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Short Communication

The role of private conservation areas in biodiversity representation and target achievement within the Little Karoo region, South Africa

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A B S T R A C T

It is becoming increasingly difficult to manage and expand statutory conservation areas (i.e., parks and formally protected areas). Therefore, alternative opportunities for land conservation merit closer attention. This paper examines the extent to which privately owned conservation areas contribute to biodiversity representation. Gap analyses were performed for a large semi-arid region in South Africa with a comprehensive database of private conservation areas. The distribution of private conservation areas was compared to statutory conservation areas using several landscape characteristics: biome and vegetation variant, elevation class, ecological process area, total area, and threat status (endangerment). Conservation target achievement for the vegetation variants was also assessed, as was the degree to which private conservation areas complemented statutory conservation areas by representing different landscape characteristics. The number of targets achieved nearly tripled if private conservation areas were considered in addition to statutory conservation areas. Further, private conservation areas significantly complemented statutory conservation areas in the types of biomes, elevation classes, and threat status classes conserved. Private conservation areas were especially important in conserving lower elevation habitat, and by association, endangered vegetation. This particular relationship is expected to be common worldwide. Our results indicate that private lands conservation deserves an increased allocation of resources for both research and implementation.

1. Introduction

The use of statutory conservation areas (SCAs) has been the cornerstone of biodiversity conservation strategies in most countries of the world. Unfortunately, the global protected areas network is far from reaching its goal of comprehensively conserving biodiversity (Brooks et al., 2004; Rodrigues et al., 2004b). In a global gap analysis, only 26% of the 11,633

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vertebrates were represented to target levels in protected areas (Rodrigues et al., 2004a). Even though the global network of SCAs covers a respectable 11.5% of the World's land surface (Chape et al., 2003), this area is strongly biased towards certain types of geographies, and hence, habitats. Protected areas are usually located in the least productive portions of the landscape, where the costs to society of conservation are lowest (for example, in rugged, scenic and infertile landscapes) (Pressey, 1994; Norton, 2000; Scott et al., 2001; Rouget et al., 2003). Meanwhile, habitat conversion outpaces conservation at alarming rates (Knight, 1999), for example at a rate exceeding 8:1 in temperate grassland and Mediterranean scrub biomes (Hoekstra et al., 2005). Additionally, management of existing parks is chronically under-funded. The mean operating budget for parks in developing countries covers only 30% of their budgetary needs (James et al., 1999). It is increasingly clear that the global network of statutory reserves alone is not going to be adequate for conserving biodiversity (Morton et al., 1995; Norton, 2000). One response to these problems would be for the developed world to help pay the $4 billion annual budget required for the maintenance and creation of new protected areas in developing countries (Bruner et al., 2004). But indications are that society is not ready to pay the cost of conserving biodiversity in reserves (e.g. James et al., 2001; Pearce, 2007).

In response to the problems at hand we examine an emerging strategy: strengthening the network of private conservation areas (PCAs) (Hale and Lamb, 1997; Knight, 1999; Langholz and Lassoie, 2001; Langholz and Krug, 2004). One study found that if PCAs were used in conjunction with SCAs for conserving biodiversity, then the state would save 80% in acquisition costs (Pence et al., 2003). PCAs are sometimes termed private protected areas, and for this study meet four characteristics: (i) owned by freehold or long-term leasehold by a private investor(s) or syndicate; (ii) funded and/or run by a private investor or syndicate; (iii) managed for biodiversity and possibly for nature tourism, game-based ventures or leisure; and (iv) owned with the intent of preserving the land in a predominantly undeveloped state (Pasquini, 2007). For the most part, PCAs have been left out of conservation statistics, national conservation–planning frameworks, and until recently, generally out of academic research. However, the few studies performed show that thousands of PCA owners have demonstrated a willingness and capacity to conserve several million hectares of land (Langholz, 1996; Thackway and Olsson, 1999; Langholz and Lassoie, 2001; Chacon, 2005; Figgis et al., 2005; Jones et al., 2005; Mitchell, 2005; Sims-Castley et al., 2005; Pasquini, 2007).

Conserving land is important, but not the end goal; the question remains, how well are PCAs conserving biodiversity itself (Langholz and Krug, 2004; Merenlender et al., 2004; Mitchell, 2005)? Wallace et al. (2008) made a typology of 18 potential benefits of PCAs, and found that the most commonly observed benefits in a US county were conservation of riparian areas, contiguity with other PCAs, protection of big-game concentration areas, and buffering of public protected lands. Fitzsimons and Wescott (2008) found that PCAs enhanced linkages among SCAs in three Australian sub-regions, thereby benefiting biodiversity. In a related study, Fitzsimons (2004) tallied the total area of each vegetation type conserved by PCAs and SCAs, and found several vegetation types that were represented only in PCAs.

Here we provide a comprehensive picture of how PCAs contribute to biodiversity representation and target achievement within a region, as well as test the complementarity of PCAs to SCAs. We use a data-rich region of South Africa as a case study and examine several elements of biodiversity: vegetation types, elevation classes, threatened ecosystems, and areas important for ecological processes. While the results are specific to this region, we feel that the causal relationships that emerge are applicable worldwide. We find that PCAs play a vital role in biodiversity conservation, especially in the productive lowlands. We conclude that this role deserves increased attention from conservation, research, and funding institutions.

2. Methods

2.1. Study area

Our study is located in the Little Karoo region (16,612 km^2) of South Africa's Cape Floristic Region (Fig. 1). The Little Karoo is a semi-arid, inter-montane basin, where three globally-recognized “biodiversity hotspots” intermingle (Myers et al., 2000; Mittermeier et al., 2005; Vlok et al., 2005). The low-lying parts of the basin are dominated by dwarf, succulent shrublands associated with the succulent karoo biome; lower slopes are covered in dense thicket associated with the sub-tropical thicket biome; and the upper slopes of the encircling mountains are clad in fire-prone shrublands and heathlands of the fynbos biome (Low and Rebelo, 1996). The major form of land use in Little Karoo has – since European settlement in the 1730s – been extensive grazing and browsing by livestock, chiefly ostriches but also sheep and goats (Hoffman et al., 1999; Herling et al., in press). Overgrazing is especially destructive, as the biocrust of cyanobacteria, lichens, and mosses is particularly fragile. Loss of this crust causes a positive feedback cycle of erosion and water impermeability (Le Maitre et al., 2007).

2.2. Data

2.2.1. Biodiversity data

We used the detailed Little Karoo vegetation data that were digitized from polygons hand-drawn on 1:50,000 Landsat

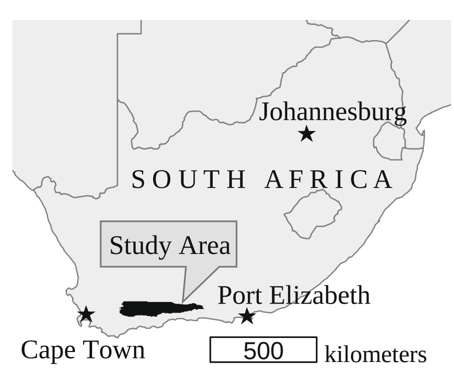

Fig. 1 – The Little Karoo study area.

images after extensive field surveys (Vlok et al., 2005). Our study area comprises the northern 85% of this vegetation layer, due to the overlay with the land management data. There are 344 vegetation types in the study area, which nest into 52 habitat types which in turn fall within six biome categories. The six "biome" categories mapped are the three mentioned earlier, as well as renosterveld (a fire-prone shrubland allied to fynbos but associated with relatively fertile, clay-rich soils), the riparian vegetation of streams, and that of rivers (Vlok et al., 2005). A conservation target for each habitat was set using the quantitative approach developed by Desmet and Cowling (2004) that utilizes the slope of the species–area curve, based on phytosociological releve data (J. Vlok and Reyers, unpublished).

Lombard et al. (2004) mapped several ecological process areas of the Little Karoo, which we used for this study. These processes include four types of habitat connectivity: (i) a corridor along the primary river of the region, providing a north–south macroclimatic gradient to allow opportunities for species movement and migration with climate change; (ii) corridors connecting habitats along the east–west trending mountain ranges, providing another macroclimatic gradient between the western (where the proportion of winter rainfall is higher) and the eastern areas (where the proportion of summer rainfall is higher; (iii) an inter-regional corridor providing for processes associated with the sub-tropical thicket biome (Rouget et al., 2006); and (iv) habitat contiguity for the migration of endemic birds that feed on (and pollinate) nectar producing plants. A final process area comprises quartz gravel plains that are genetic diversification hotspots for Aizoiaceae and other succulent lineages (Schmiedel and Jurgens, 1999; Ellis et al., 2006).

We used a 100 m resolution data layer of land degradation (Rouget et al., 2006; Thompson et al., 2009). We aggregated pristine and moderately degraded areas into a "natural areas" class, and aggregated severely degraded and transformed data into an "altered land" class. The choice of where to make this split was based on two factors: (i) moderately degraded land is where grazing pressure has only slightly altered plant composition (removal of the pressure would likely return populations to their original state), and (ii) severely degraded areas require restoration actions to return them to their original state (Thompson et al., 2009). Only "natural areas" were used to calculate habitat representation values.

We used coarse elevation data (~780 by 920 m cells, from http://www.geocomm.com) to map three elevation classes: lowlands (<400 m), foothills (400–1000 m), and mountains (>1000 m).

2.2.2. *Land management data*

We used the comprehensive land management data layer developed by Pasquini (2007) that designates the locations of SCAs and PCAs. SCAs are owned and managed by the municipal and provincial government agencies. SCAs also include public land that has been declared as a mountain catchment area (MCA) to protect water quality. Most of the areas formally registered with the PCA institutional system—voluntary conservation areas, biodiversity agreements, contract nature reserves, conservancies, and MCAs on private lands—actually met the PCA criteria defined in the introduction. However, some properties, especially those within conservancies, had lapsed into non-compliance for biodiversity management. Such properties were removed from the PCA database (Pasquini, 2007). On the other hand, there were a large number of areas that were not formally registered but that met the requirements for a PCA. These areas were identified through word-of-mouth and the outdated private nature reserve designation, and then verified or refuted through surveys and interviews (Pasquini, 2007). The original database was completed in 2005. We updated it in 2007 with new PCA registration data by consulting with local experts from the provincial conservation organization.

2.3. *Analyses*

We determined the threat status of each vegetation type: critically endangered habitat has less remaining natural habitat than the conservation target, endangered habitat has between the target level and 60% of its pre-clearing extent remaining, vulnerable habitat has between 60% and 80% pre-clearing extent remaining, and least threatened habitat has more than 80% of its pre-clearing extent remaining. This was based on a classification standard (Reyers et al., 2007), which is currently undergoing revisions.

We calculated the percentage of each vegetation type, biome, process, elevation class, land cover class and threat class represented in PCAs, SCAs, and the entire region. We also examined conservation target achievement: if the target was met by SCAs the vegetation type was classified as "well protected". If only 50–100% of the target area was conserved the vegetation was classed as "moderately protected", 5–50% was "poorly protected", and if only 0–5% of the target had been met then the vegetation was classified as "hardly protected" (Rouget et al., 2004). We then repeated the exercise assuming that both SCAs and PCAs contributed towards target achievement.

We used two methods to assess if PCAs complement SCAs, or if they are generally conserving the same elements of biodiversity. First, a metric was created to indicate how well PCAs complemented SCAs for each biome, process, elevation, land cover, and threat class.

$$\text{complementarity metric of a class} = M_c = \frac{P_c * R - S_c}{P_c * R + S_c} \tag{1}$$

where P_c = the percentage of the class conserved by PCAs; R = the total area of SCAs in the region divided by that of PCAs; S_c = the percentage of the class conserved by SCAs.

If the percentage of a class (e.g. thicket) conserved by SCAs divided by the percentage of the class conserved by PCAs was the same as R, then $M_c = 0$. But if there was one and a half times as much thicket in PCAs as would be expected by the regional ratio of R, then $M_c = 0.2$. We used this arbitrary threshold of one and a half times as a guideline to indicate the classes in which PCAs strongly complemented SCAs.

We used chi-square tests to determine the statistical significance of overall PCA/SCA complementarity for a landscape category (e.g. biome). We first tallied all of the vegetation types that had their conservation targets met entirely by PCAs and not by SCAs, or vice versa. We then correlated each vegetation type to the appropriate elevation, biome and threat status classes. (The vegetation types were assigned to an elevation class based on their mean altitude.) The frequency distributions of the different classes (e.g. thicket, fynbos, etc.) within a landscape category (e.g. biome) were then compared for PCAs and SCAs using the chi-square test. Ecological processes could not be evaluated in this manner because there is not a one-to-one relationship between process and vegetation type.

3. Results

PCAs covered 24% of the study area, while SCAs covered 14% (Fig. 2 and Table 1). SCAs met the conservation targets for 63 vegetation types in the region. This is just less than 1/5th of the total possible. Target achievement improved to just under a half of all vegetation types if PCAs were also considered (Fig. 3). The number of habitats that went from having no protection to having some degree of protection also improved similarly (Fig. 3).

PCAs strongly complemented SCAs in the Little Karoo, being especially important in protecting lowland, riverine, succulent karoo, sub-tropical thicket, renosterveld, critically endangered, and vulnerable habitats (Table 1). Meanwhile, SCAs had a relatively strong representation of montane, fynbos, and stream habitat, as well as the east–west and nectarivore corridors. The complementarity between PCAs and SCAs regarding biome representation is highly significant ($\chi^2 = 19.948$; $d.f. = 4$; $p = .00051$) (Fig. 4). In other words, some biomes are represented much better by PCAs (e.g. thicket), while all others are represented much better by SCAs (e.g. fynbos); and it is highly unlikely that this skewed distribution is due to chance. Complementarity regarding elevation is also significant ($\chi^2 = 17.5009$; $d.f. = 2$; $p = 0.00016$), with PCAs representing the lower elevations and SCAs the higher. The complementarity regarding threat classes is not as strong, but is still significant ($\chi^2 = 9.93$, $d.f. = 2$; $p = .00699$). In general, PCAs represent the more threatened habitats, and SCAs represent the least threatened.

4. Discussion

PCAs conserved nearly twice as much land as SCAs in the Little Karoo, and led to nearly three times as many targets being met. Further, they conserved markedly different types of habitat than SCAs. A striking example of this complementarity was their representation of nine times as much critical and endangered habitat as SCAs (Table 1). As is common, the foothills and lowlands of the Little Karoo have been the most productive for the regional economy, being better for cultivation, urban growth, and grazing (Hoffman et al., 1999). As a result, they have become the most transformed. Further, the creation of SCAs has occurred primarily in the less productive mountainous areas, as has also been documented elsewhere (Pressey, 1994; Pressey et al., 2000, 2002; Scott et al., 2001; Rouget et al., 2003).

Creation of new SCAs in the lowlands has been and is difficult due to high acquisition costs, high opportunity costs to society, and high management costs associated with “island” reserves away from the main reserves (Frazee et al., 2003). Hence, when conservation in the lower elevation or highly productive lands occurs in the Little Karoo, it is primarily via PCAs. Such conservation is important in three ways: (i) it increases the absolute amount of area conserved in the region, (ii) it protects habitats that are different than those protected by SCAs, and (iii) it protects habitats that are often more endangered. This third point is corroborated by Pressey et al. (2000), as they found that 85% of their study region’s high priority vegetation was on private land. For the reasons stated in the previous paragraph, this triple benefit is expected to apply to most regions that exhibit the prevailing pattern of SCAs being scarce in the lower elevation and highly productive lands.

The complementarity of the biomes appears to be driven mostly by the aforementioned elevation/productivity issue, as fynbos is associated primarily with the mountains, with a mean elevation of 1042 m.

The mapped ecological processes were represented much better by SCAs than PCAs. This might be a common tendency, but is partially because only coarse-scale ecological processes were measured in this study, and they are biased towards the mountainous regions (Lombard et al., 2004). The east–west corridor was defined by being situated in mountainous habitat, nectarivores have a strong affinity to fynbos, and the STEP thicket corridors steered clear of transformed land, thereby routing to higher elevations (Rouget et al., 2006). The inclusion of fine-scale processes in the PCA analysis (e.g. small

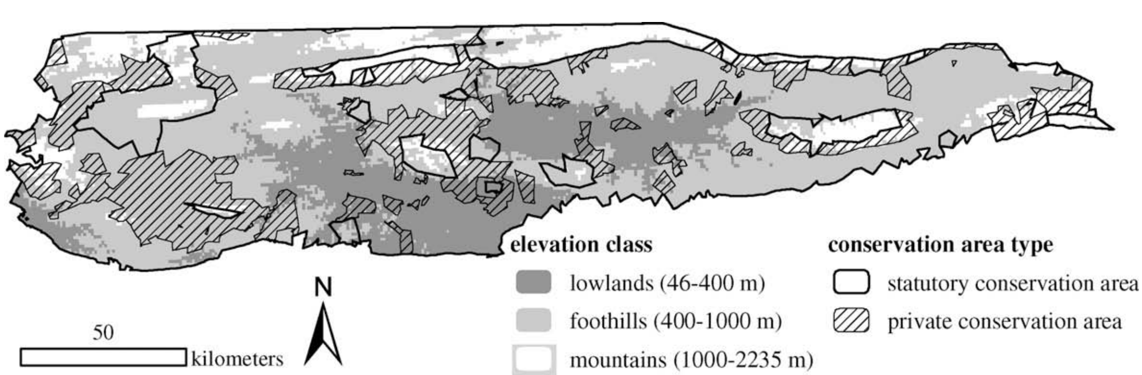

Fig. 2 – Distribution of SCAs and PCAs as well as elevation class in the Little Karoo study area. Adjacent conservation areas of the same type are merged into the same polygon.

Table 1 – Representation and complementarity of SCAs and PCAs for each landscape class.

Landscape category and class	% Of region	% Of class in SCA	% Of class in PCA	Complement arity metric[a]
Entire study area	100.0	14.2	24.4	0.00
Land cover				
Altered land				
Urban and cultivated	9.8	1.3	7.6	**0.55**
Severely degraded	15.5	6.5	18.6	**0.25**
Natural habitat				
Moderately degraded	55.9	12.5	27.0	0.11
Pristine	18.8	32.5	27.6	−0.34
Elevation				
Lowlands	20.5	1.8	13.6	**0.63**
Foothills	63.0	10.8	26.5	0.18
Mountains	16.6	42.7	30.0	−0.42
Biome[b]				
River	3.1	7.4	22.3	**0.27**
Succulent karoo	12.2	10.8	27.6	**0.20**
Sub-tropical thicket	30.4	7.2	24.6	**0.33**
Stream	1.7	43.9	32.6	−0.40
Renosterveld	9.4	9.1	27.4	**0.27**
Fynbos	17.9	43.4	34.2	−0.37
Threat status[b]				
Critically endangered	0.8	2.1	15.7	**0.63**
Endangered	8.2	1.7	19.6	**0.73**
Vulnerable	10.9	7.5	24.7	**0.31**
Least threatened	54.8	22.1	29.9	−0.12
Ecological process				
East–west corridor	15.0	49.2	28.7	−0.49
North–south corridor	4.3	13.6	25.1	0.03
Thicket corridor	17.6	14.4	20.7	−0.09
Necterivore corridor	21.3	44.9	31.3	−0.42
Speciation hotspots	7.7	13.9	25.1	0.02
All processes	48.7	25.6	26.6	−0.25

a PCAs exhibit strong complementarity to SCAs for values in bold.
b Biome and threat status calculations of area do not include altered land.

species connectivity, insect pollinators) might increase the area of mid- and low-elevation land deemed important for ecological processes.

The magnitude of PCA coverage in the Little Karoo may be higher than most places in the world. In three sub-regions in Australia, the ratios of SCA area to PCA area were 0.5, 8.9, and 64.0 (Fitzsimons, 2004), compared to 0.6 for the Little Karoo. In Larimer County, Colorado, PCAs covered 3% of the landscape (Wallace et al., 2008). This high magnitude of PCA coverage in the Little Karoo may be due to the long legacy of a strong conservation ethic in South Africa (Anderson and Grove, 1987; Beinart, 2003). This legacy manifested in several ways, including the institutionalized encouragement of private lands in the mid-1970s through private nature reserves and conservancies. Other inter-related drivers behind private conservation are the profitability of ecotourism and game hunting reserves (e.g. Sims-Castley et al., 2005), as well as the decreasing profitability of traditional agricultural operations (ABSA, 2003; Archer, 2004; Pasquini, 2007). The South African example also provides the following lesson: the regions/nations that provide cultural and institutional support for private conservation, and/or market the beauty of their natural resources, have the potential to attain high levels of private conservation.

A second reason for the large magnitude of PCA coverage is that we included unregistered PCAs in the analysis. These are an often ignored sub-class of PCAs. Some may question the validity of such areas. But in a recent qualitative study, unregistered conservation areas in the Little Karoo were found to be (i) as likely as registered ones to operate over a long timescale (20+ years); (ii) just as likely to have developed formal conservation-management plans, and management goals; (iii) more likely not to be run for profit; and (iv) just as strongly driven by conservation motivations (Pasquini, 2007). There was also no difference in the mean conservation-management scores of the two types. Further evaluation of the differences between registered and unregistered PCAs appears to be a ripe research opportunity. Indeed, identifying the unregistered PCAs of a region may prove to be a previously overlooked yet vital component in successful conservation methodologies.

4.1. *Other future research regarding PCAs*

A common perceived limitation of PCAs is that they generally do not conserve land in as pristine a state as SCAs. This limitation holds true in the Little Karoo, but in a fairly benign manner. While PCAs have much more cultivated and

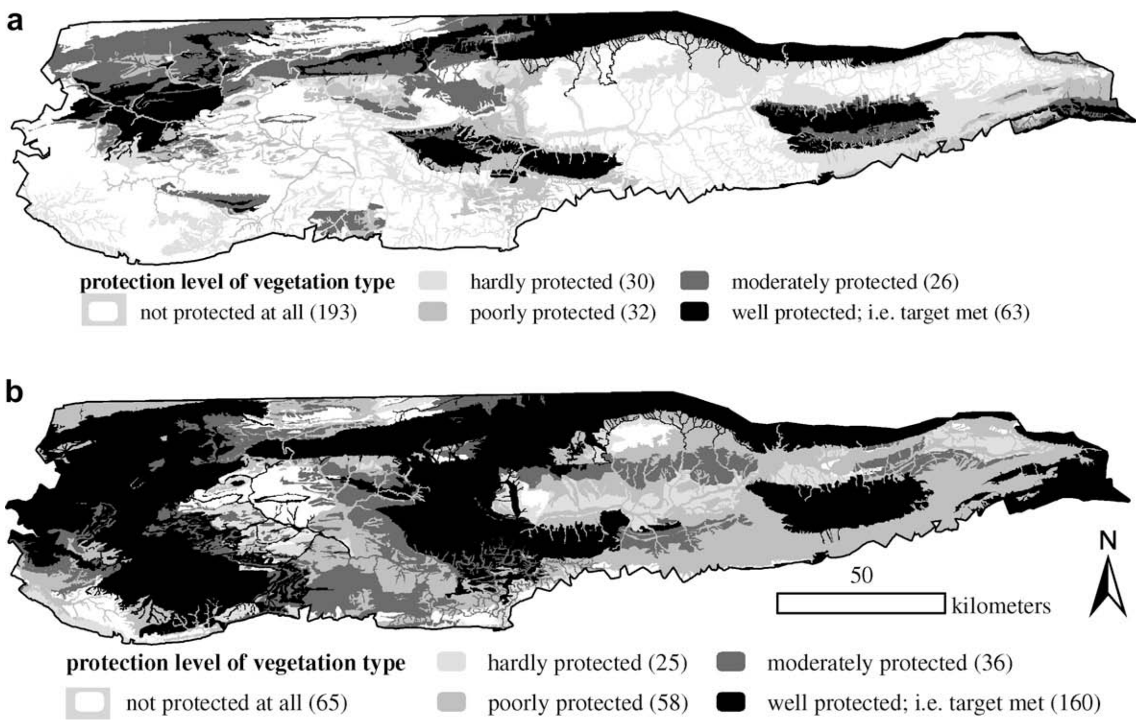

Fig. 3 – Protection status of vegetation types if (a) only SCAs count towards conservation target achievement, or (b) both SCAs and PCAs count. Parentheses contain the number of vegetation types in each category.

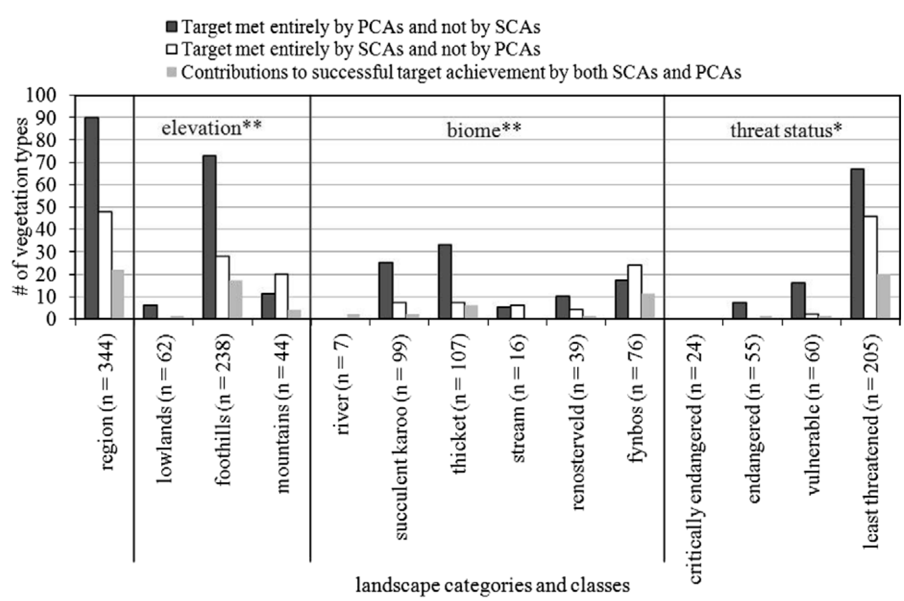

Fig. 4 – The number of vegetation types in each landscape class that had their targets met by SCAs and/or PCAs. * Significant complementarity ($p \leqslant 0.01$). ** Highly significant complementarity ($p \leqslant 0.001$). Vegetation types in which the target was not met are not graphed, but are included in the total sample size (*n*). The category in grey could not be used in the chi-square test, but is displayed to show total target achievement for each class.

severely degraded land compared to SCAs (Table 1), this land makes up less than 1% and 3% of the region, respectively. Similarly, PCAs have more moderately degraded land than SCAs do, but at least this land maintains most ecological processes and is likely to become pristine if the moderate grazing activity is removed (Thompson et al., 2005). These minor shortcomings appear to be greatly offset by the overall representation and complementarity benefits provided by PCAs. Further, in regions with poor enforcement of protected area boundaries (e.g. Liu et al., 2001), PCAs (which are enforced by the landowner themselves) may actually be more pristine than SCAs. Rigorous evaluation of PCA versus SCA habitat quality and functioning would constitute a useful avenue for future research, perhaps using new approaches to reference conditions (Gibbons et al., 2008), as would the related topic of examining mechanisms for encouraging and achieving improved PCA management.

Another perceived limitation of PCAs is that they are not as likely as SCAs to persist into the future. Research is needed in quantifying this issue, and especially in examining the policies, mechanisms, and treatments for strengthening PCA persistence. In the Little Karoo, it appears that the most effective and low cost treatments would be to publicly recognize the stewards as valued managers of the landscape while also paying personnel knowledgeable about agriculture, ecology, and conservation to assist the stewards on a needs-be basis (Pasquini, 2007). This corroborates other research (Doremus, 2003; Chacon, 2005; Winter et al., 2005) and demonstrates that financial incentives, while important, are only one of many motivations for stewardship. Recognition of stewards can occur through government programs (Figgis et al., 2005; Rambaldi et al., 2005; SANBI, 2006), classification systems (e.g. recognition in a revised IUCN protected areas classification), and the private sector (e.g. www.parks-network.org). The private protected areas action plan (Langholz and Krug, 2004) offers valuable guidance for additional actions that could be implemented and studied. Further research regarding motivational factors for sustained stewardship, as well as testing conceptual models of how these factors combine (e.g. Kabii and Horwitz, 2006) is sorely needed.

This study also has implications for the ontology of conservation science, especially systematic conservation planning. A key step in such planning is the assessment of current reserve contribution (e.g. "Stage 3" of Margules and Pressey, 2000), which by current convention only considers SCAs. Inclusion of PCAs for meeting biodiversity targets, even if their contribution were downweighted, would likely make dramatic changes to any network design. For a simplified example, prioritizing where to locate a new reserve in the southwestern corner of the Little Karoo will be a much different exercise using Fig. 3b rather than Fig. 3a. Furthermore, PCAs and SCAs differ in terms of their socio-economic costs and benefits, as well as access and tenure. Understanding these differences is critical to the successful integration of PCAs into conservation plans and strategies.

5. Conclusions

PCAs play an extremely important role in biodiversity conservation in the Little Karoo. PCAs are also likely to play a key conservation role worldwide because of the general tendency for the most productive and hence most threatened portions of a landscape to be privately owned. Conservation of these areas is achievable through private mechanisms, which may not be ideal, but nonetheless contribute underrepresented and vulnerable habitat to the reserve network. Given these findings, we argue for the allocation of more resources to PCA research, especially in finding the strategies and instruments to strengthen the persistence, quality, and extent of PCAs.

For practitioners and decision-makers within the Little Karoo and South Africa, the results of this study are especially timely. Despite the strong showing of PCAs, much work is still needed in maintaining current PCAs and adding new ones. For instance, only 11% of the lowland conservation targets have been met (Fig. 4). Here, and elsewhere, we strongly recommend increased institutional support from governments, conservation organizations, and funding agencies for actions that strengthen PCAs.

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