Comment

Ranking threats using species distribution models in the IUCN Red List assessment process

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ABSTRACT

Within the Red List of the International Union for Conservation of Nature, species distribution models (SDM) are used with two main purposes: (1) to estimate extents of occurrence as a parameter of risk of extinction and, more recently, (2) to explore potential impacts of climate change on species distribution. In this paper I propose a third use of SDM: to generate objective and quantitative rankings of threats for the species categorized within the Red List. Although some authors have published threat analyses based on SDM, most current ranking of threats conducted within IUCN Specialist Groups still relies on the subjective perspectives of workshop attendees or individual experts. I found that SDMs are ideal for incorporating theoretical and mathematical rigor to the ranking threat process, because: (1) they are of relatively easy and fast implementation, (2) they can be used with different levels of knowledge about the species in question, and (3) they are particularly suitable for use at the geographical scale for which the IUCN Red List is designed.

Key words: conservation biogeography, population viability analysis, specialist groups, threat assessment.
Running head: Ranking threats with species distribution models.

Red lists are ranks of species based on their risk of extinction. The International Union for Conservation of Nature (IUCN) Red List of Threatened Species is widely recognized as being the most authoritative of red lists at a global scale. The 2010 IUCN Red List (www.iucnredlist.org) contains assessments for almost 56,000 species. Each taxon has a 'fact sheet' that includes a description of the biology and status of the species, and a ranking of threats. The success of the IUCN Red List is based on the use of objective and quantitative criteria to measure the risk of extinction, described in the 'Red List Categories and Criteria' report (IUCN 2001). Clear and comprehensive rules based on population size, rate of decline, and area of distribution are used to designate species as being in one of a number of conservation categories, ranging from 'Least Concern' to 'Extinct in the Wild' (IUCN 2001).

While categorization of the global level of imperilment for individual species is the main objective, the fact sheets of the Red List also provide a description of threats to each species. The types of threats are organized according to the explicit classification provided in the 'Threats Classification Scheme'. Threats are not only described but in many cases are hierarchized in a ranking from highest to lowest impact. These rankings are very important in the management of biodiversity by helping to identify priority conservation actions.
However, there is no analogue to the 'Red List Categories and Criteria' report (IUCN 2001), so the threat ranking for each species is credited to one or more assessors, to the members of a specific group of specialists, or to specific organizations. The consequence is that the listing of threatening processes lacks the theoretical and mathematical rigor of the conservation-status listing process and relies on the perspectives of workshop attendees or individual experts (Hayward 2009). This lack of objective and quantitative criteria involves at least two risks: a possible lack of agreement between experts, and local biases (Hayward 2009). The IUCN Red List is a global-level assessment, so differences between people with experience from single sites should be avoided at all costs.

Species distribution models (SDMs) are defined as associative models relating occurrence or abundance data at known locations of individual species (distribution data) to information on the environmental characteristics of those locations (modified from Elith & Leathwick, 2009). Most models, especially those developed during the last decade, produce a habitat suitability map as their output, but this definition of an SDM also includes models that use multivariate analysis to identify environmental predictors that do not have a geographical expression. Several publications have reviewed the available SDMs (Austin 2002; Hirzel *et al.* 2002; Guisan & Thuiller 2005; Heikkinen *et al.* 2006; Elith & Leathwick 2009). These reviews found that SDMs have been used with good results to characterize the natural distributions of species and to apply this information to investigate a variety of scientific and applied issues. Cassini (2011) showed that SDMs possess a strong assumption called 'the matching law', which is rooted on the population ecology theory and the principle of evolution by natural selection. Whenever SDMs are based on fundamental principles of ecology and evolution, their analyses of the factors that determine the distribution of a species will move from being purely correlative to attain more predictive power. Therefore, threats rankings obtained with SDM analyses may have more than a heuristic value and may become truly explanations of causal relationships.

Species distribution models have several properties that make them suitable for the ranking of threats. First, the models are relatively easy and fast to implement. Conservation biology has been described as a mission-oriented science where decisions must be made quickly without complete information (Soulé 1985). Conservationists frequently have to make decisions based on limited time. Species distribution models allow obtaining decision criteria within a relatively short period of time: with presence–absence and GIS-based descriptions of habitats, models that predict species responses to changes in environmental conditions can be easily generated.

Closely related to the issue of emergency is the problem of the scarcity of information. Given ongoing habitat loss and degradation, we must use the best information that is available to make choices about where to invest limited funds for biodiversity conservation (Grantham *et al.* 2009). There are different SDMs that are designed to work with different degrees of information. Some of them can be applied even when data are incomplete and often taxonomically, temporally and geographically biased. For example, Maximal Entropy ecological niche modelling software is a general purpose method for generating predictions or inferences from presence-only data that can show great modelling accuracy even with datasets of less than 25 occurrences (Phillips *et al.* 2006; Pearson *et al.* 2007).

These two qualities of SDMs – ease of implementation and low requirements for information – differ from the other types of models used in the conservation biology of individual species, such as Population Viability Analysis (PVA), which requires previous studies that provide long-term data to be successfully implemented (Burgman *et al.* 1993). A third quality of the SDMs is that they are particularly suitable for use at the geographical scale, for which the IUCN Red List is designed. This document only includes global-level assessments, i.e. it takes into account the entire geographical distribution of each species. Recently, the IUCN developed an additional guideline for risk assessment at the regional level (IUCN 2003). The SDMs are designed to operate at both scales, global and regional, but they are ineffective at the local level (Whittaker *et al.* 2005). Locally, PVA are certainly more appropriate than SDMs for identifying threats. Many of the IUCN fact lists include PVA results as case studies for local populations. These local results are frequently extrapolated to the entire distribution of a species. As Hayward (2009) has already pointed out, representations of participants at IUCN workshops and members of specialist groups may be biased by people with experience from single sites. He described an example of the lion (*Panther leo*), which is the only large predator listed as being threatened with extinction by civil war.

I proposed that IUCN assessors follow a procedure divided into four stages: First, species assessors should select the types of threats that may be affecting the target species (without an assessment of impact levels), using the IUCN Threats Classification Scheme as the main source of threat categories. Second, species and SDM specialists should interact to define the values with which to measure each threat-variable, which must be translated into geo-referenced data that will be transferred to thematic layers in a geographic information system. Third, species experts provide geo-referenced information on the location of the target species and on the values taken by local threats in the geographic region of their knowledge. Fourth, SDM assessors select the best type of model based on the type and quality of information available. Four, the model is implemented and the ranking is constructed.

Several commonly used models have the option of weighing the importance of each independent variable or threat. Maxent software provides a table that gives a heuristic estimate of relative contributions of the environmental variables to the model. To determine the estimate, in each iteration of the training algorithm, the increase in regularized gain is added to the contribution of the corresponding variable, or subtracted from it if the change to the absolute value of lambda is negative. Garp software also has an option to point out what environmental factors are more significant or important than others for a given species. This operation is called environmental layer jackknifing. Bioclim software indirectly ranks variables because it maps variables based on their percentile rank. In ENFA analysis, the rank of habitat variables can be obtained from the eigenvalues adopted by the variables in marginality factor.

The IUCN are increasingly integrating spatial databases of species that greatly facilitates the implementation of the SDMs. In 2010, about 50% of the species in the list had spatial data (http://www.iucnredlist.org/technical-documents/spatial-data). In addition, the IUCN has recently begun to explicitly incorporate the theoretical framework and models of conservation biogeography. In the last version of the 'Guidelines for Using the IUCN Red List Categories and Criteria', the recommendation for 'threatening processes' was related to the impact of global climate change (IUCN Standards and Petitions Subcommittee, 2010). This section of the report suggests using bioclimate envelope models to explore the potential impacts of climate change on species distribution. This background suggests that the IUCN is gradually adopting tools and approaches from conservation biogeography. The use of SDMs to determine rankings of threats would be a further step in this process.

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