Are the most important tropical montane regions being prioritised for conservation?

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Summary: The need for conservation of species, particularly in vulnerable ecosystems such as tropical mountains, has resulted in numerous conservation prioritisation schemes. A 1km raster map of "bio-importance", giving each pixel an integer score of 0 - 6 based on the number of conservation priority schemes applicable, was used to assess the effectiveness of conservation priority schemes at prioritising areas of conservation value. Comparing the proportional ratios of area of each bio-importance class to biodiversity and geodiversity conserved by that class revealed bio-important areas are not prioritising more biodiversity or geodiversity than would be expected by area alone.

KEYWORDS: Geodiversity, conservation, biodiversity, GIS, conservation prioritisation.

1. Introduction

Mountains tend to be highly biodiverse when compared with lowland regions of similar size; the presence of many climatic zones in close proximity, leads to higher habitat heterogeneity and increased niche space (Korner, 2002). Biodiversity in the tropics tends to be higher than in temperate regions (e.g. Ding et al., 2006), so tropical mountains tend to be more biodiverse than their temperate counterparts and, when corrected for area, more biodiverse than adjacent lowlands (Hamilton, 2002). Tropical mountains are also of high conservation value due to their a-biotic diversity - this can be termed geodiversity; diversity in overall resource availability, spatial structure in resources and temporal variability in resources (Parks and Mulligan, 2010). These high levels of biodiversity and geodiversity mean tropical mountains are highly important, yet highly vulnerable ecosystems in urgent need of effective and strategic management (CBD, 2011).

Conservation need regularly exceeds available funding, resulting in pressure on conservation organisations to ensure available funds are spent effectively (Myers et al., 2000). Despite the need for global strategic monitoring and prioritisation (Faiths et al., 2008) there is little consensus over what should be conserved, with organisations often commissioning their own research to develop schemes tailored to their mission (e.g. WWF and the Global 200, Olson and Dinerstein, 1998). This results in a wide range of different conservation schemes, with 79% of the terrestrial surface of the earth being included in one or more of nine key prioritisation schemes (Brooks et al., 2006).

One technique to streamline this multitude of prioritisation schemes and assess the effectiveness of conservation prioritisation is to use a measure of bio-importance; this can be calculated by overlaying prioritisation schemes, with areas prioritised by a higher number of schemes earning a higher bio-importance score. Mulligan (2011) summed six different prioritisation schemes; WWF's G200 Ecoregions (G200, Olson and Dinerstein, 1998), Birdlife International's Endemic Bird Areas (EBAs, BirdLife, 2009a) and Important Bird Areas (IBAs, BirdLife, 2009b), the Wildlife Conservation Society's Last of the Wild (LOTW, Sanderson et al., 2002) and Conservation International's Biodiversity Hotspots (BH, Myers et al., 2000) and Key Biodiversity Areas (KBAs, Eken et al., 2004). These were selected to represent a broad range of prioritisation techniques, with measures of endemism (EBAs and Hotspots), conservation operational policy (IBAs and KBAs), ecology (G200) and pristineness (LOTW). These incorporate both proactive schemes (where priority is high and threat low as well as reactive schemes where priority and threat are high). Whilst none of the schemes specifically target conservation of evolutionary processes (Mace and Purvis, 2008), each represents a different aspect of biodiversity and / or ecology, so a high score on the combined overlay suggests an area is biologically important and threatened on a range of criteria.

This paper aims to investigate whether such 'bio-important' areas consistently prioritise areas of vulnerable biodiversity and / or high geodiversity. By comparing the proportion of overall biodiversity (as indicated by species richness overlays of IUCN redlist species for mammals and amphibians) and geodiversity (a measure of topographically induced environmental diversity) conserved per unit area for each class of bio-importance, the effectiveness of conservation prioritisation can be assessed. Regions deemed important on many prioritisation schemes would be expected to select a higher proportion of biodiversity or geodiversity than would be expected by area alone.

2. Methods

2.1. Study regions and data

Three study regions were selected, representing the three major tropical continents; each site consisted of a ten degree tile covering predominantly mountainous terrain. The South American site covered the majority of the Colombian Andes and was selected as it represents a wide range of topographic and climatic conditions and therefore has a broad range of geodiversity. The African site covers the Rwanda / Uganda / Democratic Republic of Congo border, whilst the South East Asian site covers Papua New Guinea. The latter were selected as they contain a large proportion of mountainous terrain.

Three data layers were required for the analysis; bio-importance, biodiversity and geodiversity. Bio-importance was calculated as outlined in the previous section (Mulligan, 2011); biodiversity was calculated as an overlay of IUCN distribution maps for mammals and amphibians (the only taxa for which maps were available at the time, IUCN et al., 2008a, IUCN et al., 2008b); geodiversity was calculated based on the theoretical model outlined in Parks and Mulligan (2010). These datasets were clipped to each of the three study areas (Figure 1).

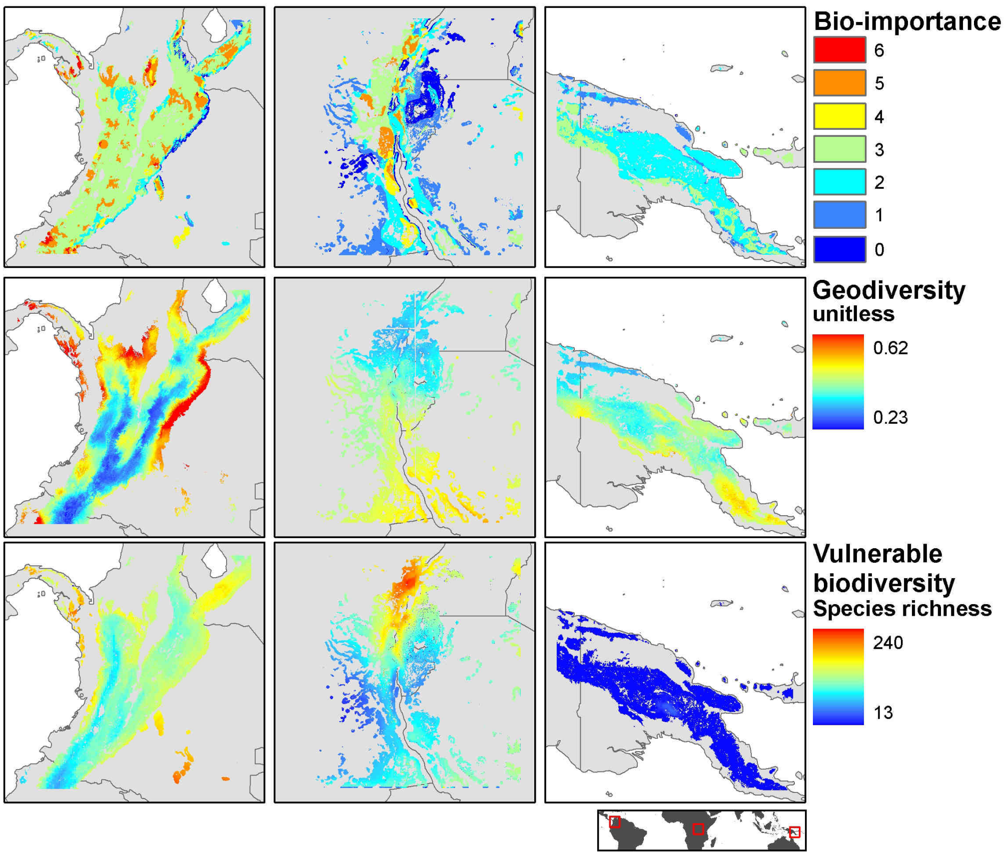

Figure 1. Data used in the analyses. The top row shows a measure of bio-importance (Mulligan, 2011) for each study site, the middle row shows geodiversity scores expressed as a process based implementation of (Parks and Mulligan, 2010), whilst the bottom row shows biodiversity (based on IUCN red-list distributions for mammals and amphibians at all threat ranges (IUCN et al., 2008a, IUCN et al., 2008b). Note that, whilst Papua New Guinea appears to have a lower overall species richness, there are high levels of endemism.

2.2. Work flow

For each study region, the proportion of total geodiversity and proportion of biodiversity conserved within each bio-importance class (0 – 6) was calculated (Figure 2). These proportions were then compared with the proportion of total area for each bio-importance class; if highly bio-important areas select for high levels of biodiversity or geodiversity it would be expected that higher bio-importance classes would have a ratio of greater than 1, whilst less bio-important areas would have a ratio less than 1.

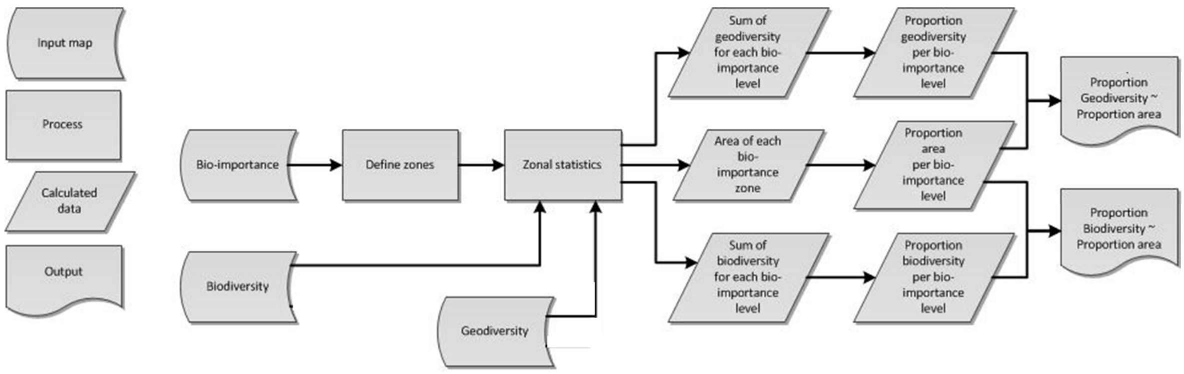

Figure 2. Work-flow implemented for each study region.

3. Results

The ratio of proportion area to proportion diversity within each bio-importance class is approximately 1:1 for both measures of diversity and across all three study regions (Table 1). The only exceptions to this are found in Papua New Guinea, where class 1 conserves biodiversity at a ratio of 0.555, whilst class 2 conserves biodiversity at a ratio of 0.876. When the proportions of biodiversity and geodiversity conserved within each class are compared with the proportion of area covered by each level, there is no significant difference across any of the study regions ($p = 0.99$ in all cases). When considering the relationship between increasing bio-importance and conservation efficiency, the strongest rank correlation found was between the proportion of biodiversity conserved per unit area and the bio-importance class, in Papua New Guinea ($r_s = 0.8$, $n=4$, Table 2).

Table 1. Ratio of biodiversity and geodiversity conserved per unit area at each of the bio-importance levels found within the three study sites. Values in brackets give the rank score based on the efficiency of conservation (i.e. conserving a higher proportion of diversity per unit area)

Bio-importance level	Colombia		Africa		Papua New Guinea	
	Biodiversity	Geodiversity	Biodiversity	Geodiversity	Biodiversity	Geodiversity
0	1.111 (3)	1.281 (1)	0.952 (6)	0.930 (7)	0.555 (4)	0.992 (2)
1	1.134 (2)	1.102 (2)	0.916 (7)	1.042 (1)	0.876 (3)	0.942 (4)
2	1.090 (4)	1.061 (5)	0.986 (5)	1.036 (3)	1.038 (1)	0.992 (3)
3	0.961 (7)	0.970 (7)	1.133 (1)	0.940 (6)	0.959 (2)	1.048 (1)
4	1.141 (1)	1.094 (3)	1.049 (3)	1.037 (2)	-	-
5	1.033 (6)	1.006 (6)	1.129 (2)	0.971 (4)	-	-
6	1.065 (5)	1.085 (4)	1.046 (4)	0.955 (5)	-	-

Table 2. Spearman Rank Correlation Coefficients (r_s) for ranked conservation efficiency at each bio-importance class.

Study Region	r_s Biodiversity~ Bio-importance	r_s Geodiversity~ Bio-importance
Colombia	-0.393	-0.536
Africa	0.643	0.036
Papua New Guinea	0.800	0.400

4. Discussion

Results suggest that bio-important areas, as a whole, are not conservation efficient; a somewhat concerning finding, given the need for economically efficient conservation. Whilst the ineffectiveness of conservation prioritisation methods is not an unprecedented finding (e.g. (Williams et al., 2000, Balletto et al., 2010), it is important to fully explore the limitations of the techniques implemented here before reaching such a conclusion.

Although the layers selected for the calculation of bio-importance represent different aspects of biodiversity conservation, it is possible that they may not be directly comparable. For example, LOTW covers large tracts of pristine habitats, meaning any given pixel in the dataset is more likely to be included in LOTW than KBA or IBA which are smaller, operational units. Future work evaluating the importance of each prioritisation scheme in determining overall bio-importance, and the impact of varying the definition of bio-importance on the analysis presented here, would prove valuable in further determining the collective effectiveness of conservation prioritisation schemes.

A further limitation of the analysis carried out here is that bio-importance may not be quantifying the measures used to assess conservation efficiency (i.e. mammal / amphibian richness, or geodiversity). This is particularly pertinent when considering taxon based prioritisation schemes, such as IBAs and EBAs, which target a taxa not included in the measure of biodiversity. Furthermore, whilst BH implicitly include "at risk" in their definition, other schemes included in bio-importance specifically prioritise pristine environments (LOTW) meaning areas included on these schemes probably do not specifically contain vulnerable biodiversity. This is somewhat overcome in the analyses presented here by also using prioritisation of geodiversity as a measure of success.

5. Conclusion

The key conclusion that can be drawn from this work is that, based on these analyses, there is little evidence of conservation efficiency within bio-important areas and limited support for a positive relationship between increasing bio-importance and increasing conservation efficiency. In order to provide increased evidence substantiating this conclusion, additional work on testing the effectiveness of conservation priority schemes against other measures of biodiversity should be carried out, along with further refinement of the definition of "bio-importance".

6. Acknowledgements

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8. Biography

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