badia* in the Central and Southern Iberian Peninsula. *Sustainability*, 11, 1111.
- Cano Ortiz, A., Spampinato, G., Piñar Fuentes, J. C., Pinto Gomes, C. J., Quinto-Canas, R., & Cano, E. (2021). Taxonomy, ecology and distribution of *Juniperus oxycedrus* L. Group in the Mediterranean Basin using bioclimatic, phytochemical and morphometric approaches, with special reference to the Iberian Peninsula. *Forests*, 12, 703.
- Casazza, G., Giordani, P., Benesperi, R., Foggi, B., Viciani, D., Filigheddu, R., Farris, E., Bagella, S., Pisanu, S., & Mariotti, M. (2014). Climate change hastens the urgency of conservation for range-restricted plant species in the central-northern Mediterranean region. *Biological Conservation*, 179, 129–138.
- Costa, R., Fraga, H., Fernandes, P. M., & Santos, J. A. (2017). Implications of future bioclimatic shifts on Portuguese forests. *Regional Environmental Change*, 17, 117–127.
- Fick, S., & Hijmans, R. (2017). WorldClim 2: New 1km spatial resolution climate surfaces for global land areas. *International Journal of Climatology*, 37(12), 4302–4315.
- Géhu, J., & Rivas-Martínez, S. (1981). Notions fondamentales de phytosociologie in Syntaxonomie. J. Cramer, Vaduz.
- Mawdsley, J., O'Malley, R., & Ojima, D. (2009). A review of climate-change adaptation strategies for wildlife management and biodiversity conservation. *Conservation Biology*, 23(5), 1080–1089.
- Maxent software for modeling species niches and distributions (Version 3.4.1), [http://biodiversityinformatics.amnh.org/open\\_source/maxent/](http://biodiversityinformatics.amnh.org/open_source/maxent/). Last accessed 09 June 2022.
- Orlikowska, E., Roberge, J., Blicharska, M., & Mikusiski, G. (2016). Gaps in ecological research on the world's largest internationally coordinated network of protected areas: A review of Natura 2000. *Biological Conservation*, 200, 216–227.
- Podani, J. (2006). Braun-Blanquet's legacy and data analysis in vegetation science. *Journal of Vegetation Science*, 17(1), 113–117.
- Thibaud, E., Petitpierre, B., Broennimann, O., Davison, A. C., & Guisan, A. (2014). Measuring the relative effect of factors affecting species distribution model predictions. *Methods in Ecology and Evolution*, 5, 947–955.
- Thomas, C., & Gillingham, P. (2015). The performance of protected areas for biodiversity under climate change. *Biological Journal of the Linnean Society*, 115, 718–730.
- Urban, M. (2015). Accelerating extinction risk from climate change. *Science*, 348(6234), 571–573.