Journal for Nature Conservation 51 (2019) 125736

Contents lists available at ScienceDirect

Journal for Nature Conservation

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

Exploring vulnerability of listed Mediterranean plants in relation to risks of population loss

Perrine Gauthier*, Cyril Bernard, John D. Thompson

CEFE UMR 5175, CNRS, 1919, Route de Mende, 34293 Montpellier Cedex 5, France

ARTICLE INFO

Keywords:
Rarity
Urbanisation
Fragmentation
Protection
Spatial conservation planning

ABSTRACT

In this paper, we propose a method to assess population numbers and quantify their vulnerability for listed plant species. For six study species, the spatial aggregation of point data allowed us to identify the numbers of populations for each species and thus how they differ in regional abundance. We assessed vulnerability by according a score to each population in relation to three criteria: (i) land-use (urbanisation, agriculture and natural areas), (ii) fragmentation of populations by infrastructures and (iii) protected status of populations. As a result of the combination and scoring of populations across the three criteria, only 9% have a low extinction risk and 73% are in one of the three classes of high vulnerability with 16% in the highest category. Finally, 29 of 32 populations monitored in a separate study are in one of the three highest categories of vulnerability. This study illustrates how information on population numbers of listed species at the regional scale brings to the fore their generalised vulnerability to threats in the Mediterranean landscape. This information is vital for conservation management staff to develop a strategy and appropriate actions for listed species' protection.

1. Introduction

Multiple threats to biodiversity have been identified as the human footprint on ecosystems across the World increases. A major task in conservation science has thus become the identification of the vulnerability of natural areas and species to increasing threats.

The notion of vulnerability integrates three main dimensions: exposure to threats, sensitivity to threats and the resilience or adaptability of ecological systems or human activities to the threats (Wilson et al., 2005). Vulnerability can be integrated into spatial conservation planning by assessing threats to particular habitat types and their connectivity (Pressey & Taffs, 2001; Rouget, Richardson, Cowling, Lloyd, & Lombard, 2003; Rouget, Cowling, Lombard, Knight, & Kerley, 2006; Vimal et al., 2012) or by quantifying the vulnerability of rare or endangered species (Abbitt, Scott, & Wilcove, 2000; Amat, Vargas, & Gómez, 2013; Gauthier, Foulon, Jupille, & Thompson, 2013). A comprehensive estimation of these threats is a difficult task; a complex array of factors are involved, making it necessary to adopt an approach based on multiple threat criteria (Noss, Carroll, Vance-Borland, & Wuerthner, 2002). The risk of impact is essentially due to the landscape context in which populations occur (Vimal et al., 2012). This risk concerns three main threats: the fragmentation of natural populations (reduced spatial extent, increased distance among populations and the occurrence of artificial barriers), a general risk associated with the amount of transformed land in the surrounding landscape (urbanisation, infrastructures, commercial and tourist activities) and the absence of a protected status.

In the Mediterranean region, urbanisation is a major component of threats to biodiversity (Underwood, Viers, Klausmeyer, Cox, & Shaw, 2009; Vimal et al., 2012). All five Mediterranean Type Ecosystems have recently witnessed increasing human population size by >10% in the period 1990–2000 and in the Mediterranean Basin the percentage area touched by urbanisation has increased by 17%, i.e. markedly more than the four other regions where urbanisation has not increased by more than 11% and has generally increased by around 8% (Underwood et al., 2009). It has thus become essential to quantify the direct impacts of human activities on natural populations and the ever-increasing threat to populations associated with urbanisation in the surrounding landscape. In a previous study of different populations of *Allium chamaemoly* in the Mediterranean region of the South of France, the combination of factors directly impacting population trends (meteorological events and direct human disturbance) with surrounding indirect threats due to fragmentation and human presence provides insights into the vulnerability and conservation status (Gauthier, Pons, Letourneau, Papuga, & Thompson, 2017).

The objective of this study is to develop a method to combine land-

* Corresponding author.
E-mail address: perrine.gauthier@cefe.cnrs.fr (P. Gauthier).

https://doi.org/10.1016/j.jnc.2019.125736
Received 26 March 2019; Received in revised form 18 July 2019; Accepted 20 August 2019

use criteria into an assessment of population level vulnerability for species listed for protection in Mediterranean France. It complements a separate study of 32 populations of six listed species across the same study region where we have shown that vulnerability is due to the occurrence of extreme meteorological events and direct human disturbance within populations (Gauthier et al., unpublished ms). To do so we first quantified the numbers of populations of each species across the study region using point data in a large botanical database. Second, we mapped the spatial area of populations of each species against maps of land-use (urbanisation, agriculture and semi-natural areas), the presence of major infrastructures that cause fragmentation and the network of protected areas. Finally, we scored each population relative to the above three criteria and used the scores to develop a decision tool to quantify the relative vulnerability of all populations of each species in five categories.

2. Material and methods

2.1. Study species

To assess overall vulnerability of rare plant populations and their surrounding areas we studied six species. To encompass the range of typical species in open, lowland habitats close to the Mediterranean coast, we chose six species that are listed for protection in France (under decrees of 01/20/1982 and 08/31/1995 that fixed the list of species for protection in France). In the South of France these species all occur at the northern limits of their Mediterranean distribution and, with the exception of *Allium chamaemoly,* are all rare in the study region but to different degrees. The six species were chosen to cover a range of different life histories with two different annuals (grass and herb) and four very different perennial growth forms (Table 1). In addition they have all been subject to a monitoring study that assesses direct disturbance in a total of 32 populations (Gauthier et al., unpublished ms).

2.2. Population numbers and locations

The "*SILENE*" database (http://flore.silene.eu) established and maintained by the Conservatoire Botanique National Méditerranéen de Porquerolles contains (January 2017) between 119 and 3,110 data points for the occurrence of each of the six species in Mediterranean France. However, because many sites were visited on repeated occasions and often by different people (as revealed by the dates and observer identity in the database for each point), many of the points represent repeated observations within individual populations. In order to delimit populations, we considered that two points with a distance of at least 500 m (for annual species) or 1 km (for perennial species) between them are part of different populations if there are no other points between them (in a similar way as done by Gauthier et al., 2017). We thus aggregated points that occur at lower distances into populations. To do so we used QGIS 2.18 (QGIS development Team, 2017) and the 'Kernel Density Estimation' SAGA function, with respectively a 250 m or 500 m search radius. Using the raster grid created with the Kernel Density function, we generated polygons from pixels with density > 0. This method delimited populations with a surrounding zone that encompassed an additional distance equivalent to a little less than half the distance used to discriminate populations. Hence, the area we identified is that of the extent of occurrence plus a part of the surrounding territory that cannot overlap with that of another population. In this way, we were able to map and identify from 14 to 131 populations for the six species in the two regions of Mediterranean France west and east of the Rhône valley (Table 1, Fig. 1). One species only occurs west of the Rhône, one species only occurs east of the Rhône (except one population) and the four other species have populations in both areas in varying proportions. In the rest of the methods and results sections the combined surface of the population occurrence (based on the point data) with its surrounding zone is used in the estimation of population

Table 1
The initial number of points in the original date base, the distance used to distinguish populations and the resulting number of populations and the life history and broad habitat type occupied by each of the study species.

	Initial point numbers	Scale for point clusters (km)	Number of populations	Life history	Broad habitat
Stipellula capensis (Thunb.) Röser & H.R.Hamasha	191	0,5	29	Annual	Thermophilous grassland, garrigues
Ononis mitissima L.	2,196	0,5	53	Annual	Garrigues, pastures, old fields
Convolvulus lineatus L.	1,267	1	131	Clonal perennial	Garrigues, rocky pastures, old fields
Helianthemum marifolium Mill.	3,110	1	43	Woody perennial	Garrigues, path edges
Allium chamaemoly L.	1,485	1	116	Geophyte	Garrigues, rocky pastures
Astragalus glaux L.	119	1	14	Herbaceous perennial	Garrigues, rocky pastures, old fields

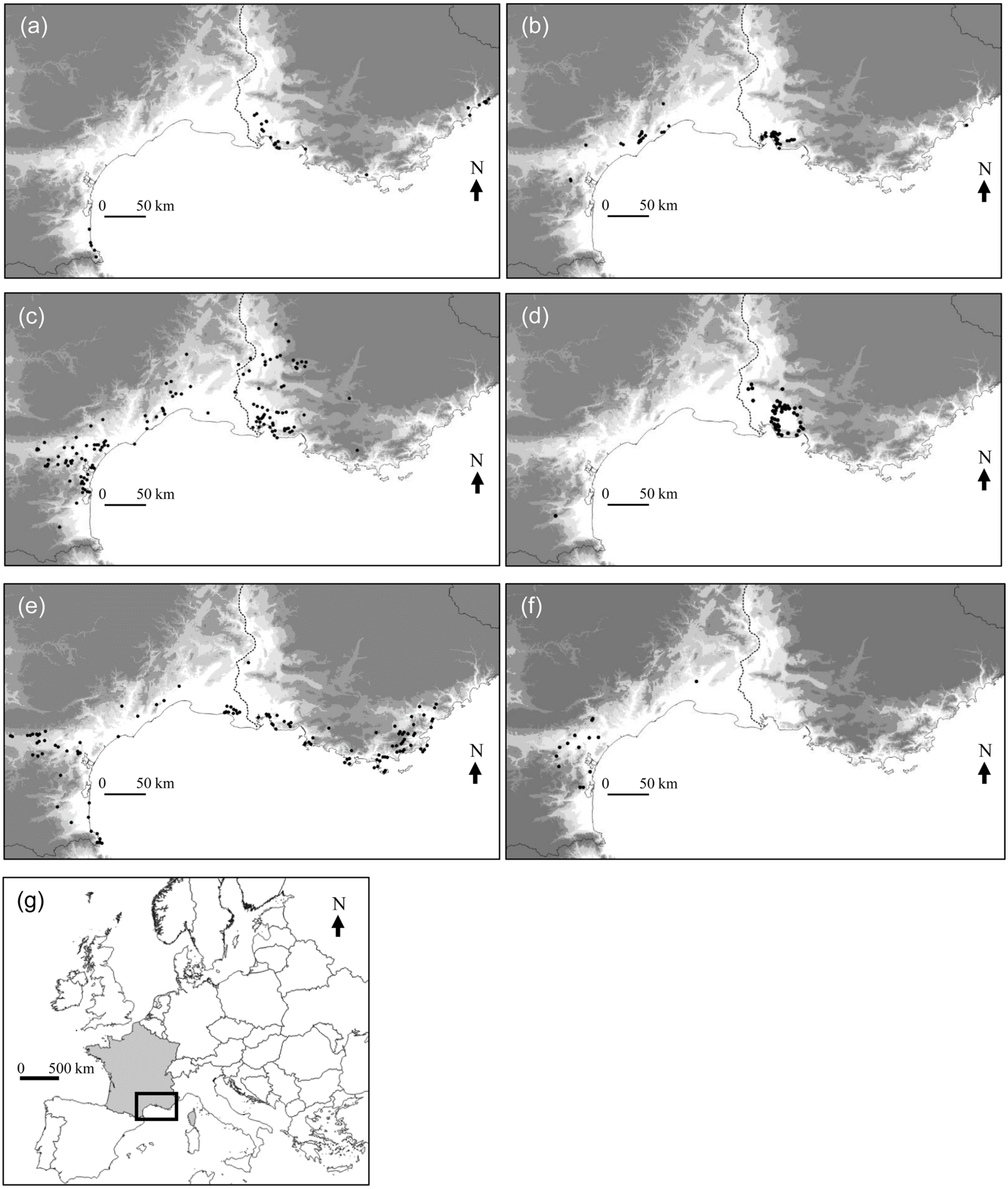

Fig. 1. The distribution of populations of the six study species in Mediterranean France: (a) *Stipellula capensis*, (b) *Ononis mitissima*, (c) *Convolvulus lineatus*, (d) *Helianthemum marifolium*, (e) *Allium chamaemoly* and (f) *Astragalus glaux*, and location of the study area; in France (in Grey) and Europe (g) The Rhône valley separates the two administrative and biogeographic regions of Mediterranean France and is shown by a dashed line.

vulnerability in relation to human activities.

2.3. Landscape vulnerability

In order to estimate the risk of extinction due to human activities for each population, the distribution of the populations and their surrounding zone was mapped against the most recent land cover vectorial shape for France (CORINE Land Cover, 2012). This land cover describes soil occupation in 50 types that we regrouped into three categories: (i) urbanised (including commercial zones), (ii) agricultural (cultivated land with crops or orchards) and (iii) semi-natural areas. If aquatic type habitats (in the CORINE Land Cover database) occurred within the zone identified for a population, the surface area of this part of the zone was deleted from the space occupied by the population. The distribution of

Table 2
Scoring classes in relation to four criteria that asses the percentage of "natural areas", the percentage of urbanisation relative to the total surface that is not natural (urbanisation + agriculture) for populations with less than 90% of their area in natural areas, (3) fragmentation of populations by a major road or train line and (4) percentage of the area of a population in a protected area.

Score	Natural area(%)	Urbanisation(%)	Fragmentation	Protection(%)
5	<5			
4	5–39			
3	40–59			
2	60–89	>66		<33
1	>90	33–66	Present	33–66
0		< 33	Absent	>66

all populations and their surrounding zone was then mapped against the layer with all main roads (i.e. highways and roads with high traffic flows) and railways to identify whether populations are fragmented by such infrastructures. Finally, to estimate the degree of protection of each population, the map of their distribution was compared with that of the spatial distribution of National Parks, National and Regional Nature Reserves, sites of the Coastal Conservation Agency and Natura 2000 sites.

Each population was thus characterized by the proportion of its area (including the surrounding zone) that is either urbanised, agricultural or semi-natural, whether or not it is fragmented by main roads or railways and the proportion of its surface covered by one or more of the five “protected” areas. These three criteria were combined in a decision tool to estimate individual population vulnerability with classes based on observed natural breaks in the quantitative data (Table 2).

First, based on the proportion of semi-natural area, populations were scored from 1, for the most natural populations with >90% of semi-natural area to 5 for the lowest proportion of semi-natural area (<5% of natural habitats). Populations with a score of 2–5 (<90% of semi-natural area) were noted for the ratio between urbanisation and agriculture in the rest of their area in three classes, more than 66% urbanisation (score of 2), 33–66 % urbanisation (score of 1) or <33% urbanisation (scored as 0). The proportion of the population covered by a protected area was then attributed to three classes with more than 66% covered by a protected area (score of 0), 33–66 % in a protected area (1) or <33% in a protected area (2). Fragmentation was noted as being present (score of 1) or absent (score 0) for a given population. The sum of the four scores for each population produced a total score of increasing vulnerability from 1 to 10 within which we could distinguish five categories: least risk (total score of 1), low risk (total score of 2 or 3), three classes of increasing vulnerability (total score of 4–5, 6–7 or 8–10).

3. Results

The results for each species are shown in Table 1 and Fig. 2.

3.1. *Stipellula capensis*

The 191 initial points in the regional database produced a total of 29 populations in four distinct groups (containing from 1 to 16 populations) around the French Mediterranean coast. Eleven populations (38%) had more than 50% of their surface that is urbanised, only six populations had a total absence of urbanisation in their surface area and just three populations were entirely in semi-natural areas. Main roads and railways fragmented 10 (34%) populations. Four populations (14%) overlapped the edge of Natural Reserves, five populations (17%) overlapped with Coastal Conservation Agency sites and 14 populations (48%) overlapped Natura 2000 sites. Finally, 15 populations (52%) occurred in sites with no protected status. Only two populations had the minimum total vulnerability score of 1, 23 populations (79%) were in the three categories of vulnerability (scores 4 to 10) with nine populations in the highest vulnerability category.

3.2. *Ononis mitissima*

From the 2,196 initial points, 53 populations were identified with three main geographic groups (of 1–32 populations). Twelve populations (23%) were located in zones with a high proportion of urbanised areas (>50%), 38 populations (71%) were not fragmented by a major infrastructure, 13 populations (25%) overlapped with Coastal Conservation Agency sites and eight populations (15%) with Natura 2000 sites. 39 populations (74%) had no protected status. Only three of the 53 populations occurred in the least risk category of vulnerability and 44 populations (83%) were in one of the three categories of vulnerability with 16 populations (30%) in the highest category. Most of these populations (13 in total) were in a single geographic group located to the east of the Rhône valley.

3.3. *Convolvulus lineatus*

The 1,267 initial points produced 131 populations distributed quite regularly along a large band of the Mediterranean coast. 63 populations (48%) were exempt of urbanisation but only 14 of these (22%) were exempt of cultivation. 45 populations (34%) were fragmented by roads and / or railways. 10 populations (8%) overlapped with Natural Reserves, 19 populations (15%) overlapped with Coastal Conservation Agency sites and 50 populations (38%) overlapped Natura 2000 sites. 78 populations (60%) had no protected status. Only four of the 131 populations were part of the least risk category and although 99 populations (76%) fell in the three categories of vulnerability, with 14 populations (11%) in the highest category.

3.4. *Helianthemum marifolium*

The 3,110 initial points were clustered in 43 populations in one major geographic group to the east of the Rhône and one isolated population in the south-western part of the study region. Ten populations (23%) had no urbanisation although only one of these had no cultivated surface. 23 populations (53%) were fragmented by roads and / or railways. 11 populations (26%) and 15 populations (35%) overlapped with Coastal Conservation Agency sites and Natura 2000 sites respectively and 23 populations (53%) had no protected status. None of the 43 populations fell in the least risk category and 35 (80%) were in one of the three vulnerability categories, with four populations in the highest class of vulnerability.

3.5. *Allium chamaemoly*

The 1,485 initial data points were aggregated into 116 populations with a regular distribution across Mediterranean France. For these populations, 56 (48%) showed no urbanisation, 27 of these had no cultivated surface, 26 populations (22%) were fragmented by roads and / or railways. 18 populations overlapped with the core area of a National Park and Nature Reserves, 35 populations (30%) overlapped Coastal Conservation Agency sites and 64 populations (55%) overlapped Natura 2000 sites and 48 populations (41%) had no protected status. 24 populations (21%) were in the least risk category, however 70 (60%) were in one of the three categories of vulnerability with 16 (14%) in the highest category of vulnerability.

3.6. *Astragalus glaux*

The 119 data points were aggregated into 14 populations located in the western part of the French Mediterranean region. Three populations (21%) were urbanised over less than 25% of their surface and 11 had no

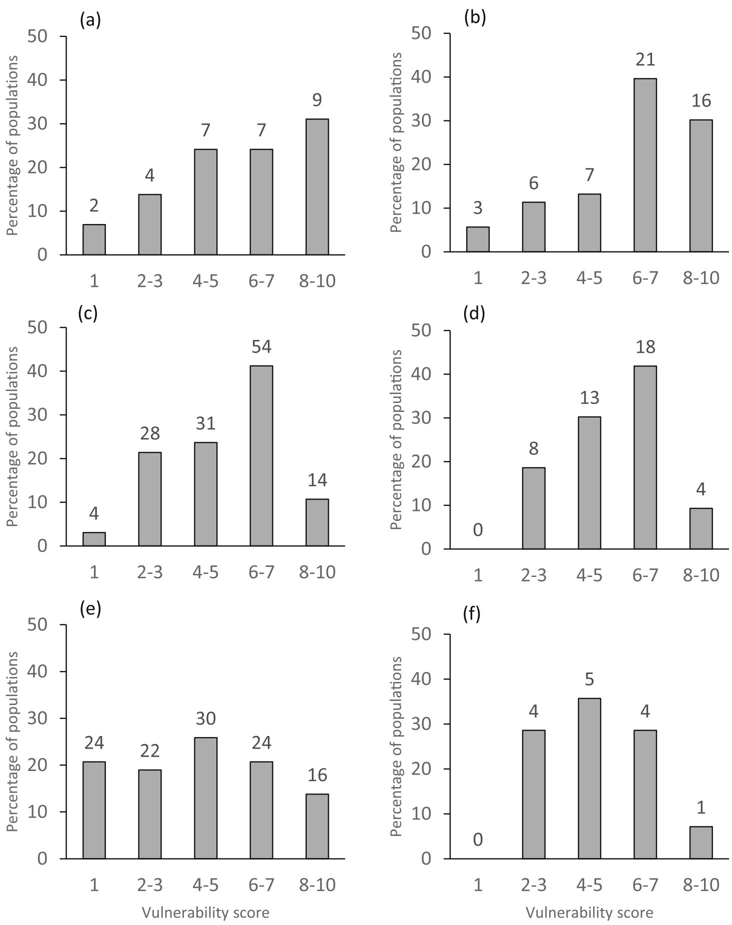

Fig. 2. The percentage of populations of the six study species in each class of vulnerability from (1) least vulnerability to (8–10) high vulnerability. Species are: (a) *Stipellula capensis*, (b) *Ononis mitissima*, (c) *Convolvulus lineatus*, (d) *Helianthemum marifolium*, (e) *Allium chamaemoly* and (f) *Astragalus glaux*. The number of populations per class of vulnerability is indicated above each histogram.

urbanisation, 10 of them with partial cultivation. Roads and / or railways fragmented two populations. 12 populations (86%) had no protected status and two populations (14%) overlapped with Natura 2000 sites. None of the populations fell in the least risk category and only one population in the most vulnerable category.

3.7. Global patterns

For the total number of 386 populations and their surrounding zone, 14% (55) had more than 50% of their surface that is urbanised and 45% (172) showed no degree of urbanisation, although a variable proportion of their surface was cultivated and thus only 53 populations (14%) were in the category of high proportion of semi-natural areas (with their whole area in this category). 121 populations (31%) have been fragmented by major ground level linear infrastructures. Finally 215 populations (56%) had no overlap with a protected area designation and only 32 of the 386 populations (8%) overlapped with a site of regulatory protection. As a result only 33 populations (9%) were identified as being of least risk and 281 populations (73%) were in one of the three vulnerable classes with 60 (16%) in the highest category.

3.8. 32 monitored populations

Only one (3%) of the 32 monitored populations was attributed to the least risk category, two in the low risk category (6%) and 29 populations were in one of the three classes of vulnerability with five populations (15.6%) in the highest category. The three populations that went extinct during the ten years monitoring period all had high vulnerability scores of six for population of *Stipellula capensis*, six for the population of *Ononis mitissima* and nine for the population of *Convolvulus lineatus*. As 90% of the 32 populations had a high score for overall vulnerability, we were not able to correlate population monitoring with vulnerability classes.

4. Discussion

Information on threat processes that contribute to the risk of habitat destruction and the loss of natural populations of listed species is crucial for effective conservation planning (Amat et al., 2013; Gauthier et al., 2013; Rouget et al., 2006; Vimal et al., 2012). A comprehensive assessment of these threats is complex. We detected high levels of vulnerability to threats in the Mediterranean landscape that is vital information for conservation management staff to develop a strategy and appropriate actions for listed species' protection.

For the overall data set, although we have focused on only a limited number of major threats, our result are in agreement with previous work that shows how, in the Mediterranean region, urbanisation is a major component of threats to biodiversity due to its increase in spatial area of around 17% in recent decades (Underwood et al., 2009; Vimal et al., 2012). It has thus become essential to quantify this ever-increasing threat to populations associated with urbanisation in the surrounding landscape. A second major threat we identified is landscape scale fragmentation. In this study one third of populations (n = 121) have been fragmented by major linear infrastructures. It is also possible that spatial distance may be part of the threat, i.e. distance to a major infrastructure or to a protected area and even the distance to the coastline. However, the species were chosen because of their presence in habitats near the coastline. Although the species differed in their degree of aggregation in different parts of the region they all had large numbers of populations in the three vulnerability classes.

Our study thus brings to the fore the generalised vulnerability of natural populations of listed plant species in the Mediterranean landscape. As a result of the combination and scoring of populations across the three criteria only 9% were considered as being of least risk whereas 73% were in one of the three classes of vulnerability with 16% in the highest category. This finding of a generalised vulnerability to on-going threats in the Mediterranean landscape illustrates the need for information on population numbers of listed species at the regional scale. Our study provides a method that can be used to assess threat status and provide vital practical information for conservation management staff to develop a strategy and appropriate actions for listed species' protection at the scale of their populations.

In a separate study of the dynamics of 32 populations of six listed species in Mediterranean France we detected high levels of population vulnerability in terms of significant declines in occupation and abundance in relation to extreme meteorological events and direct disturbance due to human activities. Indeed, 50% of monitored populations were subject to a decline following direct disturbance (Gauthier et al., unpublished ms). In the present study, we found that 29 of these 32 monitored populations were in one of the three highest categories of vulnerability in terms of risk of loss due to land use activities in and around the populations. Many populations of listed plant species thus combine both direct disturbance and landscape scale threats to persistence, despite their listed status.

In terms of habitat protection we found that 56% of populations had no overlap with a protected area designation and that only 8% of populations overlapped with a site of regulatory protection. However, in four of the study species between 35% and 55% of populations occurred in sites of the Natura 2000 Habitats Directive (Council of the European Community, 1992) and a further but smaller proportion occur in sites of the Coastal Conservation Agency. Likewise, in previous work on 142 listed species (Clech, 2007) and 612 plant species identified as priority species by conservation management staff in our study region (Vimal, Mathevet, & Thompson, 2011), the majority of species were completely absent from sites with a regulatory protection but a large majority (>1/3) of species had at least one data point in a site covered by the regional network of Natura 2000 Habitats Directive sites.

This finding of an important presence of populations outside of protected areas and, for those which overlapped with protected areas, an important presence in Natura 2000 sites points to two critical recommendations for their conservation management. The first concerns the importance of impact assessment and the detection of populations in areas of projected development programmes and the identification of necessary measures to avoid impacts. By spatially mapping populations, it will be more feasible for consultancy and conservation management staff to propose practical mitigation measures to avoid, reduce or compensate for future impacts and their cumulative nature. The second important point concerns the need to incorporate listed species into Natura 2000 site management plans. The study species are all listed for protection in France but are not part of the Habitats Directive annexes and are thus not considered as eligible for management plans within the Natura 2000 programme. Given the high level of population occurrence in such sites there is thus a clear need for them to be included in management plans for such sites where they are often ignored. Their broad habitat is open garrigues and fields, along woodland edges and sometimes on the edges of paths or fields used for crops or grazing. They may thus also decline because of natural succession that occurs following the abandonment of pastoralism. In a separate study where we monitored a total of 32 populations we observed vegetation succession in semi-natural areas that may potentially cause competition (six populations) with the study species (Gauthier et al., unpublished ms). However, this was found to be rare in the study area of lowland habitats near the Mediterranean coast where the primary direct influence on population dynamics of these six species (19 of 32 populations) comes from direct, physical human disturbance on populations.

Finally, our study provides an easily applicable method to quantify population numbers and their vulnerability. This method could be used to identify conservation priorities and red list status of Mediterranean plant species based on quantifiable information concerning their population ecology and threats to their populations.

Acknowledgements

We thank GRT Gaz (contract 048522), GPMM (contract CT060235) and Autoroutes du Sud de la France (contract 093034) for financial support. We also thank the Conservatoire Botanique National Méditerranéen de Porquerolles for access to their database.

References

Abbitt, R. J. F., Scott, J. M., & Wilcove, D. S. (2000). The geography of vulnerability: Incorporating species geography and human development patterns into conservation planning. *Biological Conservation, 96*, 169–175.

Amat, M. E., Vargas, P., & Gómez, J. M. (2013). Effects of human activity on the distribution and abundance of an endangered Mediterranean high-mountain plant (*Erysimum penyalarense*). *Journal for Nature Conservation, 21*, 262–271.

Clech, L. (2007). *Analyse de la représentativité et sélection de nouvelles aires de protection pour la conservation de la flore protégée à l'échelle régionale : Application à la région Languedoc Roussillon.* Montpellier: Université de Montpellier 2.

CORINE Land Cover (2012). http://www.statistiques.developpement-durable.gouv.fr/clc/fichiers/.

Council of the European Community (1992). Council directive 92/43/EEC of 21 may 1992 on the conservation of natural habitats and of wild fauna and flora. *Official Journal L, 206* 22.7.1992, p. 7.

Gauthier, P., Foulon, Y., Jupille, O., & Thompson, J. D. (2013). Quantifying vulnerability to assess priorities for conservation management. *Biological Conservation, 158*, 321–325.

Gauthier, P., Pons, V., Letourneau, A., Papuga, G., & Thompson, J. D. (2017). Combining population trends with criteria for habitat vulnerability to assess the conservation status of populations of rare and endangered plants. *Journal for Nature Conservation, 37*, 83–95.

Noss, R. F., Carroll, C., Vance-Borland, K., & Wuerthner, G. (2002). A multicriteria assessment of the irreplaceability and vulnerability of sites in the Greater Yellowstone ecosystem. *Conservation Biology, 16*, 895–908.

Pressey, R. L., & Taffs, K. H. (2001). Scheduling conservation action in production landscapes: Priority areas in western New South Wales defined by irreplaceability and vulnerability to vegetation loss. *Biological Conservation, 100*, 355–376.

QGIS development Team (2017). *QGIS geographic information system. Open source geospatial foundation project. Version 2.18.12*.

Rouget, M., Cowling, R. M., Lombard, A. T., Knight, A. T., & Kerley, G. I. H. (2006). Designating large-scale corridors for pattern and process. *Conservation Biology, 20*, 549–561.

Rouget, M., Richardson, D. M., Cowling, R. M., Lloyd, J. W., & Lombard, A. T. (2003). Current patterns of habitat transformation and future threats to biodiversity in terrestrial ecosystems of the Cape Floristic Region, South Africa. *Biological Conservation, 112*, 63–85.

Underwood, E. C., Viers, J. H., Klausmeyer, K. R., Cox, R. L., & Shaw, M. R. (2009). Threats and biodiversity in the Mediterranean biome. *Diversity & Distributions, 15*, 188–197.

Vimal, R., Mathevet, R., & Thompson, J. D. (2011). Complémentarité et efficacité des différents dispositifs de protection : de l'analyse des lacunes à une stratégie de création d'aires protégées. In J. D. Thompson, & P. Gauthier (Eds.). *Activités humaines et dynamique de la biodiversité en région méditerranéenne. Problématique scientifique, enjeux de conservation* (pp. 73–74). Bastia: Centre d'Ecologie Fonctionnelle et Evolutive and Mediaterra.

Vimal, R., Pluvinet, P., Sacca, C., Mazagol, P. O., Etlicher, B., & Thompson, J. D. (2012). Exploring spatial patterns of vulnerability for diverse biodiversity descriptors in regional conservation planning. *Journal of Environmental Management, 96*, 9–16.

Wilson, K. A., Pressey, R. L., Newton, A. N., Burgman, M. A., Possingham, H. P., & Weston, C. J. (2005). Measuring and incorporating vulnerability into conservation planning. *Environmental Management, 35*, 527–543.