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# Are we ready for biodiversity offsetting?

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**Significance:**

Biodiversity offsetting is a last-resort scheme to prevent biodiversity loss due to development. However, measuring biodiversity is a complex endeavour, even more so in hyperdiverse landscapes. With few South African scientists able to comprehensively measure biodiversity, assuming equivalence between sacrificial and offset areas would be problematic and potentially fatal. Caution is required as the erosion of our unique biodiversity is at stake. We advise that a panel of biome-specific experts and data modellers unite to provide tools for more accurate trade-offs, based on functional diversity. In the meantime, the value of focusing on landscape heterogeneity is highlighted.

## Biodiversity offsetting: Ideals vs reality

### *Background*

South Africa's National Biodiversity Offset Guideline, Government Gazette 48841 (Notice No. 3569), was published on 23 June 2023. Biodiversity offsets are designed to compensate for residual biodiversity loss after a development's initial avoidance or minimisation plans were deemed ineffective. These guidelines heeded national calls to mitigate increasing ecosystem losses even more intently, as outlined in the National Biodiversity Assessment 2018.[1]

Aligned with the *National Environmental Management Act* (NEMA), biodiversity offsets may be triggered during the environmental impact assessment (EIA) process. Draft and implemented provincial offset guidelines have been around for more than a decade. However, now EIA practitioners and other environmental services have a nationally standardised framework to work from, and all regional authorities can request biodiversity offsetting where deemed necessary. Effectively, it is a last-resort tool to ensure national environmental management law compliance, whose objective is to ensure a healthy environment for all: "When designed well, a biodiversity offset system may provide opportunities for the achievement of ecological integrity, economic efficiency and social justice"[2].

### *Ideally*

Biodiversity offsetting mainly intertwines a no-more-loss philosophy with the polluter-pays principle. During the Anthropocene, we can no longer allow ruthless profiteering that contributes to ecological and societal collapse. Publishing these national guidelines is testament to the ongoing efforts by policymakers and legislators to align South Africa with good global environmental practice, putting us on par with global trends in combatting the biodiversity crisis. Where developments are fatally flawed – that is, there is irreplaceable loss of species and no vetoing public interest in the project – losses can not be offset. The proposed area would be declared an area unsuitable for development (a no-go zone) for the foreseeable future. However, in the event offsetting is prescribed, the ethical and ecological principles behind it are not straightforward.

### *Reality*

Potential ethical and implementation issues around biodiversity offsets have been comprehensively detailed in general[3], and for South Africa in particular[4,5]. From these works, and references therein, there is a clear warning of the likelihood of abuse. Most worryingly, deceptive marketing, popularly known as greenwashing, becomes more plausible when complex-to-grasp policies such as biodiversity offsetting are implemented. Reviewing biodiversity offset policies across Australia, Maron et al.[6] highlight that, by not clearly communicating to stakeholders what constitutes no net loss or gain, biodiversity might still be declining in some regions, so no net loss does not equate to no more loss – society might be misled by believing they are biodiversity secure in the future, encouraging these policies. Concerns around non-additionality and leakage are also important to recognise[5]: double counting of conservation gains is possible if developers buy offset land already earmarked for conservation by governments (non-additionality), and, if large tracks of land are removed as offset areas, adjacent ecosystems might bear the brunt of increased human activity to compensate for this 'loss' (leakage).

Many of the caveats of biodiversity offsetting originate from the fact that when biodiversity becomes a commodity, species and ecosystems will become priced credits with which to buy deemed-equivalent land. This is redefining non-human life as inherently movable or interchangeable at a cost (value), as determined by humans, simplifying the complex (hyperdiverse) reality.[7] Powerful economic incentives also may override even fatally flawed development concerns, such as where large-scale road and housing infrastructure are required to resettle rural people closer to the free market, regardless of what stands in the way.[8] Thus, in lieu of an evidence-based, more transparent decision-making framework, biodiversity offsetting is likely to have unintended and counterproductive consequences: a gameable incentive system is likely to be, and has been, exploited by people for financial gain.[3]

A focus on biodiversity offsetting might overshadow our more immediate restoration needs. Finance instruments to help unlock biodiversity offsetting potential already exist, such as the UN's Biodiversity Finance Initiative, even though current restoration projects may suffer from sustainable funding issues. It has been suggested that one would need about 50% intact nature to retain a 'safe' percentage of biodiversity.[9] Below this threshold, ecosystems are compromised, and an area would struggle to provide the full breadth of ecosystem goods and services, impacting the well-being of humans and other species.[9] Some South African vegetation types already fall short of this level (>50% transformed).[10] We should first recoup our losses by rehabilitating as much degraded land as possible.

Ecosystems with less than 50% remaining should be considered unsuitable for offsetting from the start. South Africa has regions such as the Cape Winelands, with many critically endangered vegetation types[10], that have seen high levels of 'semigration', placing increasing pressure on terrestrial and freshwater resources. If we accept a 50% safety threshold, most new development there would be stopped, regardless of framing the development as ecologically sensitive. For example, in South Africa, some 'eco-estates' technically contribute to de-greening or urban sprawl.[11] Moreover, if offsetting is allowed in such threatened landscapes, which mechanisms are in place to safeguard any offset agreement should a land user become insolvent? For highly impacted biomes, a focus on restoration rather than offsetting losses would be advised. For example, an existing residential estate can become more ecologically minded, instead of creating new versions on irreplaceable biodiversity. However, development will remain key in South Africa to pursue a more equal and healthy society. Hence, we can expect biodiversity offsetting to be increasingly implemented.

Are we equipped to implement well-informed, future-proof biodiversity offsetting schemes to counteract these anticipated future losses? Currently, there is no apparent evidence to support this debate at a national level. Counterfactual thinking, or the outlining of all alternative scenarios should a conservation measure be implemented or not, is a powerful tool to assess the likelihood of achieving conservation success. For biodiversity offsetting, we now know that a range of counterfactuals is necessary to evaluate its efficacy to achieve set biodiversity conservation ideals.[12] The fact that a range of counterfactuals is required to fill the expected gradient of outcomes, neatly fits the call for more robust metrics integrating multiple aspects of biodiversity science, acknowledging ecological complexity.[13] Then there needs to be rapid transfer of this and future-found knowledge to all practitioners nationally.

Knowing if we can sufficiently measure biodiversity, or ecological complexity, is of fundamental importance; without doing so, insufficient baseline sampling is likely to exaggerate the real impact of offset areas on ecosystem goods and services.[6] Well-established carbon-offset markets were recently exposed to be greatly flawed in modelling impacts on deforestation.[14] Key weaknesses identified were finding a true control or equivalent site to measure performance against when in a biophysically diverse biome and not incorporating, or having foresight, of the temporal changes in drivers of ecosystem change – natural or anthropogenic. This negative outcome has essentially knocked confidence in such schemes – an error one cannot allow for biodiversity offsets when dealing with irreplaceable biodiversity.

## Can we reliably measure biodiversity?

### *Ecological complexity in hyperdiverse South Africa*

Biodiversity studies are often fixated on the loss of specialist, rare species, or species of special concern. Their presence clearly red flags the potential for extinction prevention. Yet, these specialist species often rely on a mutualistic network of generalist species to lower environmental flux.[15] A decrease in the ecological dynamics that helped shape hyperdiverse landscapes would lead to a proportionate decrease in available ecosystem services.[16] Although species vulnerability data are clearly important, many records might be outdated, and others need validation. For example, very few species are Red-Listed based on quantitative data, with land-cover quality (habitat loss) the determining factor predicting their extinction.[17] Moreover, most Red-Listed species are vertebrates and plants, with little information on two major ecosystem-engineer groups: insects and fungi.[17] Soil biota can significantly enhance ecosystem resilience.[18] Yet, these microbes and their interaction networks are difficult and costly to detect. They also require much longer time scales to ascertain than those afforded in the EIA process. Nonetheless, it is exactly this ecological complexity, especially an understanding of the natural dynamics of species interactions, that needs to be measured and assessed for truly society-friendly biodiversity offsetting.[19]

Biodiversity offsetting is thus likely to focus on alpha diversity – counting and comparing the number of species per site – due to its relative ease. This instead of functional diversity, which would more appropriately determine if there is a like-for-like replacement of ecological processes and, ultimately, ecosystem goods and services. The idea of no more loss might be difficult to execute if assessments are based on species lists of a few charismatic, easy-to-measure species. It becomes even more problematic when exchanging diversity across hyperdiverse biomes, such as fynbos and grasslands. Equivalence is extremely difficult to establish without knowing the extent of what needs to be conserved in the landscape. There are very few scientists currently in South Africa who can calculate total biodiversity to a high degree of certainty, let alone independent consultants who require such knowledge transfer from academia to implement these policies in the field.

### *Caveats of basing offsetting on species richness instead of intactness*

Intact biodiversity is associated with more stable and efficiently functioning ecosystems. The general argument is that a decrease in plant species numbers leads to a decrease in ecosystem stability, and hence plant species diversity could indicate ecosystem intactness in a given area.[20] A study of montane grasslands in KwaZulu-Natal, South Africa showed that, in 18 intact grassland patches, species richness ranged between 40 and 90.[21] Developing the lower richness area (site with 40 species) and offsetting the area with 90 species, could be seen as representing a biodiversity gain. Yet this is misinformed without knowing whether the area with 40 species represents a unique community and the site with 90 species is bolstered by generalist species. In fact, for the studied montane grasslands, it was abiotic heterogeneity – a gradient of ecosystems – and not species richness that performed better in helping to conserve multiple functional groups.

### *Recognising the third dimension: Topography*

It is known that lowland areas are more impacted than sloped, mountainous areas. Conditions are tough at the top, typically harbouring species adapted to colder, windier, and drier conditions. These areas are naturally less preferred for development due to logistical and engineering problems associated with steep slopes, and far from ideal for any large-scale residential development. Thus, trading up the slope would be inaccurate, even if the sites are within a short distance of each other. We should avoid an archipelago-like remnant distribution, where mainly high-lying biodiversity is offset, effectively leading to isolated intact 'islands' in an inhospitable 'sea' of degraded ecosystems.[22]

### *Is ecosystem degradation a good proxy for habitat loss?*

The biodiversity offset guidelines do state one has to also describe the level of ecosystem degradation as a surrogate of intactness (the extent of natural biodiversity left in each ecosystem[23]). Qualitative measures of degradation will vary among observers and in time. Offsetting between ecosystems may also be problematic considering the temporal nature of a disturbance. A grassland disturbance may disappear in a year's time, but in the karoo, the same disturbance might take a century to recover from (*sensu* Bailey[24]). Thus, whereas ecosystem intactness can be measured more reliably in time, degradation can be fleeting. Understanding the spatial and temporal scale of the disturbance that caused any deemed degradation is crucial, as the offset ratios are ultimately dependent on accurate assessments of the current state of the offset area.

Lastly, any observed degradation, such as biological invasions, should not be used as an argument to relieve the offset ratio; rather, it should trigger rehabilitation efforts. Indeed, to rectify or remain within safe ecosystem boundaries in time, preserving intactness and restoring as widely as possible is the first prize.[23] For accurate biodiversity offsetting, it would make more sense to assess ecosystem intactness; that is, the offset ecosystem must contain similar natural heterogeneity to the to-be-developed area.

## Potential solutions

### *Focusing on landscape heterogeneity: The role of specific landscape features*

Specific landscape features – e.g. water bodies, decaying logs in a forest, riparian zones, rocky outcrops, or a hilly topography – are often associated with specific biotic communities compared to the matrix. Vegetation mapping often does not include the whole complement of these features, and especially not 'small natural features', which have significant ecological influence disproportionate to their size.[25] In highly disturbed environments, specific landscape features can be perceived as too small or insignificant in the larger landscape due to their extent. Yet many features are important refuges for a variety of species, such as rockiness as protection against fire in hyperdiverse South African grasslands.[21] The result is that specific features are often unappreciated due to insufficient documentation of their existence and value, and are thus vulnerable to degradation, some even at risk of complete destruction.[25]

The implication for biodiversity offsetting is that the offset areas should be similarly heterogeneous in landscape features to the sacrificial ones. Conversely, the traded patches should be similar ecological regions (ecoregions), indicating homogeneous ecosystem types. Similar ecoregions would ensure that the quality and quantity of the total environmental resources are maintained, and thus also the customary ecosystems goods and services.[26] Loss of these features must not be negotiated but explicitly included, even if they were introduced at some stage to aid in biodiversity conservation. Considering landscape heterogeneity in all biodiversity conservation plans is crucial.

### *Open-access web tools constructed by expert ecologists and data modellers*

As it is impossible to include all species in offsetting assessments, bioindicators are often used. They are great measures of environmental stress, although they are less well developed as biodiversity indicators. Biodiversity science is a complex and dynamic discipline, with better methods and data analysis tools constantly emerging. Furthermore, the statistics necessary to do these analyses would be daunting to many individual specialists and authorising agencies. In support of calls for capacity building[4], we suggest expert ecologists and data modellers work more closely together to simplify biodiversity assessments for all stakeholders involved in biodiversity offsetting. For example, workshops consisting of experts in each biome, together with ecological data modellers, could create an online platform to calculate the thresholds of offsetting, which are especially important when traversing ecosystems. Documenting the functional diversity of each site also needs to be explored. Sites with higher functional diversity and divergence are more likely to have higher ecosystem service contributions and the sites themselves to have long-term resilience. Surrogacy is the best we have at present, but a no-more-loss principle requires more evidence-based methods with fewer assumptions. Make no mistake, this is an immense task.

## Conclusion

Multiple ecosystems can exist within a vegetation type. Accounting for the variety of ecosystems, no matter how small, would more accurately depict intactness and thus landscape resilience. Only after recognising and implementing such a finer-scale approach nationally, would we get a more representative idea of the breadth of ecosystem services one stands to lose or gain by biodiversity offsetting. To make offsetting easier for environmental practitioners, a cost-saving for developers, and more reliable, an evidence-based, expertly modelled, continuously updated tool, specifically designed to measure biodiversity offsetting, would be beneficial to add to the existing national biodiversity assessment toolbox. Such a tool would require only minor oversight by the appointed specialist and competent authority. In the meantime, a focus on special landscape features – abiotic and biotic landscape heterogeneity – would aid biodiversity inventories.[25] Being visually easy to identify, landscape features allow for a variety of differently trained consultants to standardise their approaches. This standardisation must be communicated more clearly and widely; it must be instilled in the process.

South Africa is a country on the rise, and this means more development is inevitable. As biodiversity offsetting is predicted to increase after publishing the official, national guidelines, we need to ask the tough questions: Are we ready to implement these guidelines nationally? Are quick-and-dirty reports regarding only a few species or groups, where time constraints inhibit proper investigation, leading to merely qualitative likelihood synopses? To truly achieve the aims of biodiversity offsetting, more discussion, workshopping, and efficient distribution of practical tools for South Africa are necessary. The cost of getting offsetting wrong, is the erosion of our unique biodiversity.

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## Declarations

We have not used any type of AI for the writing of this manuscript. Both authors read and approved the final manuscript.

## Competing interests

We have no competing interests to declare.

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