Biological Conservation 179 (2014) 129–138

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Climate change hastens the urgency of conservation for range-restricted plant species in the central-northern Mediterranean region

Casazza Gabriele [a,*], Giordani Paolo [a], Benesperi Renato [b], Foggi Bruno [b], Viciani Daniele [b], Filigheddu Rossella [c], Farris Emmanuele [c], Bagella Simonetta [c], Pisanu Stefania [c], Mariotti Mauro Giorgio [a]

[a] DISTAV, Polo Botanico Hanbury, Università degli Studi di Genova, C.so Dogali 1M, I-16136 Genova, Italy
[b] Department of Biology, University of Florence, Via La Pira 4, I-50121 Firenze, Italy
[c] Department of Science for Nature and Environmental Resources, University of Sassari, Via Piandanna 4, I-07100 Sassari, Italy

ARTICLE INFO

Article history:
Received 22 January 2014
Received in revised form 4 September 2014
Accepted 10 September 2014

Keywords:
Distribution models
Extinction risk
Projected threat
Rare species

ABSTRACT

With the consensus that human activities are leading to dangerous interference in Earth's climate, there has been growing policy pressure for clear quantification and attribution of the resulting biological impacts. Despite the exceptional diversity in the Mediterranean biome, largely due to the number of rare and endemic plant species, the effect of future climate change on present Mediterranean plant species has only been examined in a few studies. In this study we presented an analysis of the potential effects of climate change on 22 plant species whose range is restricted to central-northern Mediterranean region. We used species distribution modelling to test whether projected climate change may affect the current suitability of species' habitat; to evaluate possible future threats due to climate change; and to test any relationship between extinction risk and ecological and life-history predictors. The studied species were predicted to lose some 50% of their current range by 2020. Similarly, the probability of occurrence in known localities was predicted to drop drastically by 2020. Our results support a relationship between biological characteristics and range contractions. Although the Mediterranean species were projected to lose a lower amount of habitat than Alpine ones, species with restricted geographic range seem to be more prone to climate change effects than widespread ones. Our results emphasize the need for immediate monitoring and conservation actions and suggest that rare species might be useful for monitoring the conservation status of habitat in relationship to the effects of global warming in the Mediterranean region.

1. Introduction

Anthropogenic emissions of greenhouse gases have committed the Earth to warmer global temperatures and associated changes in the climate system through the 21st century (Meehl et al., 2007). With the consensus that human activities are leading to dangerous interference in Earth's climate (Rockström et al., 2009), there has been growing policy pressure for clear quantification and attribution of the resulting biological impacts. Species extinction is a natural process and would occur also without human actions. However, biodiversity loss, including species extinction, has accelerated massively (Rockström et al., 2009; Bellard et al., 2012) in the Anthropocene era (*sensu* Crutzen and Stoermer, 2000). For example, one prominent analysis predicted that 15–37% of species would be endangered or extinct by 2050 depending on the biome (Thomas et al., 2004). Another global analysis of future climatic range change of common and widespread species predicts more than 50% loss of present climatic range by 2080 without mitigation for 57% of plant species (Warren et al., 2013). Scientists have been able to deduce a background extinction rate before the influence of man on other species existence (Edenic Period, 545 Ma–50 ka), a useful point of comparison for use by conservation biologists. According to Hogan (2010) the present rate of extinctions induced by humans appears to be running at approximately 10,000 times the background rate and is likely to be accelerating.

Predictions play therefore an important role in alerting scientists and decision makers to potential future risks, provide a means to bolster attribution of biological changes to climate change and can support the development of proactive strategies to reduce climate change impacts on biodiversity (Pereira et al., 2010; Parmesan et al., 2011). Even though estimating the future potential range of species does not address the direct causes of species extinction, a substantial reduction in the potential distribution of

* Corresponding author.

http://dx.doi.org/10.1016/j.biocon.2014.09.015
0006-3207/

a species is likely to lead to an increased risk of local extinction (Thomas et al., 2004; Thuiller et al., 2005a).

Rare and/or narrow-ranged species are the ones raising the highest concern in the scientific community and in the institutional framework responsible for addressing conservation targets and measuring success towards ambitious conservation goals. Mouillot et al. (2013) showed that rare species are not functionally redundant within ecosystems, but instead, they possess unique traits that might have disproportionate ecosystem-level effects if they went extinct.

It is generally believed that the risk of extinction under climate change strongly corresponds to the inability of species to shift with suitable habitat (Engler et al., 2009; Ozinga et al., 2009). However, the velocity of the predicted climate change is very likely to exceed the migration capability of many range-restricted species (Pearson, 2006), particularly because these species are often habitat specialists and weak dispersers. Moreover, the risk of species extinction might be increased by additional drivers. Indeed, other components of global change, such as habitat fragmentation, pollution, overexploitation and biological invasions, have all been documented as major additional threats for the future of biodiversity, with possible synergies, or reinforcing feedbacks among the different components.

Recent studies (Médail and Verlaque, 1997; Casazza et al., 2005, 2008; Casazza and Minuto, 2009; Trigas et al., 2013) reported interesting results concerning the distribution pattern of Mediterranean endemic plant species and how it can be explained. In the Mediterranean, climate models forecasted the decrease of cold days, the increase of warm days and the increase of frequency and intensity of drought (IPCC, 2013, 2014). However, the effect of future climate change on Mediterranean plant species has been examined in a few studies, mainly on woody species, whereas information on rare herbaceous plants is lacking. The high biodiversity of the Mediterranean basin is primarily due to particular climatic conditions, habitat heterogeneity as a result of paleogeographical and historical factors, and different origins of the flora itself (Quézel, 1985, 1995; Thompson, 2005).

In our study, we present an analysis of the potential effects of climate change on plant species with a range restricted to central-northern Mediterranean region. In particular, our questions are: Will projected climate change affect the current suitability of range restricted species habitat? To what extent will range restricted species be threatened by climate change in the future? Are there predictors related to the extinction risk of range restricted species?

2. Material and methods

2.1. Study area

The area involved in this study (Fig. 1) is in the central-northern part of the Mediterranean basin and comprises mountain (up to 2700 m a.s.l.) and coastal parts of Maritime and Ligurian Alps, northern Apennines, Tyrrhenian Islands of Corsica, Sardinia and Tuscan archipelago. Most of the study area has a Mediterranean climate, ranging from thermo- to oromediterranean. The highest altitude sectors of the area are characterised by a temperate climate (*sensu* Rivas-Martínez et al., 2011). The geology is quite complex, owing to the many lithological typologies recorded in the study area (sedimentary rocks, siliceous outcrops and ultramafic rocks). The number of taxa with range restricted to the study area was estimated in approximately 450, including intra-specific ranks, apomictic species, and agamospecies (Médail and Quezel, 1997; Casazza et al., 2005; Bacchetta et al., 2012).

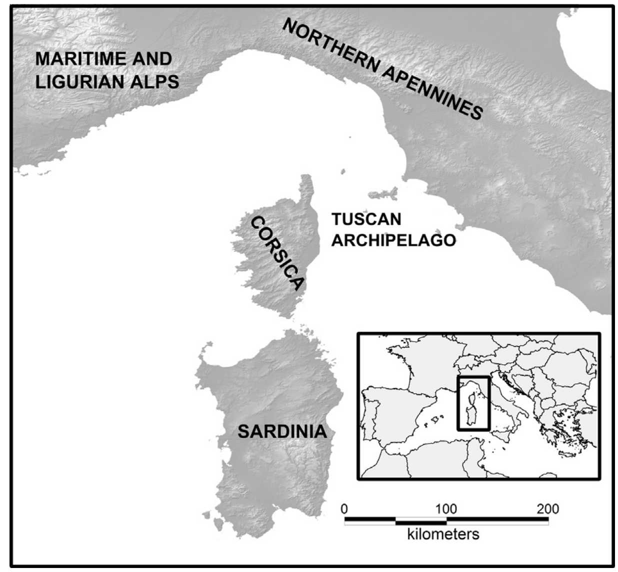

Fig. 1. Map of the study area reporting the main geographical place names.

2.2. Species and occurrence data

To assess the potential impact of climate change in the central-northern Mediterranean region, twenty-two species were selected (Table 1). Specifically, these species were selected on the basis of data availability within the whole species distribution range and considering different ecological and life-history traits. Species occurrence data were obtained from literature (Arrigoni et al., 1977–1991; Jeanmonod et al., 1986; Jeanmonod and Burdet, 1988, 1989a,b, 1990; Jeanmonod and Gamisans, 1992; Valsecchi, 1993; Jeanmonod and Burdet 1994, 1996, 1997; Bagella and Caria, 2013), from Herbaria vouchers (FI, GE and SS) and from a network of local databases of georeferenced occurrence data: ReNaTO (Regione Toscana; http://www.regione.toscana.it/-/repertorio-naturalistico-toscano-re-na-to-), FloTo (Department of Biology, University of Florence), Sira (Regione Sardegna), LiBiOss (Regione Liguria; http://www.cartografiarl.regione.liguria.it/SiraWebGis/), and the Global Biodiversity Information Facility (GBIF; http://data.gbif.org), all last accessed in 2013. We removed occurrence records exactly matching using ENMTools (Warren et al., 2010; see also Warren and Seifert, 2011). Overall, a final data set of 1228 presence records, ranging from 15 to 148 occurrences per species, was applied in species distribution model (SDM) analysis.

2.3. Environmental predictors

Nineteen bioclimatic variables representative of the period 1950–2000 were downloaded from the WorldClim database website (http://www.worldclim.org) at 30-s (c. 1 km) spatial resolution (Hijmans et al., 2005). To reduce the multicollinearity between predictors, in order to minimize model overfitting, we performed a pairwise Pearson correlation between bioclimatic predictors, and we retained predictors that showed a high relative contribution to the SDMs and were not highly correlated ($r \leqslant |0.70|$). Six variables were retained for the analyses: BIO3 – Isothermality (mean diurnal range divided by annual range of temperature), BIO4 – Temperature Seasonality, BIO8 – Mean Temperature of Wettest Quarter, BIO9 – Mean Temperature of Driest Quarter, BIO13 – Precipitation of Wettest Month, BIO15 – Precipitation Seasonality.