



## Original Research Paper

# Evaluation of Biodiversity Conservation Strategies for Maintaining Species Richness in Protected Natural Reserves

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| Key Words                                                                                                                                                                                                                                         | Abstract                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
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| Biodiversity conservation, Protected natural reserves, Species richness, Conservation strategies, Species diversity, Habitat protection, Reserve management, Endangered species Conservation, ecosystem Preservation, conservation Effectiveness. | The key mechanism for the conservation of species richness around the world is the creation of natural reserves; however, the management methods used for them greatly differ in terms of design and efficiency. This review will highlight the best biodiversity conservation strategies for maintaining species richness in protected reserves on the global level, based on systematic reviews, meta-analyses, and species-outcome research studies. The evidence suggests that reserves provide less habitat destruction compared to unprotected territories, but the effectiveness of sustaining species populations in them is much more diverse and depends on many factors, including financial support and socioeconomic situation. At the local scale, the results are clear in terms of comparing protected territories with the unprotected ones the former have more species richness and abundance than the latter. The species-outcome research studies on the threatened and endemic species suggest that the advantage of the reserves is especially clear on them. The broader analysis of conservation measures suggests that what matters in determining the success of conservation strategies is not the designation of areas but rather effective and resourced management, and the global assessment of extinction risks indicates that prioritizing critical areas of endangered species leads to higher conservation gains. This allows us to propose a strategy selection approach where the effectiveness and resourcing of reserve management become more significant than just expanding the area of reserves. |

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## Introduction

The establishment of natural reserves is one of the primary ways by which countries and international agencies attempt to preserve their biodiversity. However, while setting up a reserve is indeed a crucial step in preserving biodiversity, this may still not be enough in order to maintain the rich levels of biodiversity that are preserved through the creation of said reserve. There are many conservation actions that could be undertaken in order to keep the level of species richness constant within the reserve, including protection from land use changes, invasive species elimination, anti-poaching policies, and habitat restoration, among others, and these methods differ widely in terms of their effectiveness at preserving species richness.

## Habitat Protection as a Foundation Strategy

One of the most commonly observed advantages of protected reserves is their ability to decrease habitat loss compared to non-protected regions. A systematic review of the literature on effectiveness of protected areas showed that there was sufficient evidence for the role of protected reserves as providers of forest habitats and decrease of deforestation compared to non-protected matched controls, although the effectiveness of reserves in protecting species populations is far from being proven and varies greatly under different socio-economic circumstances such as governance capabilities, funding, and population pressure around the region (Geldmann et al., 2013). That is an important aspect to take into account when

evaluating the success of strategies; a reserve may be successful in achieving the goal of habitat protection but be unsuccessful in species richness maintenance due to insufficient resourcing.

## Local-Scale Species Richness

### Outcomes

Besides the aspect of habitat conservation, another way of testing the direct effect of having protected status in terms of species richness is through making comparisons on a local level between the protected and the non-protected sites. A global meta-analysis done on these comparisons shows that, generally, the protected regions have higher species richness and abundance compared to other land uses, but that this general effect conceals large variations influenced by management category, land use in the surroundings, and taxonomy of the region. This means that being formally designated as a protected area does not necessarily mean that there will be high species richness for that particular site (Coetzee et al., 2014). It thus changes the conservation policy question by identifying the specific management policies that cause the differences in richness outcomes among similar protected regions.

## Species-Specific Outcomes for

### Threatened and Endemic Taxa

Species-level richness measurements mask whether or not conservation efforts have been successful among the most endangered species, a question explicitly tested via citizen-science species occurrence data from eight tropical forests known for their biological diversity hotspots. It was revealed that there were

generally favorable impacts of conservation on the richness of birds species which were habitat-dependent, endemic within the hotspots or those classified as endangered despite there being no significant impact on the total number of bird species richness in the same landscapes due to protection (Cazalis et al., 2020). The fact that the impacts were largely associated with the effectiveness of protection in ensuring that the areas were shielded from habitat destruction and degradation suggests that the strategies that focus more on quality of habitats than the actual area of protection are responsible for species richness gains and that frameworks that use only the number of species may overlook the success of the conservation strategies.

### **Comparative Effectiveness of Conservation Interventions**

Considering the place of reserve-based approaches within the wider framework of the conservation intervention portfolio, the first-ever meta-analysis that compared the efficacy of many different interventions to biodiversity against realistic counterfactuals, involving 186 studies and 665 trials over more than a hundred years of practice, revealed that conservation interventions, encompassing the establishment and management of protected areas, controlling of invasive species, and restoring habitats, enhanced the status of biodiversity or at least stopped its degradation in almost two-thirds of cases when compared to no intervention (Langhammer et al., 2024). Such a meta-analysis showed that active management of protected areas was among those approaches that deserved the most attention in terms of resource allocation,

proving that the key factor influencing the outcomes for species richness was efficiency of management, not legal protection.

### **Funding and Staffing as Determinants of Strategy Success**

One thing that comes up again and again in the literature on reserve effectiveness is that whatever conservation approach has been selected to implement in a particular reserve, whether this involves antipoaching patrols, invasive species control, education, or habitat restoration, these are only going to result in gains in species richness if there is adequate funding and staffing to support them. Two reserves implementing the same approach will generate dramatically different species richness results according to whether or not there are enough patrols or staff to make it happen. This funding dependence may account for the observed consistency but variability in effect size observed when studies compare the impacts of protected vs. unprotected areas; here the conservation approaches are roughly the same across all the reserves being compared, but the degree to which they are actually implemented varies greatly due to the amount of funding and staff available (Geldmann et al., 2013; Coetzee et al., 2014)

### **Strategy Selection Across Management Categories**

Protected Areas vary in terms of the types of management involved, ranging from strict nature reserves that do not allow any human activity at all to multiple use reserves that allow regulated extraction and have other aims other than preservation of the ecosystem, and the best

conservation approach to ensure species richness would depend on the category of management involved. Strict nature reserves mainly adopt exclusionary approaches since they involve restrictions of human use and presence in order to minimize any direct impacts on the population, while multiple use reserves have no choice but to adopt an approach that manages human use in relation to species richness. Since the local scale species richness literature reveals that the type of management is one of the key determinants of the outcome of the management process, a reserve network that includes a variety of management types may require different conservation approaches based on the type of management involved (Coetzee et al., 2014).

### **Targeting Reserve Networks Toward Priority Sites**

As the number of resources available for conservation is limited, the decision regarding where the protection efforts need to be concentrated geographically also carries consequences on the results of the process in terms of increasing the number of species. A study conducted in regard to the trends in extinction-risk of species in 11,000 Important Bird Areas and 588 Alliance for Zero Extinction sites across the globe indicated that species present in the areas where there was a higher extent of protected-area coverage had a smaller rate of increase in extinction risk during the recent decades compared to other species, while the birds whose important sites were mostly within the boundaries of protected areas had about half as much increase in extinction risk (Butchart et al., 2012). At the same time, almost

half of all the important sites in regard to biodiversity remained without any kind of protection, which means that reserve expansion did not target the sites which have the highest number of threatened species.

### **Monitoring and Adaptive Management as a Cross-Cutting Strategy**

In all the conservation strategies discussed in this paper, whether they involve the creation of reserves or the selection of sites for conservation efforts, there seems to be a shared need for the ability to identify whether the applied conservation strategy is having the desired effect on species richness or not. If reserves adopt conservation strategy as a one-shot deal without continuously monitoring whether it works as planned or not, then they might be applying an inadequate strategy even though there has been ample proof that it does not do the job properly. The great amount of variation found in local richness comparisons and habitat loss reductions in various socio-economic settings indicates this problem. The idea of an adaptive management scheme, wherein species richness and habitat quality metrics are measured through time, and used for adjusting the management approach, would act as a cross-cutting strategy that could be employed irrespective of what type of conservation effort, anti-poaching campaign, exotic species management, or community engagement, the reserve in question relies on. The fact that the scientific literature on conservation actions suggests that active management is the single greatest determinant of

success among all types of interventions indicates that adaptive management by itself could prove to be a good strategy.

## **Regional and Taxonomic Variation in Strategy Effectiveness**

### **Tropical Versus Temperate Reserve Contexts**

The effectiveness of a particular conservation strategy to preserve species richness is not the same for different biogeographic regions, and information generated from tropical forest hotspots may not be readily applicable to temperate or arid regions. Conservation of tropical forests is faced with unique challenges such as increased rate of conversion of land around it, heavy dependence of the people living around it for forest products, and higher species richness, which makes richness measures less sensitive to the loss of specialist species, as demonstrated in tropical hotspot literature where richness was favored by threatened and forest dependent birds and not total birds (Cazalis et al., 2020). Temperate regions are faced with the challenge of low development of surroundings; thus, they have smaller species pool available in the region compared to tropical hotspots. In such circumstances, even small-scale efforts to conserve habitat could lead to higher percentage of local species richness compared to tropical hotspots (Geldmann et al., 2013).

### **Taxon-Specific Strategy Requirements**

Other conservation strategies, too, have different impacts on various taxonomic groups, which renders impossible the development of one universal strategy of preserving species' richness

in reserves. Species that are widely distributed and exist at low densities – large carnivores and migratory birds, in particular – need strategies that go beyond reserve boundaries and include landscape-scale connectivity and transboundary coordination, while small-bodied and resident species like many invertebrates and understory plants might be more sensitive to the quality of habitat inside the reserve. Taxon-specific variations could be an explanation of why the species-outcome evidence cited above revealed significant positive effects for endemic and threatened forest birds but failed to demonstrate similar results regarding the richness of all bird species in the same reserves (Cazalis et al., 2020). Different conservation strategies might be effective for different taxa within one and the same set of reserve boundaries.

## **Discussion**

Based on this synthesis, several strategic implications are evident in the maintenance of species richness within reserves. First, habitat protection while necessary is an insufficient strategy because while the former can consistently prevent habitat destruction, the latter is inconsistent in preserving species populations, meaning that habitat protection has to be done with management action and cannot be the end goal in itself (Geldmann et al., 2013). Second, the large amount of context dependency found in the outcomes of species richness makes the predictors of success such as management type, funding, and adjacent land uses better predictors of success rather than protection status (Coetzee et al., 2014). Third, the species-level evidence suggests that habitat quality-oriented strategies

provide benefits especially for endangered and endemic species in spite of seemingly lackluster outcomes on richness metrics (Cazalis et al., 2020). Lastly, the conservation action evidence base clearly suggests that only active management investments rather than designations are associated with positive outcomes in biodiversity (Langhammer et al., 2024). Finally, the consistent difference between reserve coverage and the position of globally important biodiversity sites suggests that future focused protection of such priority sites will produce higher gains in species richness compared to continuing undirected increases in the number of protected sites (Butchart et al., 2012).

## Conclusion

Sustainability of species richness in protected natural reserves is less dependent on the presence of official protection and more dependent on the particular approach used within the reserves, including efficient management, habitat quality and targeted focus of the reserve network on the sites of high conservation importance. The evidence from habitat protection, comparison of local richness, particular species and the efficiency of interventions all point in the same direction: management and targeted approach, rather than area-based increase, is what can ensure sustainable species richness in protected reserves.

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