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Climate Change Impacts and Extinction Risk Assessment of Nepeta Representatives (Lamiaceae) in Greece

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Abstract: The ongoing climate change has already left its imprint on species distributions, with rare, endemic species being more threatened. These changes are more prominent in regional biodiversity hotspots, such as Greece, which is already facing the short term impacts of human induced climate change. Greek flora hosts numerous endemic medicinal and aromatic plant taxa (MAPs), which are economically important and provide integral ecosystem services. The genus *Nepeta* is one of the largest Lamiaceae genera, containing several MAPs, yet, despite its taxonomical and economical significance, it remains vastly understudied in Greece. We explore the effects of climate change on the range of the Greek endemic *Nepeta* MAPs, via a species distribution models (SDMs) approach in an ensemble modeling framework, using soil, topographical and bioclimatic variables as predictors in three different time steps. By doing so, we attempt to estimate the current and future extinction risk of these taxa and to locate their current and future species richness hotspots in Greece. The taxa analyzed are expected to experience severe range retractions, with minor intraspecific variation across all time steps ($p > 0.05$), driven mainly by soil- and aridity-related variables. The extinction risk status of only one taxon is predicted to worsen in the future, while all other taxa will remain threatened. Current species richness hotspots are mainly located in southern Greece and are projected to shift both altitudinally and latitudinally over time ($p < 0.01$).

Keywords: biodiversity conservation; climate change; ecosystem services; extinction risk; GIS analysis; Greece; Mediterranean; range contraction; species distribution modelling

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1. Introduction

Habitat loss, degradation, fragmentation, and over exploitation were among the main factors driving species extinctions until two decades ago [1], while many studies have shown that climate change affects species physiology, distribution and phenology and could cause more extinctions, even in the absence of other threats (e.g., [2–4]). Approaches to extinction risk assessment have been widely studied and discussed [2,5–12]. Extinction risk assessment of species was also one of the main aims of Aichi Biodiversity Targets 2, 11 and 12 (CBD X/17). As these targets were not met in 2020 (e.g., [13–16]), as was planned, it is, thus, increasingly important to estimate climate change effects and extinction risk for genera with a high rate of endemism and that are of significant importance by providing ecosystem services (e.g., aromatic and pharmaceutical uses, genetic resources, importance for pollinators, traditional uses, as cultural services, etc.) [17–20]. Many studies use and assess species distribution models (SDMs), which are key tools for the prediction of species population responses to climate change and of habitat suitability under different climate change scenarios [21–26].

One of the key goals of the biodiversity protection agenda is the preservation of taxonomic, phylogenetic, and functional diversity, since this provides long term evolutionary potential for changing environmental conditions [20]. As extinction rates are increasing compared to the background extinction rate and biodiversity loss accelerates, it is imperative to understand how these declines will affect ecosystem functioning [27]. Extinction risk assessments, targeted especially at endemic and rare species, is critical for the effective conservation of high biodiversity areas [28]. Thus, such studies, performed at a regional level, are essential for species conservation and management planning purposes [28,29], since there might be considerable species' range changes in a relatively short time [30] and across different climate change scenarios, leading to different rates of species loss and turnover [2].

Greece, a regional biodiversity hotspot in the Mediterranean Basin, is already facing short term effects of climate change and studies dealing with the long term effects on endemic plant species distribution are necessary to layout conservation goals and measures [31–34]. An extinction risk assessment of the rich endemic flora of Greece [31] based on IUCN criteria and standards, provides the baseline for future conservation research and ecosystem services maintenance.

Greek flora is rich in aromatic and medicinal plant species (MAPs), many of them endemics, with economic importance. All MAPs, and especially the local endemics, should be considered as an important and unique part of the country's natural capital and should be integrated into local, regional, and national decisions and policy-making processes [17]. The genus *Nepeta* L. includes mainly MAPs and is one of the largest genera within the family of Lamiaceae [35,36]. It is rich in endemic taxa that are integral ecosystem services providers by supporting traditional practices, and by acting as the wild relatives of cultivated plants [17].

MAPs provide important ecosystem services through their economically important constituents and potential bioactivities, e.g., they contribute to modern human medicine and play a crucial role in its traditional practice [37]. The representatives of the genus *Nepeta* are widely used in traditional medicine for their antimicrobial, anticarcinogenic, analgesic, and many more properties [38]. As for most taxa of the Lamiaceae family, the medicinal properties of the *Nepeta* species are attributed to a high concentration of essential oils [39–46], as well as to a high concentration of nepetalactones, tannins, and minerals [27,47], thus justifying their healing importance [38,48–51]. That climate change impacts the populations of highly prioritized and economically important aromatic and medicinal plants is an issue, and includes decreases in the availability and productivity of medicinal plants, as well as in their phytochemical content, and, consequently, in the pharmaceutical properties of surviving populations (among others [21,37,52,53]).

Biosystematic studies concerning the taxa of the genus *Nepeta* in Greece are very limited [54,55], despite its high rate of endemism (almost 60%; [56]) rendering it a valuable genetic source. Among the *Nepeta* taxa present in Greece, two Greek endemics occurring at high altitudes in Crete and Evvia, namely, *Nepeta sphaciotica* P.H. Davis and *Nepeta argolica* subsp. *dirphya* (Boiss.) Strid and Tan, are included in Annexes II and IV of the Habitats Directive, with the former being a priority for protection species in the EU. The conservation status of their populations is being monitored, and this is extremely important, since the Cretan Mountain massifs and the mountains of Evvia island, which are renowned for their plant species richness and endemism, are considered as extinction risk hotspots in Greece [31,33,34].

In the framework of the ongoing Flora of Greece project, in a series of interconnected papers, we aim to investigate the morphological, phylogenetic, and ecological complexities of this taxonomically intriguing genus. Thus, the main aims of the current study focus on the ecological aspects of the genus *Nepeta* in Greece and, more specifically, are: (a) to investigate how climate change may alter the distribution of the endemic *Nepeta* representatives in Greece via an SDM approach, (b) to estimate the current and future extinction risk of these taxa based on the IUCN Criteria A and B, and (c) to locate the *Nepeta* species richness hotspots in Greece and investigate whether these hotspots might shift in the future.

2. Materials and Methods

2.1. Species Occurrence Data

Seventeen representatives of the genus *Nepeta* (Table S1) occur in Greece, ten of which are Greek endemics [56]. Regarding nomenclature, we followed [56]. We extracted occurrence data from the Flora Hellenica Database (Strid (~1.2 M occurrences; ongoing)). Duplicate data were removed and then we followed the protocols suggested by [57,58] regarding the spatial thinning of our occurrences. This procedure reduced our initial dataset to 239 records for seven Greek endemic taxa (Table S2), since any taxa that had less than 3 occurrences were discarded from any further analyses, following [59].

2.2. Environmental Data

We estimated baseline monthly climate data for 1981–2009 (as most of our occurrence data were collected post-1980) for our study area using altitudinal data extracted from WorldClim [60] at 30 arc-sec resolution, based on ClimateEU v4.63, as laid out in [61–63]. Afterward, we generated the standard 19 WorldClim bioclimatic variables, as well as 16 additional environmental variables using functions from the "dismo" 1.1.4 [64] and the "envirem" 2.2 [65] R packages, respectively. Finally, we generated five more abiotic (aspect, heat load index, slope, topographic position index and terrain ruggedness index) variables based on the altitudinal data derived from WorldClim and the functionality of the "raster" 2.6.7 [64] and the "spatialEco" 1.2-0 R packages [66].

We generated data for three time slices (i.e., 2020s, 2050s and 2080s) for three different (CCSM4, HadGEM2, and an ensemble of 15 global circulation models) global circulation models (GCMs) and two different Intergovernmental Panel on Climate Change scenarios from the representative concentration pathways family: RCP4.5 (mild scenario) and RCP8.5 (severe scenario), as described previously.

Twelve to twenty (depending on the taxon analyzed; Table S3) uncorrelated predictors (Spearman rank correlation < 0.7 and VIF < 10; [67]) were retained in our analyses after assessing multicollinearity via the "usdm" 1.1.18 R package [68], in order to minimize model overfitting.

2.3. Species Distribution Models

Since all the taxa we included in our analyses have a low occurrence/predictors ratio (<10:1) [69], we followed the modelling procedure suggested by [70–72] to model the realized climatic niche of our taxa, using the random forest (RF) algorithm with the "ecospat" 3.1 R package [73]. We used functions from the "ConR" 1.1.1 package [74] to calculate the background area of each taxon, based on the alpha hull method [75], as their exact distribution is imprecisely known in Greece. We created several sets of taxon-specific pseudo-absences, according to the suggestions of [76,77]. We split our data ten times into training and testing sets (80:20 ratio) and then we evaluated our models' performance using various metrics (AUC, AUC-PR, Brier score, Cohen's kappa, Continuous Boyce Index (CBI), Somer's D, TSS) [78–82] using functions from the "CalibratR" 0.1.2, "DescTools" 0.99.40, "ecospat" 3.2, "enmSdm" 0.5.3.2, "Metrics" 0.1.4, "MLmetrics" 1.1.1 and "modEvA" 2.0, R packages [83–89]. Finally, we compared our models against null models following [90].

We reconstructed the potentially suitable area of each taxon for every time slice using ensemble models [91], based on excellent calibrated ESM models (TSS $\geq$ 0.8). The TSS score of each ESM model was used as weight for each model's contribution to the ensemble projection.

The metric that maximizes the sum of sensitivity and specificity [92–94] was used to generate binomial presence/absence maps for each GCM, RCP and time slice combination. We also nullified the suitability of any cells that had non-zero values in the clamping mask, to be more conservative in our predictions [69].

The "BIOMOD_RangeSize" from the "biomod2" 3.3.7 R package [95] helped us assess the direction (contraction or expansion) and magnitude of the range shift of all the taxa included in our analyses. We did not assume that our taxa had unlimited dispersal capacity, since this would be unreasonable for their dispersion mode (their nutlets are rather large and not wind dispersed).

2.4. Identifying Biodiversity Hotspots

In order to locate the current and future biodiversity hotspots for Nepeta in Greece, we followed the same framework as the one in [34]. We defined L1 hotspots as the cells falling into the 1% quantile for species richness following [96,97]. We used functions from the "phyloregion" 1.0.4 R package [96–98] to locate the L1 hotspots. L1 hotspots, as herein outlined, come under the regional hotspots, according to [99].

2.5. Latitudinal and Altitudinal Shifts of the biodiversity Hotspots

We assessed, via Kruskal–Wallis (for equal medians) and Watson tests, if the distribution centroids of the L1 hotspots might experience a spatiotemporal and altitudinal shift using base R functions.

2.6. Future IUCN Extinction Risk Assessment

We assigned each taxon included in our analysis to a preliminary IUCN threat category according to the IUCN Criteria A and B under future conditions for every time slice, GCM and RCP combination, using the R code provided by [100] and the "ConR" 1.1.1 R package [74], following the framework presented by [100], as outlined and applied in Greece by [31]. We then compared their future with their current preliminary IUCN extinction risk status, as proposed by [31].

3. Results

3.1. Extent of Occurrence

The background area of each taxon (*Nepeta argolica* subsp. *argolica*, *Nepeta argolica* subsp. *dirphya*, *Nepeta argolica* subsp. *malacotrichos*, *Nepeta camphorata*, *Nepeta melissifolia*, *Nepeta orphanidea* and *Nepeta scordotis*) included in our analyses, based on the alpha hull method [75], is presented in Figure 1.

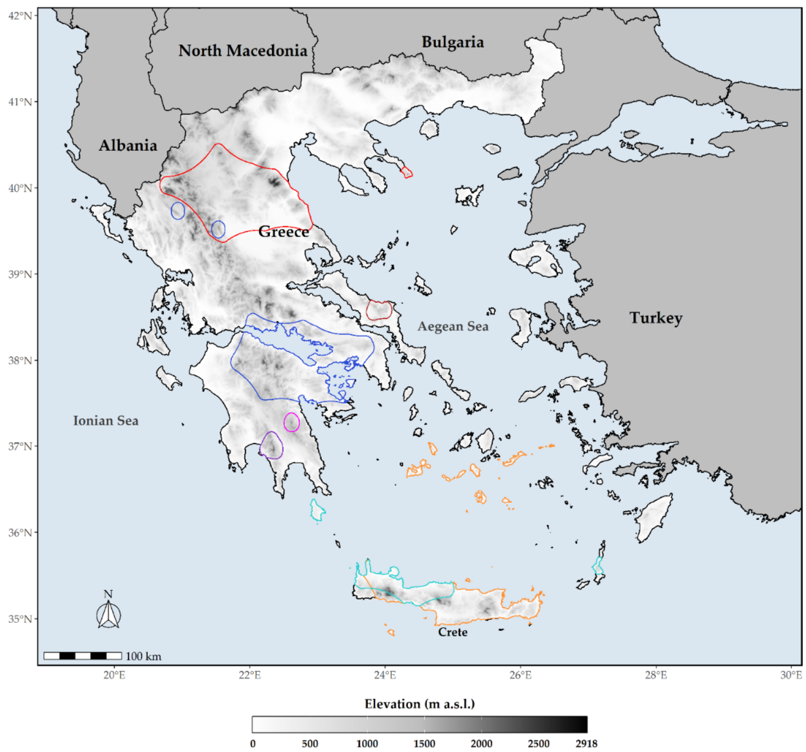

Figure 1. Extent of occurrence (EOO) of each taxon included in our analyses, estimated via the alpha hull method. Blue: *Nepeta argolica* subsp. *argolica*. Dark red: *Nepeta argolica* subsp. *dirphya*. Bright red: *Nepeta argolica* subsp. *malacotrichos*. Purple: *Nepeta camphorata*. Orange: *Nepeta melissifolia*. Magenta: *Nepeta orphanidea*. Turquoise: *Nepeta scordotis*.

3.2. Species Distribution Model Performance

All models performed very well and better than random at $p < 0.01$ (median AUC: 1.00 ± 0.00; AUC-PR: 0.94 ± 0.05; Brier score: 0.00 ± 0.00; CBI: 0.95 ± 0.08; Cohen's kappa: 1.00 ± 0.00; Somer's D: 1.00 ± 0.00; TSS: 1.00 ± 0.00; Figure 2; Table S4). Different soil and climate related variables drive the distribution of most of the taxa included in our analysis, with the sole exception of *Nepeta argolica* subsp. *Dirphya*, which is mainly affected by topographical variables (Tables S4 and S5). As there was virtually no variation regarding the future projections for all the representatives of the genus *Nepeta* we analyzed for each time slice, we focus on the CCSM4 RCP 8.5 combination for the 2080s hereafter (the trends are similar between GCMs/RCPs for each time slice and they are steadily deteriorating across the different time slices).

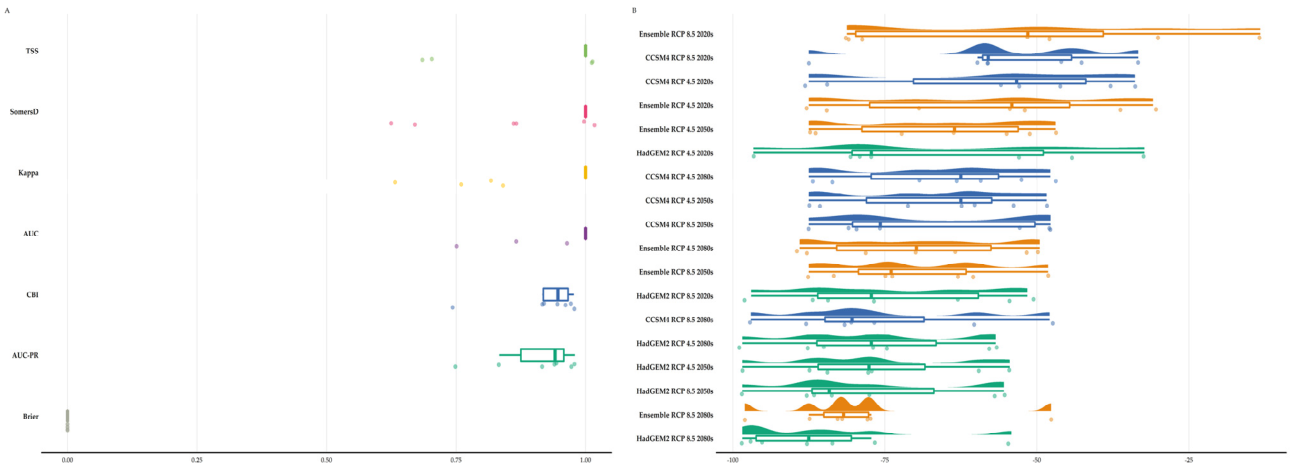

Figure 2. Raincloud plot of the (**A**) metrics to evaluate the models' performance for all the taxa included in our analyses and (**B**) projected proportion of area range loss for all the taxa included in our analyses under any global circulation model (GCM) and representative pathway concentration (RCP) combination for every time slice.

3.3. Habitat Suitability Range Change

All seven taxa are expected to experience severe range retractions, with minor intraspecific variation across all time slices and GCM/RCP combinations (Table S6; Figure 3), while the median range contraction was 74.85%. There is an evident temporal negative trend across all taxa, with *Nepeta scordotis* displaying the largest range contractions, irrespective of the time slice considered (Table S6). HadGEM2 and the ensemble GCM showed the highest and lowest mean range contractions, respectively, for any time slice and RCP combination (Table S6; Figure 3).

3.4. Species Richness Hotspots

The areas surrounding Mt. Avgo and the coasts of Rethymno in Crete currently display the highest SR (Figure 4). Regarding the future projections, in all cases, SR is predicted to be highest in the northern coasts of Crete (Figure 4). Current SR L1 hotspots occur in Crete, Kythira, northern Peloponnese, and in the northern mainland, while future SR L1 hotspots are projected to occur in roughly the same areas, with the northern mainland being the only L1 hotspot in the 2080s (Figure 5).

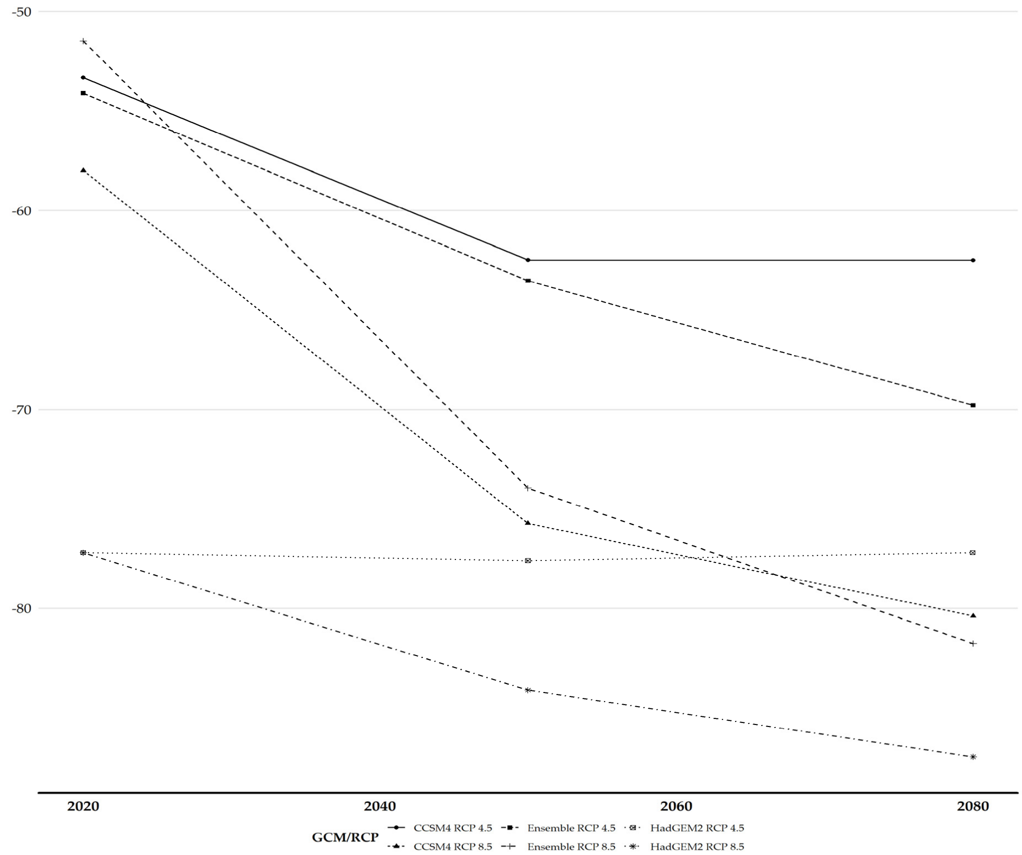

Figure 3. Temporal trend of the median range loss for each global circulation model (GCM) and representative concentration pathway (RCP) combination for all the taxa included in our analysis.

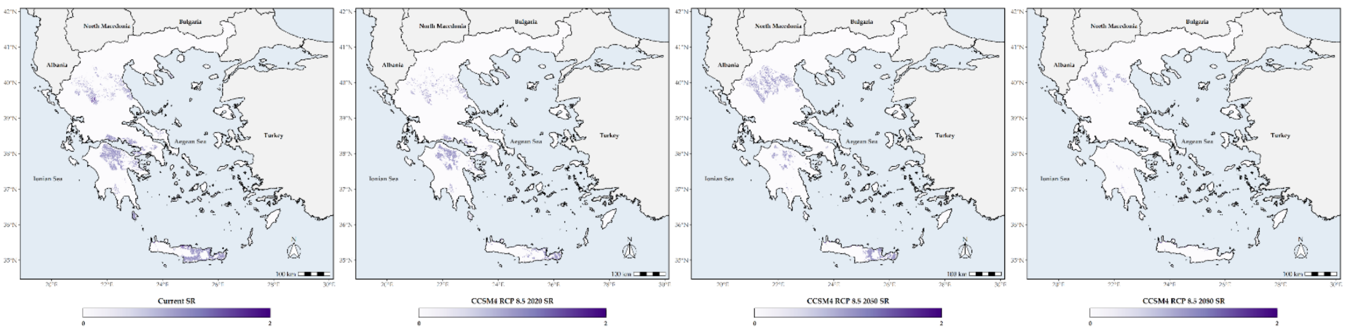

Figure 4. From left to right: current *Nepeta* species richness (SR) and future SR for the 2020s, 2050s and 2080s based on the CCSM4 8.5 GCM/RCP combination, respectively.

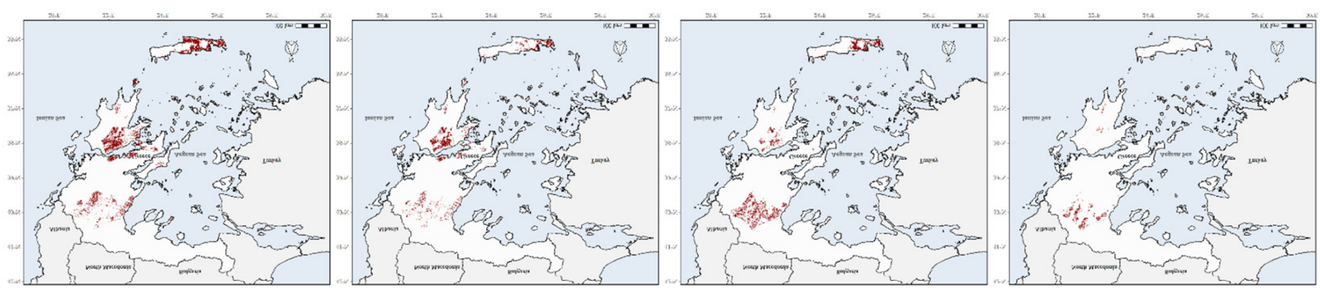

Figure 5. From left to right: L1 (top 1%) species richness hotspots (red cells) for the current and future species richness for the 2020s, 2050s and 2080s based on the CCSM4 8.5 GCM/RCP combination, respectively.

3.5. Altitudinal and Latitudinal Shifts

We detected statistically significant latitudinal shifts regarding the time slices' L1 species richness centroids, which were predicted to move northwards in most circumstances (Watson tests with p-values < 0.01 at α = 0.05; Figure 6). The mean altitude for the L1 hotspots is statistically significantly different between all-time slices and GCMs/RCPs (Kruskal–Wallis ANOVA: H = 157,663, d.f. = 198,315, p < 0.001), with current hotspots occurring in lower altitudes (Table S7).

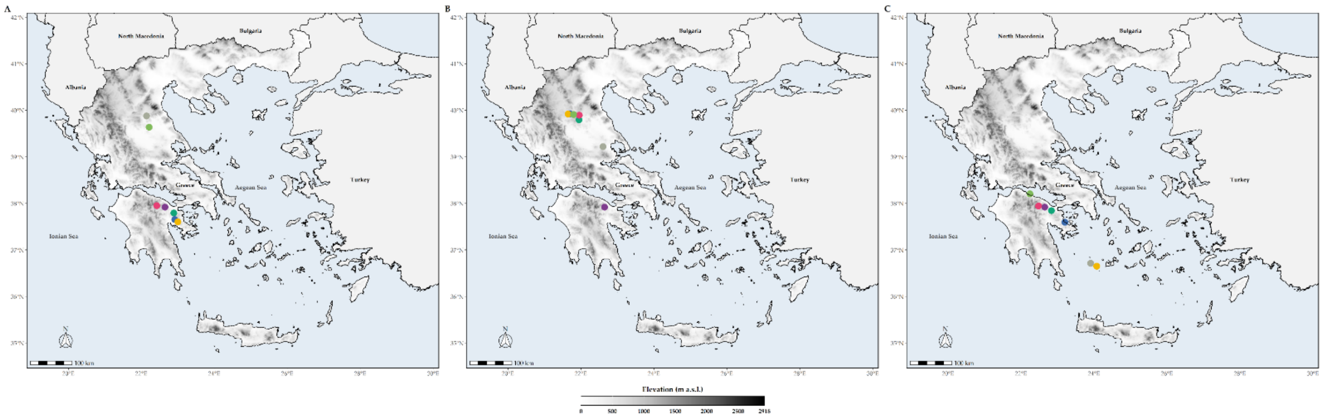

Figure 6. Distributional centroids for the L1 species richness hotspots. Colored circles represent the distributional centroids of the current (purple), the 2020s RCP 4.5 (dark green), the 2050s RCP 4.5 (blue), the 2080s RCP 4.5 (yellow), the 2020s RCP 8.5 (pink), the 2050s RCP 8.5 (olive green) and the 2080s RCP 8.5 (grey) time period. Left to right: CCSM4, Ensemble and HadGEM2 Global Circulation Model, respectively.

3.6. IUCN Extinction Risk Assessment

All taxa included in our analyses are projected to fall under one of the IUCN threat categories based on both Criteria A and B (Table S8; Figure 7). The taxa characterized as critically endangered by [31] will still be threatened, according to our predictions, but they seem to be able to fare better in the future (Table S8). The extinction risk status of only one taxon, namely, *Nepeta scordotis*, is predicted to worsen in the future, switching to an IUCN threat category and becoming endangered, while the rest of the taxa are projected to stay under the same IUCN threat category as the one reported by [31] (Table S8).

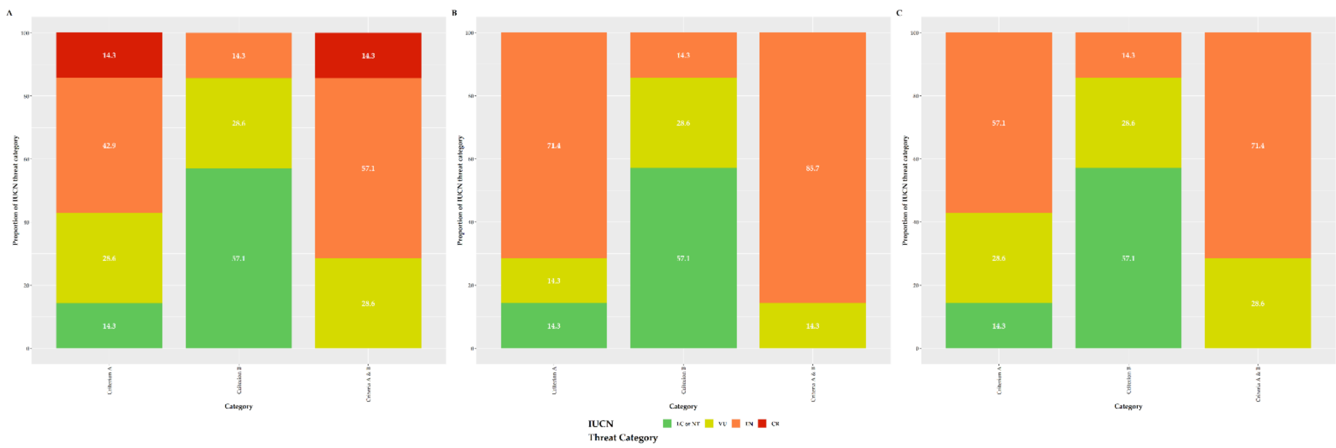

Figure 7. Proportion of the *Nepeta* taxa included in our analysis under the IUCN threat categories for the (**A**) 2020s, (**B**) 2050s and (**C**) 2080s under the CCSM4 RCP 8.5 combination conditions according to both criterion A and B.

4. Discussion

Climate change (11.1–11.3 and 11.5 types of the IUCN threat classification scheme) may alter environmental conditions, thus affecting the distribution of MAPs, causing their shift to more climatically suitable and newly appropriate habitats. This might translate to financial issues when local rural communities' MAPs, or other economically important plants, are lost from locally accessible lands [21,37]. The conservation of MAPs considered as flagship species on a local scale can raise public interest and result in the protection of biodiversity and its sustainable management in combination with socioeconomic and cultural values [101]. Concerning the taxa of the genus of *Nepeta,* they have, as a large number of endemic MAPs, a particular economic and cultural importance [17], and an assessment of their extinction risk is important not only for conservation management [34], but also for the extensive spectrum of ecosystem services they provide (or potentially provide). Management plans must try to ensure the greatest resources for today and preserve the potential for the future [102].

Several environmental parameters (e.g., soil characteristics, topography, and land-use change)—apart from climate related variables and biotic interactions—seem to drive the future potential distribution of species [103], with temperature and precipitation largely dictating the species' latitudinal and longitudinal distribution, respectively [104]. Regarding MAPs, soil nutrient availability, enzymatic activity, temperature, and precipitation [21,105–107] seem to be the most critical factors shaping their distribution, as well as their concentration of secondary metabolites [102,108]. This means that MAPs with different functional traits and environmental demands might need different conservation approaches, as their responses to future climate change will largely depend on their physiological or phenological characteristics [109,110]. The present study of the effects of climate change on the range of the Greek endemic *Nepeta* MAPs, using soil, topographical and bioclimatic variables as predictors in three different time steps, showed that Greek MAPs—at least the ones we analyze here—might not be an exception to this rule. The distribution of the majority of the Greek endemic *Nepeta* species is mainly driven by soil and topographical variables, while water availability seems to be crucial for the occurrence of only three species *N. malacotrichos*, *N. camphorata*, and *N. melissifolia*; Tables S4 and S5). Hence, these species might be less affected by climate related threats compared to other Greek endemics or rare species occurring in Greece [32,33,111–115]. Nevertheless, future climate change will have a profound impact on the species' potential distribution, with these effects becoming more prominent over time (Table S6; Figures 2 and 3).

Over collection (harvesting in the wild) might be a more serious threat in the near future (5.2.1 type of the IUCN threat classification scheme) and quite possibly also land use change, since overharvesting for local to global consumer markets is a particular threat when combined with climate change [37,116]. For instance, alongside climate change impacts, extensively collecting MAPs or the long history of land use disturbances and grazing have been indicated as drivers for local extinctions of *Nepeta* species [117]. Intensive harvesting of wild populations should be restricted, and vulnerable, endemic medicinal and aromatic plants should be protected by improving the harvesting and drying of MAPs [102]. Climate change and other threats to medicinal plants, such as farmland expansion, fire, and intensive grazing, are certainly going to interact and will probably have devastating impacts on vulnerable MAP taxa [37,116], such as the ones we analyze here. These impacts will most probably be exacerbated by habitat fragmentation, which tends to reduce genetic diversity [118,119]. This phenomenon is more prominent in endangered, locally rare, endemic species [120], such as the ones we investigate here. Habitat fragmentation, together with the intensifying land use change, will most probably pose an even more serious threat to the representatives of the genus *Nepeta* in the short-term future in Greece, compared to climate change, which will test their resilience and could push their populations beyond their tipping point, as it seems that it has already done for other, highly threatened Greek endemics [114] or elsewhere [121]. That is why our research team has already collected specimens from the Greek endemic *Nepeta* taxa, in order to examine their genetic diversity as a next step, which is crucial for their conservation and their detailed and holistic, extinction risk assessment.

Moreover, species range shifts are critical for the future conservation status of all species [122,123]. Concerning the Greek *Nepeta* taxa, all will still be threatened in the near future and only *Nepeta scordotis* will probably need to be moved to a higher IUCN threat category than the one currently standing (Table S8; Figure 7). This is another indication of the fact that these species are not significantly affected by the anticipated rapid climate change, since the IUCN criteria that we used in our analysis are mostly based on area range changes and we have not taken into consideration any land use changes, which are bound to intensify in the future in Greece [124,125]. We have to note, however, that this might also be due to the fact that Kougioumoutzis et al. [31] estimated the extinction risk status of these taxa based on their actual occurrences, while, in our case, this was based on their potential occurrence points. All in all, our IUCN predictions should be considered conservative, supporting future surveys and not a reason for complacency regarding their protection.

The assessment of habitat suitability can provide valuable information in order to develop conservation strategies to prevent negative trends in the future [107]. Even if an MAP taxon is predicted to slightly improve its local protection status due to the increased proportion of its distribution area, it is very important to improve its protection status at in situ and ex situ repositories considering, in combination with the climate change influence, future socioeconomic impacts and manmade land use changes [126]. Moreover, even if climate change does not affect a given MAP species' range, it may affect its productivity or chemical composition [37]. However, clearly defined steps and processes should be taken into account in order to find rational solution(s) for each conservation need, with respect to the target species, its habitat and its uses; Battisti [127] provides a conceptual flowchart on the decision-making process for conservation projects, which can be useful for MAP species protection and the amelioration of their conservation status and trends.

Species richness hotspots for the Greek *Nepeta* taxa we analyzed are currently located in the northern parts of the Greek mainland, as well as those of Peloponnese and Crete, and are mainly found in lower altitudes than the ones that will occur in any future time period (Table S7; Figures 4–6). The altitudes where the L1 SR hotspots are currently located are characterized by moderate to high agricultural and tourism activity. The L1 SR hotspots will also shift latitudinally (Figure 6), as they are projected to move northwards over time. Species that are predicted to become critically endangered in the future should be prioritized in conservation planning, since this will also ensure their provision of ecosystem services at local, regional, and global levels [128].

Concluding, according to the results of the present study: (a) the taxa of the genus *Nepeta* in Greece are predicted to experience severe range retractions, with minor intraspecific variation across all time steps, determined mainly by soil and topographical variables, while aridity related variables seem to be crucial for the occurrence of only three of these taxa; (b) current *Nepeta* species richness hotspots mainly located in northern and southern Greece are projected to shift both altitudinally and latitudinally over time; and (c) one of the taxa is expected to present a worse extinction risk status in the future, while all other taxa will present the same extinction risk and remain threatened.

It is essential to disseminate the IUCN extinction risk status of Greek endemic taxa—even if preliminary—including MAPs, since it is considered a reliable source of information for in depth conservation assessments and to appropriately assign conservation funds in Greece to conservation and protection actions [31].

Biodiversity hotspots, endemism centers, and priority hotspots in Greece, as identified by Kougioumoutzis et al. [34], are fundamental for the nationally designed, holistic approaches of conservation management and strategic rural planning. In addition, MAPs and, in particular, endemics with restricted geographical distribution, constitute an important and unique part of the country's natural capital, while accounts of their properties and related ecosystem services should be developed [17] under the perspective of future projections. In this way, the information provided by the present study should be considered for integration in policy-making processes in order to: (a) sustainably exploit MAPs and their habitats that occur in zones of special interest, (b) ameliorate ecosystem based conservation management, and (c) support nature based solutions, aiming to support no net loss or, if possible, the net gain of their population, condition and extent, under current and future conditions.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su14074269/s1, Table S1: The representatives of the genus Nepeta that are found in Greece. Table S2: The Greek endemic representatives of the genus Nepeta that were included in our analyses. Table S3: The uncorrelated predictor variables used in the main analyses for each taxon, along with their abbreviations. Table S4: Evaluation of models' predictive performance via several discrimination (AUC, AUC-PR, TSS) and calibration (Brier score, Cohen's kappa, Continuous Boyce Index (CBI), Somer's D) metrics based on a repeated (10 times) split-sampling (calibration data: 80%; evaluation data: 20%) approach. The abbreviations of the predictor variables are as in Table S2. EOO: extent of occurrence (in sq. km). Table S5: Variable importance for each of the representatives of the genus Nepeta that are found in Greece and included in our analyses. The abbreviations of the predictor variables are as in Table S3. Table S6: Proportion of potential area loss for each of the representatives of the genus Nepeta that are found in Greece and included in our analyses for every time period and climate change model/scenario. GCM: global circulation model. RCP: representative concentration pathway. Table S7: Median, mean, minimal and maximal altitude (in m) for species richness (SR) hotspots. L1 SR hotspots are delineated as the cells belonging to the 1% quantile for each metric for each GCM/RCP and time period combination. GCM: global circulation model. IQR: interquartile range. LGM: last glacial maximum. RCP: representative concentration pathway. SD: standard deviation. Table S8: The representatives of the genus Nepeta that are found in Greece and included in our analyses, along with information on each taxon's extinction risk status for both IUCN Criteria A and B for every GCM/RCP and time period combination. ERA: extinction risk based on the IUCN Criterion A. ERB: extinction risk based on the IUCN Criterion B. ERAB: extinction risk based on both the IUCN Criteria A and B. GCM: global circulation model. RCP: representative concentration pathway. Current extinction risk status is based on Kougioumoutzis et al. (2021).

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