

AREAL SIZES OF HIGH, INTERMEDIATE, LOW AND TOTAL SUITABLE HABITATS ARE CORRELATED TO THE GLOBAL EXTINCTION RISK FOR MAMMALS

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Abstract – The relationships between areal sizes of high, intermediate, low, and total sum of habitats with low, intermediate and high suitability habitat ranges, and the International Union for Conservation of Nature (IUCN) threatened status of global terrestrial mammals were studied. Polyserial correlation analysis showed that all types of areal size closely and positively correlated with IUCN categories of threatened species. The results indicate that area-based extinction risk assessment is feasible and reliable in species' conservation prioritization. Furthermore, the partial polyserial correlation test indicates that significant correlations between the IUCN threatened status of species and range sizes of high, intermediate and low suitability habitats are not influenced by the polyserial correlation between IUCN threatened status and total suitability habitat range size. Thus, the prediction of species' extinction risks can be accurately fulfilled by evaluating the areal size of any one of total, high, intermediate or low suitability ranges. The present study implies that if the area size information of a totally suitable range is not available for species' extinction risk assessment, the usage of areal sizes from any parts of suitable habitats (high, intermediate or low) are effective surrogates.

Key words: range size; extinction risk; macroecology; habitat suitability; conservation prioritization

INTRODUCTION

The International Union for Conservation of Nature (IUCN) Red List of Threatened Species (<http://www.iucnredlist.org/>) has been extensively used to quantify the extinction risk of species globally and nationally in the past decade (Malcolm et al., 2006). Many empirical studies have utilized IUCN threatened categories to reveal a species' extinction status by integrating some other information, such as phylogenetic history (Davies et al., 2011; Gudde et al., 2012; Yessoufou et al., 2012).

It has been predicted that an area-based extinction risk could be a good surrogate of IUCN threatened status of species (Cardillo et al., 2008; Harris

and Pimm, 2008; He, 2012). Range size is a strong predictor of species' extinction risk (Harnik, 2011). In the present study, the relationship between distributional range sizes and IUCN threatened status of global mammals is elucidated.

In the design of nature reserves, typically two zones are delimited: core (or protected) and buffer zones (Wells and Brandon, 1993). The core zone is typically in the center of a nature reserve, while the buffer zone is at the edge of the reserve (Vujakovic, 1987). Such a design recognizes that both areas are fundamentally different so that the core zone is more critical than the buffer zone in protection, as it harbors higher diversity and endemism (Myers et al., 2000; Grenyer et al., 2006).

Peripheral populations of species are those occurring at the edges of a species range (Bunnell et al., 2004; Preston, 2004). Conservation priorities of species with peripheral populations at national or regional levels might not be so high in comparison to those with central populations (Fraser, 1999), because local abundance of these populations is substantially low and limits the genetic information they convey because of the genetic drift effect (Kirkpatrick and Barton, 1997; Vucetich and Waite, 2003; Garner et al., 2004; Osborne et al., 2012). Practically the areas inhabited by peripheral populations might be regarded as low suitability habitats since no dense populations of species are supported by these areas (Bahn et al., 2006; Carrascal and Seoane, 2009).

Consequently, it is predicted that the correlations between the areal sizes of high, intermediate and low suitability ranges and the IUCN threatened status of species should be in order from high to low. The correlation between the IUCN threatened status and low suitability range size may be nonsignificant since it is presumably a small numeric value. In the present study, the above-mentioned hypothesis was tested by examining the range sizes of global mammals.

MATERIALS AND METHODS

Areal sizes of high, intermediate, low, and total suitability habitats of the 5 312 global terrestrial mammals were obtained from a previous study (Rondinini et al., 2011). The areal size for total suitability habitats is calculated by summing the areal sizes for the high, intermediate and low suitability habitats.

Each of the threatened categories of IUCN Red List is assigned a digital value for measuring the correlation between them and the range sizes of species as follows: Critically Endangered (CR: 1), Endangered (EN: 2), Vulnerable (VU: 3), Near Threatened (NT: 4). Other situations, including Least Concern (LC) or Data Deficit (DD), are assigned a value of 5.

The relationship between range sizes and categories of IUCN threatened status is investigated through polyserial correlation (Drasgow, 1986); one

ordinal and one quantitative variable are included in the correlation analysis. Conventional Pearson's product-moment correlation coefficient (Rodgers and Nicewander, 1988) is not suitable for this case. However, I used " r " as the symbol for representing the polyserial correlation coefficient, similar to that of Pearson's correlation coefficient.

RESULTS

Range sizes for the total, high, intermediate and low suitability habitat ranges and IUCN threatened status of global mammals are significantly correlated when their independence is not controlled (Table 1, Fig. 1). These correlations follow an order as expected in the original hypothesis, being highest for the correlation between IUCN threatened status and high suitability habitat range size and lowest for the correlation between IUCN threatened status and low suitability habitat range size. Thus, for predicting the extinction risk of a species, the utilization of range sizes of suitable habitat ranges from high to low is in a decreasing order of priority and effectiveness.

More interestingly, these positively significant correlations are all independent. As seen, when partial polyserial correlation analysis is performed to control the effect of total range size (Table 2), the correlations between IUCN threatened status and high, intermediate and low suitability habitat range sizes are still significant. Similar to the above, these correlation values (Table 2) follow the order expected in the hypothesis as well.

In summary, the areal sizes derived from high, intermediate and low suitability ranges are not affected by the total habitat range sizes of the species. IUCN threatened status can be independently predicted by any of the area sizes derived from high, intermediate, low and total suitability ranges.

DISCUSSION

Based on the present global assessment of IUCN threatened status and range sizes of suitable habitats for mammals, it was found that the range sizes for

Table 1. Polyserial correlations between IUCN threatened status and range sizes of total, high, intermediate, and low suitability habitats for global mammals.

Polyserial Correlations	IUCN threatened status
Range size for total suitability habitats	$r=0.429$ ($P<0.0001$)
Range size for high suitability habitats	$r=0.421$ ($P<0.0001$)
Range size for intermediate suitability habitats	$r=0.418$ ($P<0.0001$)
Range size for low suitability habitats	$r=0.414$ ($P<0.0001$)

Table 2. Partial polyserial correlations between IUCN threatened status and the range sizes of high, intermediate, and low suitability habitats for global mammals by controlling the influence of range size for total suitability habitats.

Partial polyserial correlations	IUCN threatened status
Range size for high suitability habitats	$r=0.369$ ($P<0.0001$)
Range size for intermediate suitability habitats	$r=0.365$ ($P<0.0001$)
Range size for low suitability habitats	$r=0.359$ ($P<0.0001$)

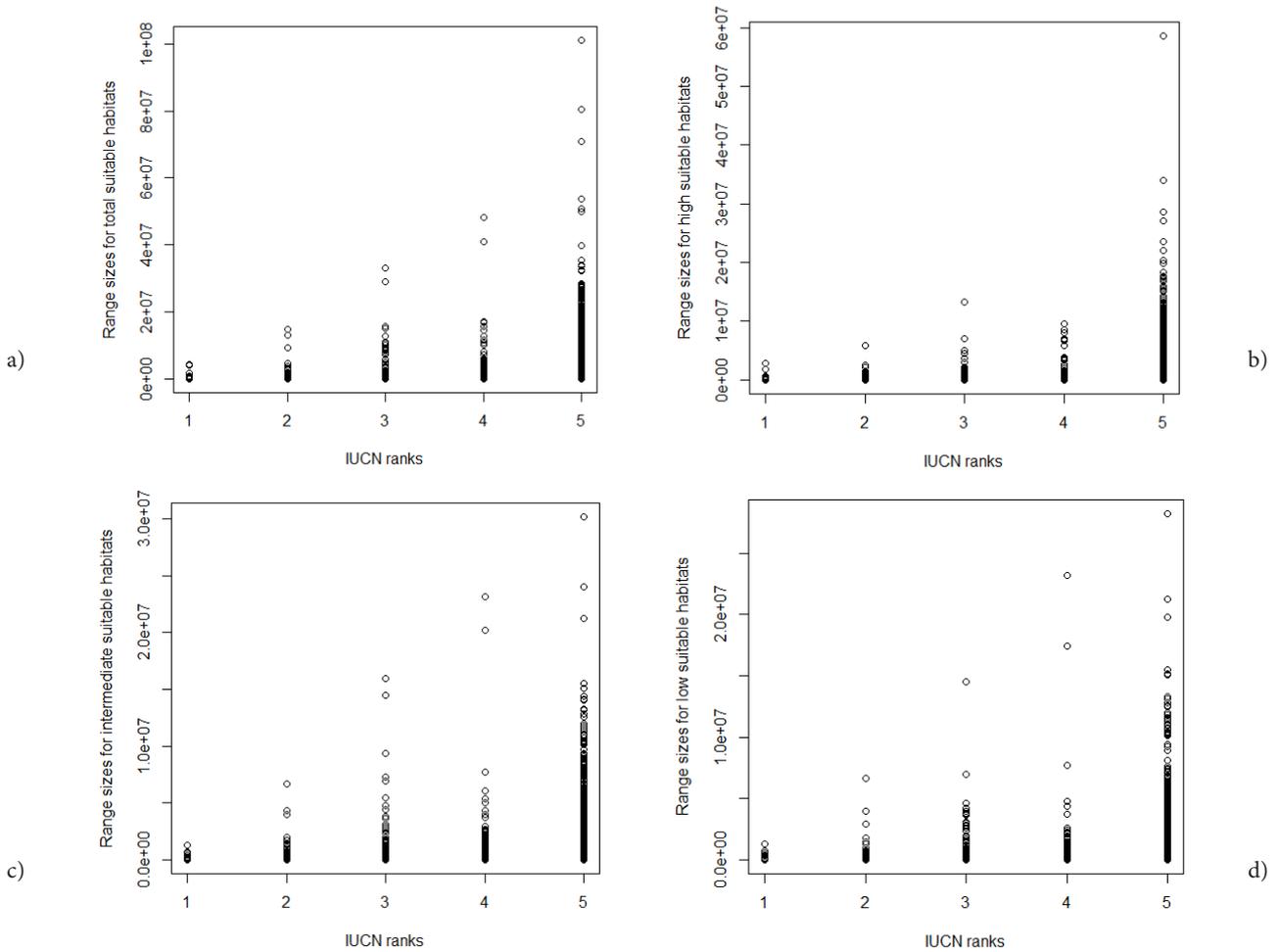


Fig. 1. The scatter plots showing the relationships between IUCN threatened status of global mammals and range sizes for total (A), high (B), intermediate (C) and low (D) suitability habitats.

low, intermediate, and high suitable areas of species are all significantly and positively correlated with IUCN threatened categories (Table 1; Fig. 1). The surprising positive correlation between IUCN-assessed extinction risk and low suitability range size is contrary to my primary prediction, which presumed that this correlation might not be significant.

These significant correlations are derived from the fact that one criterion of IUCN threatened status assessment relies on the total range size of species (<http://www.iucnredlist.org/>). As evident from the partial polyserial correlation analysis, these correlations remain persistently significant, even when the total range size of species is controlled of its influence on others (Table 2). Consequently, the range size from any quantities (high, intermediate, low or total suitability ranges) is an effective indicator of extinction risk of global mammalian species because the range sizes for low, intermediate or high suitability habitats are all independent from each other.

Consequently, the present study offers new insights into the estimation of extinction risk of species at a local setting. When the information of total range size of species is not available (for example, when only the distributional ranges of species at local, regional or country levels are available) or the research interests are on the local extinction risk of species, the utilization of partial areal sizes of distributional ranges of species in the limited marginal areas can be a possible way to evaluate the local extinction risk of species.

As such, the conservation priorities of a low suitability habitat range of species should be of equal importance as those for high and/or intermediate suitability habitat ranges. Global and climate changes might lead to a decline of core populations and habitat degradation (Fischer and Lindenmayer, 2007). In contrast, peripheral populations can have some opportunities to survive and expand through adaptive radiation (Schluter, 2000; Nielsen et al., 2001). As a consequence, a low suitability range of species may serve as refuges for the long-term persistence of the species in the context of intensive global change

(Nielsen et al., 2001). As a matter of fact, peripheral populations inhabiting low-quality habitats have been found to deserve certain conservation concerns as argued by many previous empirical studies (Lesica and Allendorf, 1995; Osborne et al., 2012; Peterman et al., 2013). Therefore, my present study further supports this statement from a macroecological perspective.

Of course, low suitability ranges may not be equivalent to the distributional margins of species because some interior ranges of distribution can be of low suitability for species to inhabit. My statement, asserting that the buffer zone of a nature reserve should be of equal importance as the core zone might be not accurate. However, in many real-world situations, low suitability ranges for species are typically located at the edges of distribution. This is because distributional edges or frontiers are the contacting areas between the individuals of focused species and other species. At these edge areas, individuals among different species face intensive interaction (Bahn et al., 2006), leading to the conclusion that they are not suitable for species to inhabit (thus in low suitability).

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