Madagascar's extraordinary biodiversity: Evolution, distribution, and use

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Madagascar's extraordinary biodiversity: Threats and opportunities

Structured Abstract

Background

Madagascar is one of the world's foremost biodiversity hotspots. Its unique assemblage of plants, animals, and fungi – the vast majority of which evolved on the island and occur nowhere else – is both exceedingly diverse and highly threatened. Following human arrival, the island's entire megafauna became extinct, and large portions of the current flora and fauna may be on track for a similar fate. Conditions for the long-term survival of many Malagasy species are not currently met, due to multiple anthropogenic threats.

Advances

We review the extinction risk and threats to biodiversity in Madagascar, using available international assessment data as well as a machine learning analysis to predict the extinction risks and threats to plant species lacking assessments. Our compilation of global International Union for Conservation of Nature (IUCN) Red List assessments shows that overexploitation alongside unsustainable agricultural practices threaten 62.1% and 56.8% of vertebrate species, respectively, and each threatens nearly 90% of all plant species. Other threats have a relatively minor effect today but are expected to increase in coming decades, in particular climate change, invasive species, and infectious diseases. As only a third (4,652) of all Malagasy plant species have been formally assessed, we carried out a neural network analysis to predict the putative status and threats for 5,887 unassessed species, and to evaluate biases in current assessments. Our analyses show that the percentage of plant species currently assessed as under threat is probably representative of actual numbers, except for the ferns and lycophytes, where significantly more species are estimated to be threatened. We find that Madagascar is home to a disproportionately high number of Evolutionarily Distinct and Globally Endangered species.

This further highlights the urgency for evidence-based and effective *in situ* and *ex situ* conservation.

Despite these alarming statistics and trends, we find that 10.4% of Madagascar's land area is protected and that the network of protected areas (PAs) covers at least part of the range of 97.1% of terrestrial and freshwater vertebrates with known distributions (amphibians, freshwater fish, reptiles, birds, and mammal species combined), and 67.7% of plant species (for threatened species, the percentages are 97.7% for vertebrates and 79.6% for plants). Complementary to this, e*x situ* collections hold 18% of vertebrate species and 23% of plant species. Nonetheless, there are still many threatened species that do not occur within PAs or *ex situ* collections, including one amphibian, three mammals, and seven reptiles, as well as 559 plants, and more yet to be assessed. Based on our updated vegetation map, we find that the current PA network provides good coverage of the major habitats, particularly mangroves, spiny forest, humid forest, and tapia, but that subhumid forest and grassland-woodland mosaic have very low areas under protection (5.7% and 1.8% respectively).

Outlook

Madagascar is among the world's poorest countries, and its biodiversity is a key resource for the sustainable future and well-being of its citizens. Current threats to Madagascar's biodiversity are deeply rooted in historical and present social contexts, including widespread inequalities. We therefore propose five opportunities for action to further conservation in a just and equitable way (Fig. 0).

First, investment in conservation and restoration must be based on evidence and effectiveness, rather than simplistic area-based metrics, and tailored to meet future challenges through inclusive solutions. Second, expanded biodiversity monitoring, including increased dataset production and availability, is key to safeguarding Madagascar's most valuable natural assets.

Third, improving the effectiveness of existing PAs, for example through community engagement, training, and income opportunities, is more important than creating new ones. Fourth, conservation and restoration should not focus solely on the PA network but should also include the surrounding landscapes and communities. And finally, conservation actions must address the root causes of biodiversity loss, including poverty and food insecurity.

In the eyes of much of the world, Madagascar's biodiversity is a unique global asset that needs "saving"; in the daily lives of many of the Malagasy people, it is a rapidly diminishing source of the most basic needs for subsistence. Protecting Madagascar's biodiversity while promoting social development for its people is of the utmost urgency.

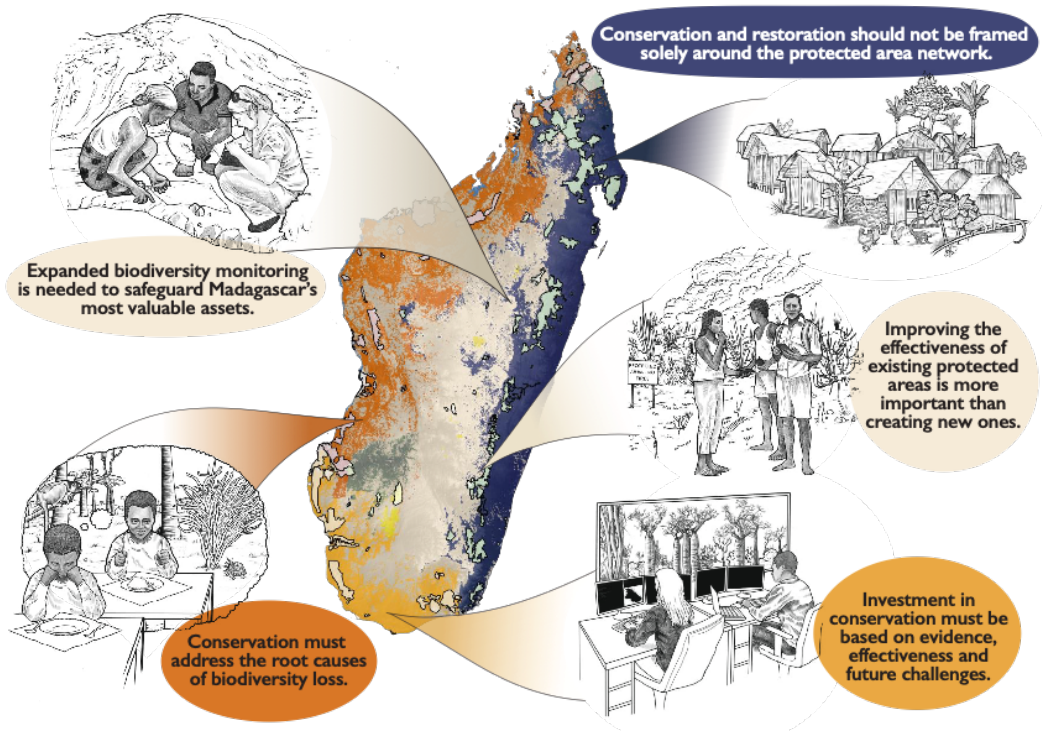

Fig. 0. Visual representation of five key opportunities for conserving and restoring Madagascar's rapidly declining biodiversity identified in this review. The arrows point to representative vegetation types where these recommendations could have tangible impact, but the opportunities are applicable across Madagascar. Colors correspond to vegetation types: dark orange = dry forest; light orange = spiny forest; yellow = tapia; dark gray = subhumid

forest; light gray = grassland-woodland mosaic; dark blue = humid forest; light blue = mangroves; black margin polygons = protected areas.