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OPINION

Getting the biodiversity intactness index right: the importance of habitat degradation data

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Abstract

Given high-level commitments to reducing the rate of biodiversity loss by 2010, there is a pressing need to develop simple and practical indicators to monitor progress. In this context, a biodiversity intactness index (BII) was recently proposed, which provides an overall indicator suitable for policy makers. The index links data on land use with expert assessments of how this impacts the population densities of well-understood taxonomic groups to estimate current population sizes relative to premodern times. However, when calculated for southern Africa, the resulting BII of 84% suggests a far more positive picture of the state of wild nature than do other large-scale estimates. Here, we argue that this discrepancy is in part an artefact of the coarseness of the land degradation data used to calculate the BII, and that the overall BII for southern Africa is probably much lower than 84%. In particular, based on two relatively inexpensive, ground-truthed studies of areas not generally regarded as exceptional in terms of their degradation status, we demonstrate that Scholes and Biggs might have seriously underestimated the extent of land degradation. These differences have substantial bearing on BII scores. Urgent attention should be given to the further development of cost-effective ground-truthing methods for quantifying the extent of land degradation in order to provide reliable estimates of biodiversity loss, both in southern Africa and more widely.

Keywords: biodiversity intactness index, biodiversity loss, land cover, land degradation, remote-sensing, South Africa

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Introduction

At the 2002 World Summit on Sustainable Development, growing concern about the continued loss of wild populations, habitats, and the benefits they confer on human society prompted signatories to the Convention on Biological Diversity (CBD) to commit themselves to achieving a significant reduction in the current rate of biodiversity loss by 2010 (United Nations Environment Programme, 2002a). An even more ambitious target – of halting declines by 2010 – has been agreed by the European Union (European Council, 2001). However, monitoring progress towards achieving these targets represents an enormous scientific challenge (Balmford *et al.*, 2005a, b). While the CBD has identified eight indicators for immediate testing and a further 10 for development (United Nations Environment Programme, 2004), most of these rely on data collected for other purposes, and as a result are inevitably unrepresentative geographically, taxonomically, and in terms of habitat types (Balmford *et al.*, 2005b).

Against this background, Scholes & Biggs (2005) recently proposed a new biodiversity intactness index (BII). Their approach centres around gathering expert opinion on how the typical population densities of each

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of a broad range of taxonomic and functional groups change with increasingly intense land use, relative to their premodern densities (assumed to correspond to those currently found in large protected areas). These profiles of changing density are calculated separately for each group and major biome. They are then combined with information on the species richness of each group in the biome and with remotely sensed data on the extent of each land-use class in the biome, to derive richness- and area-weighted BII scores. Focusing on southern Africa, the authors demonstrate that by using expert judgements rather than detailed species-by-species population data, an overall, region-wide BII that is representative of all major biomes, and of plants as well as four vertebrate groups, can be estimated in a matter of weeks. The BII, thus, provides a powerful, scaleable and readily understood complement to more detailed and direct, but taxonomically narrower, measures of population change (Butchart *et al.*, 2004; Gregory *et al.*, 2005; Loh *et al.*, 2005).

We believe that the approach advocated by Scholes & Biggs (2005) has considerable potential. Nevertheless, we are also struck that, with an estimated overall value of 84%, and annual change during the 1990s of $<0.1\%\ \mathrm{yr}^{-1}$, the overall BII for southern Africa gives a far more positive picture of the changing state of wild nature than other large-scale estimates. These suggest that as a global average, roughly one half of wild populations and habitats have already been lost, and that declines continue at around 0.5–1% yr^{-1} (Harrison & Pearce, 2000; United Nations Environment Programme, 2002b; Balmford *et al.*, 2003; Mace *et al.*, 2005). Here we explore this discrepancy, and specifically examine whether the BII score for southern Africa could be an artefact of the coarseness of the information on land degradation used by Scholes & Biggs (2005).

Land degradation, largely through overstocking, is the main cause of biodiversity loss across southern Africa. Despite this, based on remotely derived land cover and NDVI data (which were mapped less accurately for degraded habitats than for other land-use classes – Fairbanks *et al.*, 2000). Scholes & Biggs (2005) estimate that 78% of southern Africa is under what they term moderate (or 'light') use ('within. . .carrying capacity'), while only 2% is degraded. This low estimated level of degradation means that the region-wide BII, as calculated by Scholes & Biggs (2005), is in turn dominated by population densities associated with light land use, which experts suggest are only slightly lower than in large protected areas. However, quantifying land degradation remotely is notoriously difficult (e.g. Pickup & Chewings, 1994), and we suggest that the 2% figure for degradation is a serious underestimate.

Based on two ground-truthed studies of areas not generally regarded as exceptional in terms of their degradation status, we demonstrate here that Scholes & Biggs (2005) might have seriously underestimated the extent of land degradation in southern Africa. We go on to show that this may have important implications for the resultant BII scores, and that the overall BII for southern Africa is probably far lower than 84%.

Methods

We revisited the BII calculations for two areas within southern Africa where detailed land-use data exist. The first one consists of 20 730 km^2 of solid (i.e. continuous canopy) thicket, classified as 'savanna' biome in Scholes & Biggs (2005). LandSat imagery with field verification was used to quantify land transformation (Lloyd *et al.*, 2002). The second area consists of 19 370 km^2 in the Little Karoo, falling within the 'shrubland' biome in Scholes & Biggs (2005). Land degradation there was quantified using a novel technique, based on intra-annual variance in NDVI values, calibrated for different vegetation units mapped at 1 : 50 000 scale, and ground-truthed via expert assessment (Thompson *et al.*, 2005). Both studies generated a land-use map with the following categories: urban areas, forestry plantations, cultivated areas, severely degraded areas, moderately degraded areas, and pristine and protected areas. Note that in both study areas, degradation is attributed to the impacts of livestock grazing and browsing.

The BII is a species richness- and area-weighted index of the impacts of a set of land-use activities on populations of a given group of species. For a specific biome, the BII is calculated as

$$\mathrm{BII} = \left(\sum_i \sum_j R_i A_j I_{ij}\right) \Big/ \left(\sum_i \sum_j R_i A_j\right),$$

where R_i is the richness of species group i, A_j the area of land use j and I_{ij} the population impact on species group i of land use j.

For each study area (solid thicket and Little Karoo), we calculated a local BII based on published estimates of R_i for the area, estimates of I_{ij} from Scholes & Biggs (R. Biggs, personal communication), and estimates of A_j from either Scholes & Biggs (2005) or from the local land-use study. We used the same species groups, namely, plants, mammals, birds, reptiles, and amphibians.

Results and discussion

The two fine-scale and ground-truthed studies provide compelling evidence that Scholes & Biggs (2005) may have significantly underestimated the extent of degradation in southern Africa. In the case of the solid thicket, according to the local study only 25.1% was classified as intact (protected and pristine combined), and 72.4% as degraded (33.3% moderately, 39.1% severely; the remainder was cultivated, urban or plantation) (Fig. 1a). In marked contrast, Scholes & Biggs (2005) identified 93.2% of the same area as intact (protected and light-use classes combined), and only 3.1% as degraded. Almost half of the area assessed by Scholes & Biggs (2005) as under light use (and thus 'largely intact') was classified by the fine-scale study as being severely degraded, having 'lost all its functionality' (Lloyd *et al*., 2002).

Similar discrepancies emerged for the Little Karoo. The fine-scale study classified 32.6% of the study area as protected or pristine, and 56.9% as degraded (44.5% moderately, 12.8% severely), compared with values of 89.6% (protected and light use) and 2.7%, respectively (Fig. 1b) (Scholes & Biggs, 2005). Most of the area classified by Scholes & Biggs (2005) as being under light use, was assessed as degraded in the fine-scale study.

The results of these two fine-scale studies are consistent with earlier qualitative and semiquantitative assessments of livestock-induced degradation across South Africa as a whole (Hoffman, 1997; Hoffman *et al*., 1999). Using magisterial districts as the units of analysis, and expert knowledge as the source of information, Hoffman & Ashwell (2001) categorized more than 40% of South Africa as severely or moderately degraded by livestock grazing, the remainder being categorized as lightly or insignificantly degraded. This analysis, albeit crude, is thus, vastly different from that of Scholes & Biggs (2005) who estimate only 4.9% of South Africa as thus degraded.

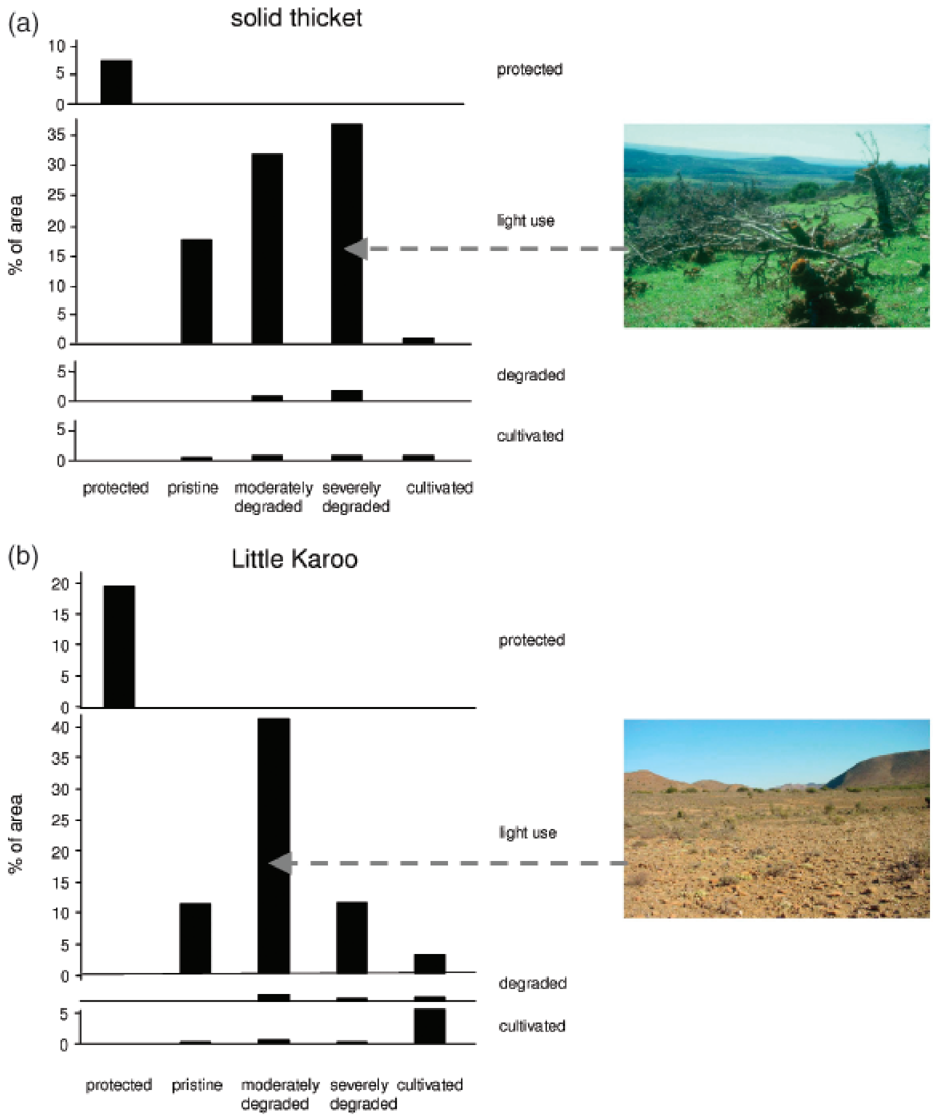

Fig. 1 Differences in land-use classification using coarse national land cover (classes on the y-axis) and ground-truthed fine-scale data (x-axis) in (a) solid thicket and (b) the Little Karoo. Urban and plantation classes have been omitted because they cover $<1\%$ of the areas.

Table 1 Changes in BII values based on fine-scale land use (local study) vs. broad-scale land use (Scholes & Biggs, 2005) in the solid thicket and the Little Karoo

Solid thicket				Little Karoo		
Species group	Species richness	BII (local)	BII (Scholes & Biggs)	Species richness	BII (local)	BII (Scholes & Biggs)
Plants	1588	67.2	91.2	2800	64.4	84.8
Mammals	106	50.9	75.0	75	58.3	74.2
Birds	349	65.9	97.2	250	74.9	104.9
Reptiles	83	77.5	93.4	50	75.2	90.6
Amphibia	27	81.9	98.1	15	88.7	121.6
All taxa		66.8	91.5		65.4	86.5

BII, biodiversity intactness index.

These land-use discrepancies in turn have substantial bearing on BII scores. Based on land-use data from Scholes & Biggs (2005), and richness estimates for the solid thicket, combined with the experts' density estimates for the savanna biome, we calculated a BII for solid thicket of 91.5% (Table 1). However, incorporating the fine-scale land-use data into the BII computation, and treating moderately and severely degraded classes as degraded, the BII for solid thicket dropped to 66.8%. Similarly, using fine-scale land-use data for the Little Karoo produced a BII of 65.4%, as opposed to an estimate of 86.5% based on Scholes & Biggs (2005).

It is very important to note that the two areas we have focused on are not unusually degraded in a regional context (Hoffman, 1997) – they are simply the only areas we know where detailed land-use studies have been conducted. By Scholes & Bigg's (2005) own estimates, degradation in these areas is only slightly higher (at 3.1% and 2.7%) than their region-wide average (2%). In terms of Hoffman & Ashwell's (2001) assessment, solid thicket and the Little Karoo correspond mostly with magisterial districts categorized as moderately or lightly degraded. Districts dominated by severe degradation are concentrated elsewhere in South Africa, particularly in the communal lands of the eastern seaboard and in the north of the country, as well as in the semidesert regions of the western interior. Therefore, we have no reason to believe that the discrepancies we found between coarse and finer-scale studies, in terms of estimates of the extent of degradation, are not typical of the region as a whole.

Given the widespread importance of land degradation as a threat to biodiversity, our results highlight the value of detailed land-use surveys. We believe that these are essential to the meaningful quantification of one of the major drivers of biodiversity loss, and to the accuracy of potentially powerful compound measures such as the BII. Fortunately, the two local-scale studies highlighted here were not expensive, costing around $11 000 each and taking less than a year to complete. We conclude that extending similar methods to many other areas, and thereby reducing our reliance on avoidably crude land-use data, would be a very valuable contribution to tracking progress against the 2010 target and beyond.

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