Species Conservation Assessments in Oceanic Islands: the Consequences of Precautionary Versus Evidentiary Attitudes

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Keywords
Biodiversity hotspots; Cape Verde; endemism; IUCN Red List; Macaronesian Islands; risk tolerance; threatened species.

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Received
21 May 2015
Accepted
22 October 2015

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Editor
Dr. Mark W. Schwartz

doi: 10.1111/conl.12212

Abstract

The application of IUCN Red List criteria to oceanic islands often produces uniform species assignments to high-threat categories, but in some cases this may result from uncertainties in the data and overly precautionary attitudes to risk. We illustrate this problem using the endemic vascular flora of the Cape Verde archipelago, and show that changing risk tolerance along the precautionary-evidentiary gradient greatly affects conservation assessments. Most taxa qualified for threat categories due to small areas of occupancy, but while precautionary assessments classified 88.9% of 81 evaluated taxa as Critically Endangered, evidentiary assessments assigned taxa to a wider range of categories. Taxa with very small ranges and restricted to one–three islands were consistently considered Critically Endangered. Our results suggest that conservation assessments under uncertainty may benefit from a more evidentiary attitude, which seem to provide higher discrimination ability among taxa, thereby enhancing the contribution of Red List assessments to prioritize conservation action.

Introduction

Oceanic islands are centers of range-restricted species, with floras and faunas often including a very large proportion of endemics (Whittaker & Fernández-Palacios 2007; Kier et al. 2009). Concurrently, these islands are centers of past and imminent extinctions, requiring urgent action to protect biodiversity from the multiple threats impeding on insular ecosystems (Caujapé-Castells et al. 2010; Pimm et al. 2014). A first step toward this goal is the assessment of species extinction risk (Rodrigues et al. 2006; Mace et al. 2008), which can be combined with information on chances of success, feasibility, and costs to prioritize conservation action (Mooers et al. 2008; Martín et al. 2010). For instance, information on species conservation status was recently used to help establishing priority actions for seabird conservation at the global scale (Croxall et al. 2012), identifying Key Biodiversity Areas in the Philippines (Ambal et al. 2012), and prioritizing islands for the eradication of invasive vertebrates in the United Kingdom overseas territories (Dawson et al. 2015).

The criteria developed under the IUCN Red List of Threatened Species provide the most authoritative framework for evaluating species conservation status (e.g., Rodrigues et al. 2006; Mace et al. 2008; Rondinini et al. 2014). Red Lists use a combination of criteria such as population size and trends, and geographic range size
and trends, which are taken as surrogates to assess the likelihood of species extinction (Mace et al. 2008). The system is sufficiently flexible to incorporate data of variable certainty and detail, making the best use of limited information to support conservation decisions (Rodrigues et al. 2006). For instance, although some assessments are based on detailed population viability analysis (Criteria E—Quantitative analysis), the conservation status is most often assigned using readily available data such as range sizes and trends (Criteria B—Geographic range) (e.g., Lewis & Senior 2011; Romeiras et al. 2014). Despite limitations and potential shortcomings identified over the years (e.g., Cardoso et al. 2011), the objectivity, simplicity, and flexibility of the system has favored its application to a wide range of taxonomic groups and geographic regions, as well as its increasing use to define conservation priorities and to estimate the success of conservation actions (e.g., Butchart et al. 2004; Young et al. 2014).

In oceanic islands, Red List assessments have shown that most endemic species are often threatened with extinction (e.g., Seoane et al. 2011; Rumeu et al. 2014). However, recent studies pointed out that the application of Red List criteria to these islands may generally overestimate extinction risks (Martín 2009; Cardoso et al. 2011; Seoane et al. 2011; González-Mancebo et al. 2012). A key problem is that most island endemics have naturally very small areas of occupancy (AOO) and extents of occurrence (EOO), and thus meet the threshold of a high-risk category under criterion B, even if they are common within their range (e.g., Gonzañez-Mancebo et al. 2012; Vasconcelos et al. 2013). Although meeting the AOO or EOO thresholds is not sufficient to classify a species, additional data on continuing range declines or extreme fluctuations are often lacking, and so whether a species meets these subcriteria or not is often judged with considerable uncertainty and based on expert opinion (Cardoso et al. 2011). As a consequence, a large number of species in oceanic islands may be clustered in the higher threat categories, making it difficult to identify those species most in need of conservation action (Martín 2009; Seoane et al. 2011; González-Mancebo et al. 2012).

To solve these problems, previous studies suggested changing the thresholds of the Red List criteria, to accommodate the peculiarities of species with naturally small ranges (Martín 2009; Cardoso et al. 2011; González-Mancebo et al. 2012; Sim-Sim et al. 2014). This is troublesome, because ad hoc changes in thresholds undermine the comparability of Red List assessments across taxonomic groups and regions. In alternative, it is possible that a higher discrimination among species could be achieved within the current Red List Framework, by adjusting attitudes to uncertainty and risk, which may greatly influence the classification of threatened species (Akcakaya et al. 2000). For instance, precaution in the face of uncertainty may classify species as threatened even under modest and highly uncertain data, though this may overestimate extinction risk and cluster species in high-threat categories. In contrast, an evidentiary attitude would demand substantial evidence of endangerment before considering a species in a higher threat category, which may result in underestimates of extinction risk and a more even spread of species assignments to threat categories. With the accumulation of biological information and a consequent reduction of uncertainties, however, precautionary and evidentiary attitudes would tend to converge to similar classifications. Therefore, it is possible that the assessment of conservation status in oceanic islands would benefit from a more evidentiary attitude, which might provide more discrimination among species than precautionary assessments.

This study addresses these ideas, based on endemic vascular flora of the archipelago of Cape Verde. This archipelago was considered particularly adequate because it includes a group of oceanic islands where the endemic flora is relatively well known, but which has yet to be systematically assessed against Red List criteria. The study was based on the most comprehensive data set currently available on the endemic flora of Cape Verde, and it aimed to: (1) apply Red List criteria to all endemic vascular plants, (2) evaluate the impact of precautionary versus evidentiary attitudes on conservation assessment, and (3) identify the attitudes to uncertainty providing the higher discriminatory ability among the conservation status of different threatened species and that may thus be most useful to inform conservation prioritization. The results obtained are used to discuss approaches for more accurate species conservation assessment in oceanic islands.

**Methods**

**Study area**

The Cape Verde archipelago includes 10 islands (35-991 km²) and several islets (<7 km²) of volcanic origin (surface: 4,026 km²; coastline: 1,050 km) lying between 14°50’–17°20’N and 22°40’–25°30’W, at about 600 km west of the African mainland (Romeiras et al. 2011). All islands are inhabited except Santa Luzia and the islets. Cape Verde is included in the African Sahelian arid and semiarid regions, and in the Macaronesian geographic region (Duarte & Romeiras 2009). The flora of Cape Verde comprises about 740 vascular plant taxa, of which 92 species and subspecies are endemics (Romeiras et al. 2015). In a preliminary conservation assessment, about half the endemic plants were considered threatened (Leyens & Lobin 1996), but this was not entirely based on the IUCN Red list criteria.
Species data

The study focused on the endemic vascular plants of the Cape Verde archipelago (Brochmann et al. 1997; Romeiras et al. 2015), and involved collection of data needed to undertake IUCN Red List assessments, including primarily population and range sizes, population and range trends, fragmentation, and threats (see details in Supplementary Methods in Supporting Information). Species occurrences were compiled from field data collected during the last decade, bibliography, and herbarium collections. Overall, we were able to compile 4,583 georeferenced specimens, which provided the basis for quantitatively estimating for each taxon the extent of occurrence (EOO), using the minimum convex hull polygon method; the area of occupancy (AOO), as the number of cells occupied by individuals in 1-km$^2$ grid cells; the number of subpopulations, as the number of islands in which the taxon occurred; and the number of locations, as the number of geographically or ecologically distinct areas of occurrence. Information on threats and on population trends was assessed whenever possible from expert opinion and data collected during the past two decades by the authors (MMR, MCD).

Conservation assessment

The conservation assessment was made at species and subspecies level, following the guidelines of IUCN Red List categories and criteria (IUCN 2014), and using RAMAS Red List software (Akçakaya et al. 2001). For each taxon, we used as input all the information available for Criteria A-D, but ignored due to lack of data the quantitative assessment of Criterion E (see details in Supplementary Methods in Supporting Information). Uncertainty in assessments was due to the interval estimates used for some parameters (e.g., population size), and because population and range trends were often coded as unknown. To evaluate the consequences of precautionary versus evidentiary assessments, we used the Risk Tolerance (RT) parameter, which ranges from 0 (risk-averse) to 1 (risk-prone), and it was introduced in IUCN Red List assessments to deal with differences in attitude toward uncertainty (Akçakaya et al. 2000; Alonso-Redondo et al. 2013). Specifically, we conducted different assessments for each species varying the risk tolerance from $RT = 0.3$ to $RT = 0.8$, at 0.1 intervals. For each assessment, we retained the most plausible threat category, and the range of plausible categories (Akçakaya et al. 2000).

Results

From the 92 taxa considered, a total of 11 were not evaluated because they were data-deficient (5), or had poorly resolved taxonomy (the 6 endemic Lotus species). Using the intermediate risk tolerance value ($RT = 0.5$), all 81 taxa evaluated were assigned either to Critically Endangered (CR; 88.9%) or Endangered (EN; 11.1%) categories (Figure 1). However, there was considerable uncertainty in the assignments, with the plausible categories for 45 of CR taxa ranging between CR and EN (39 taxa), or between CR and Vulnerable (VU) (6 taxa); only 1 taxa was considered LC (Table S1; Figure 1). For the 27 CR taxa that were assigned to a single-threat category, the assignment criteria were based on either geographic range (Criteria B; 16 taxa) or small population size and decline (Criteria D; 6 taxa), or both (5 taxa).

Changing the risk tolerance along the precautionary versus evidentiary attitude gradient caused noticeable changes in species assignment to threat categories. However, changes were abrupt rather than gradual, when shifting between $RT \leq 0.5$ (precautionary) and $RT \geq 0.6$ (evidentiary) (Figure 1). In relation to precautionary assessments, taking an evidentiary attitude caused a major reduction in the number of species assigned to the CR category, from 72 to 27 taxa. Concurrently, 39 taxa moved from the CR to the EN category, and another 6 from the CR to the VU category. All species categorized as EN using the precautionary attitude were moved to the Near-Threatened (NT) category. In general, for each species the precautionary attitude assumed the category...
of higher risk in the range of plausible categories, whereas the lower threat category was assigned when assuming the evidentiary attitude (Table S1). Assignments were mostly based on criteria B (57 taxa), with a few species also assigned using criteria D (8) or both (7) (Table S1).

Taxa with smaller EOO and AOO tended to be assigned to higher threat categories, irrespective of risk tolerance (Figures S1 and S2). The species least affected by changes in risk tolerance were those with very small AOO (<10 km²), and that in most cases were confined to just one or two islands. All these species were assigned to the CR category, irrespective of taking precautionary or evidentiary attitudes. In contrast, there was a very strong effect of risk tolerance on the risk categorization of species with the largest EOO and AOO that occurred in several islands.

**Discussion**

Our study supported previous research showing that the application of IUCN Red List criteria to oceanic islands may cluster most endemic species in top threat categories, which is mostly a consequence of their very small EOO and AOO (Martín 2009; Seoane et al. 2011; González-Mancebo et al. 2012). Also, the study confirmed that attitudes toward uncertainty strongly impact on species threat classifications (Akçakaya et al. 2000), and that assessments based on evidentiary attitudes provide more discrimination ability than precautionary assessments. Overall, our results suggest that assessing species conservation status in oceanic islands may benefit from a more evidentiary attitude, providing information that can be combined with additional criteria to prioritize conservation action (e.g., Mooers et al. 2008; Martin et al. 2010).

Our study revealed that the endemic vascular flora of Cape Verde is highly threatened, with precautionary assessments classifying nearly 90% of taxa as CR. Although the situation appeared less pessimistic in evidentiary assessments, these still assigned most taxa to one of the IUCN threat categories. A group of 27 taxa with very small AOO and single island endemics appeared particularly threatened, as they were always highlighted as CR. Overall, these results agree with previous conservation assessments in Cape Verde (Vasconcelos et al. 2013) and other oceanic islands (e.g., Seoane et al. 2011; Rumeu et al. 2014), and are consequences of the very small geographic range of most endemic species, coupled with the incidence of a variety of pervasive threats. In Cape Verde, the main threats are probably overexploitation, invasive species, overgrazing, and tourism development, which will likely continue operating in the future and contributing to further population declines (M.M. Romeiras and M.C. Duarte, Unpublished Data). These threats can operate at distinct geographical extents in the archipelago, but they will likely have a stronger impact on species with small EOO and AOO, for which a single event (e.g., establishment of an invasive species) can affect at once all individuals occupying a small geographic area. Other threats, however, may be less serious, either because they may impact on limited areas (e.g., a small touristic development along the coastline), or they affect taxa with larger geographic ranges or disjoint subpopulations. These details are not sufficiently captured in Red List assessments such as ours, requiring a more thorough evaluation of threats affecting each subpopulation of which taxa, and thus providing critical information for the development of Action Plans defining conservation actions and priorities of implementation.

Like most other studies evaluating species conservation status (e.g., Akçakaya et al. 2000; Lewis & Senior 2011; Alonso-Redondo et al. 2013; Romeiras et al. 2014), our assessment was greatly influenced by uncertainties in input data, which affected species threat classifications in relation to changes in risk tolerance. Although most species were assigned to a single-threat category, there was often a wide range of plausible categories representing uncertainty. Uncertainties in spatial distribution trends appeared particularly relevant, because most species qualified for a threat category under Criterion B due to their small geographic range. In cases like this, precautionary assessments led to assignment of species to higher threat categories even if trends in range were considered unknown, whereas lower categories were assigned under the same circumstances by evidentiary assessment. Uncertainty in this binary parameter (i.e., the species is either declining or not declining) thus justifies the abrupt shift in classifications when changing risk tolerance from RT ≤0.5 to RT ≥0.6, rather than the more gradual variation expected when considering uncertainty in quantitative parameters (Akçakaya et al. 2000). In contrast, where information on trends was available, assessments provided the same results irrespective of risk tolerance. These results highlight the importance of obtaining more consistent information to reduce uncertainty and thus to support more accurate conservation assessments, particularly on past and current temporal changes in species spatial distributions, and on impending threats that may affect such distributions in the future.

The much higher discrimination among species obtained through evidentiary than precautionary assessments, suggests that the former may be the most useful to assign species to threat categories in oceanic islands. The same probably applies to other species with naturally restricted geographic ranges, such as those occurring on mountain tops (e.g., Bässler et al. 2010). Using evidentiary assessments under uncertainty may thus contribute to solve the problem of classifying nearly all species with small ranges in the top threat categories, which may
overestimate extinction risks and make it difficult to identify those species most in need of urgent conservation action. In contrast to this approach, previous studies addressed small range sizes by changing the thresholds of Red List criteria (Martín 2009; Cardoso et al. 2011; Seoane et al. 2011; González-Mancebo et al. 2012; Sim & Sim et al. 2014), but this undermines the comparability of assessments across regions and taxonomic groups, as different assessors may use different ad hoc thresholds in different circumstances. Adjusting risk tolerance along the precautionary-evidentiary gradient may thus provide a practical approach to improve the utility of conservation assessments in oceanic islands, while maintaining the widely used IUCN Red List framework. It should be noted, however, that comparisons of species threat categories across archipelagos, or between islands and mainland regions, require using similar attitudes to risk, because otherwise conservation priorities might be biased toward species categorized using more precautionary assessments. On the long run, it would be important to thoroughly examining the impact of IUCN criteria based on EOO and AOO on the extinction risk assessment of taxa with naturally small ranges, but this was beyond the scope of this study.

Accurately assessing species conservation status is a critical first step toward the prioritization of conservation action (Rodrigues et al. 2006; Mace et al. 2008). Although the identification of conservation priorities considers a wide range of criteria such as phylogenetic uniqueness, cost of recovery and probability of success (e.g., Mooers et al. 2008; Martin et al. 2010), conservation status is important because it is often used as prioritization criteria itself, or even serve as a filter to select candidate species for prioritization (Ambal et al. 2012; Croxall et al. 2012; Dawson et al. 2015). In this context, our study adds to previous evidence highlighting the importance of attitudes to uncertainty and risk for the correct allocation of conservation resources (Akçakaya et al. 2000; Alonso-Redondo et al. 2013). Therefore, we suggest that: (1) assessments should report the range of plausible categories rather than the single most plausible category, thereby recognizing the potential impact of uncertainty, (2) the attitudes to risk should be explicitly documented, eventually by specifying the risk tolerance value (or values) assumed, and (3) in line with IUCN recommendations, assessments should explore variation in species assignments when changing the risk tolerance along the precautionary-evidentiary gradient. We believe that these relatively simple procedures would help improving Red List assessments in oceanic islands and elsewhere, explicitly incorporating uncertainty, and providing more detailed information that could be used in conservation prioritization.

**Acknowledgments**

This research was supported by the Portuguese Foundation for Science and Technology (FCT) and the European Social Fund through project PTDC/BIA-BIC/4113/2012. MMR was supported by FCT grant SFRH/BDCT/113708/2015 and Mohamed Bin Zayed Species Conservation Fund (12255026). PB and AFF were supported by the EDP Biodiversity Chair. We thank the thoughtful comments of the Associate Editor Mark Schwartz, and two anonymous reviewers, which greatly improved our article.

**Supporting Information**

Additional Supporting Information may be found in the online version of this article at the publisher’s web site:

**Supporting Methods**

**Table S1.** Summary results of the conservation assessment of endemic vascular plants of the Cape Verde archipelago, using either an evidentiary or a precautionary attitude.

**Figure S1.** Summary of the IUCN Red List Categories assigned to the Cape Verde endemic plant species, using either a precautionary (RT≤0.5) or an evidentiary attitude (RT≥0.6) (single or preferred category - black squares; range of plausible categories - black and grey squares), and relationship with areas of occupancy (AOO) (islands’ partial areas in different colors).

**Figure S2.** Mean and range (error bars) of the: a) Areas of Occupancy (AOO) and b) the Extent of Occurrence (EOO), of taxa assigned to each IUCN threat category, for assessments assuming either precautionary (RT≤0.5) or evidentiary (RT≥0.6) attitudes to risk; LC category, with only one species, omitted.

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