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Estimating the costs of conserving a biodiversity hotspot: a case-study of the Cape Floristic Region, South Africa

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Abstract

The lack of realistic estimates of the costs of protected area establishment and effective management can hinder conservation planning and result in under-funded "paper parks" that fail to meet conservation goals. This study comprises the first comprehensive and systematic estimate of the costs of conserving a globally recognised biodiversity hotspot, the Cape Floristic Region. To our knowledge, it is also the first study to use specific relationships between protected area attributes and management costs to estimate the long-term costs of implementing a regional conservation plan. We derived a configuration for an expanded protected area system and two off-reserve mechanisms (contractual reserves and other incentive mechanisms) that achieve explicit conservation targets for biodiversity pattern and process identified in a systematic conservation planning process. Using a costing model, we then estimated the costs of establishing and maintaining this reserve system. Although the reserve system is one of many potential configurations that may achieve the designated conservation targets, the results indicate that the costs of conservation are substantial. An expenditure of $45.6 million per year, assuming a 20-year implementation horizon, is required to develop a representative reserve system, while the annual costs of maintaining this system are $24.4 million. Owing to the economies of scale, especially the marked increase in unit management costs when protected area size <600 ha, the predicted cost of managing the expanded system was only 1.2 times that of the existing system. Overall, the level of expenditure required to effectively conserve the region's biodiversity is low relative to its regional and global significance.

Keywords: Conservation management costs; Off-reserve conservation; Protected area costs; Restoration costs; Systematic conservation planning

1. Introduction

In comparison to the economic benefits generated from natural ecosystems, the level of financial investment required for biodiversity conservation can be described as a "great bargain" (James et al., 1999a; Balmford et al., 2002, submitted for publication). If conservation provides high returns, then investments in biodiversity "hotspots"—25 tiny areas with more than 0.5% of the world's flora as endemics (Myers et al., 2000)-- must be bargains indeed (Balmford et al., submitted for publication). Estimating the costs of protecting these areas is essential for appropriate planning, adequate fundraising, and successful implementation of conservation strategies. Yet, inadequate information on costs and costing techniques has resulted in a situation where conservationists are in effect promoting a basket full of "bargains" with no price tags.

The lack of available information on the financial costs of conservation is easy to understand. Determining a realistic conservation price tag requires a systematic analysis of at least five components: estimates of the area of land and water required to represent and maintain biodiversity in a region; identification of a system of protected areas that will achieve these biodiversity-based targets; the costs of acquiring and establishing the protected area system; the annual expenditure required to

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effectively manage the system; and information on the costs of off-reserve conservation in the unprotected landscape. Additional economic considerations include the costs of foregone production on protected areas and the costs of building local and institutional capacity for conservation policy-making and implementation (Faith and Walker, 1996; James et al, 1999b, 2001).

Developing an understanding of each of these components, with the possible exception of acquisition and establishment costs, can require years of research and incur its own substantial costs (Balmford and Gaston, 1999). Nevertheless, several studies have employed various short cuts to provide broad estimates of the financial outlay that might be required to conserve biodiversity on a regional, national, and global scale. A comprehensive study in New South Wales estimated that the cost of establishing and maintaining a representative system of protected areas for habitats in the state would cost US$75 million annually, or the equivalent of US$10 per resident per year (Howard and Young, 1995; Young and Howard, 1996). Culverwell (1997) estimated the annual management costs for an expanded system of protected areas in Cameroon to be US$2.2 million. There have been several attempts to estimate the costs of effective on- and off-reserve conservation at the global scale (James et al., 1999a, 2001; Balmford et al., submitted for publication), and pleas have been made to incorporate these as an additional criterion for international priority setting exercises (Balmford et al., 2000). While these studies greatly contribute to our understanding of the potential range of costs, they are not based on the outcomes of systematic conservation planning (Margules and Pressey, 2000), lack detailed knowledge on effective expenditure levels for managing protected areas, and are based on average costs of expenditure across regions or countries.

A recently completed conservation plan (Fig. 1) (Cowling et al., 1999) and implementation strategy for the Cape Floristic Region (CFR) in South Africa (Gelderblom et al., 2003; Lochner et al., 2003) provide an opportunity to estimate the costs of conserving one of the biodiversity hotspots identified by Myers et al. (2000). The CFR fulfils the criteria for a biodiversity hotspot in that it is extremely rich in endemic plant species (6200) (Goldblatt and Manning, 2000) and has experienced extensive transformation with much of the remaining habitat variously threatened by agriculture, population growth, and alien plant infestations (Rouget et al., 2003a). It also has a protected area system that is not representative of the region's biodiversity (Rouget et al., 2003b). Moreover, it is widely recognised that current expenditure on the region's protected area system is inadequate to achieve effective management objectives (Burgers, 1998; Gelderblom et al., 2003).

The conservation plan formulated by Cowling et al. (1999) formed part of the Cape Action Plan for the Environment (CAPE), a 2-year project that was funded by the Global Environment Facility and designed to develop a strategy and action plan for the conservation of the CFR's imperilled biodiversity (Younge and Ashwell, 2000; Younge and Fowkes, 2003). The conservation plan sought to achieve explicit targets for both biological patterns (i.e. habitat and species distributions) and the ecological and evolutionary process that maintain and generate biodiversity (Cowling and Pressey, 2001; Pressey et al., 2003). Implementation of the outcomes of the CAPE project is ongoing, especially with regard to the establishment of additional protected areas and the introduction of off-reserve mechanisms (Gelderblom et al., 2003; see also www.capeaction.org). However, the form of conservation action, i.e. on- or off-reserve mechanisms, which will be allocated to different parts of the conservation plan, cannot be known precisely. Consequently, we identified as the basis for the costing exercise an expanded reserve system that included additional protected areas as well as an off-reserve conservation system, and which incorporated all of the land identified in the Cowling et al. (1999) conservation plan. It is important to recognise that our expanded system is just one of many options for formulating a mix of on- and off-reserve mechanisms that achieve the specified conservation targets. We assume that our final configuration is within the range of all possible options for on- and off-reserve mechanisms and is, hence, a reasonable reflection of the costs of conserving the CFR.

The aim of this study is to provide a systematic, realistic and comprehensive analysis of the financial costs of implementing a conservation plan for the CFR. We achieved this aim by providing estimates on a range of one-off and recurrent costs of implementing both on- and off-reserve conservation activities. One-off costs included the acquisition and restoration costs of establishing an expanded reserve system, comprising both protected areas and an off-reserve conservation system. Recurrent or long-term costs comprised both on- and off-protected area annual management expenditure required to maintain biodiversity in perpetuity. Including estimates of the latter costs avoids the danger of establishing "paper parks" (parks that do not have the financial means to achieve their management objectives) (Cabeza and Moilanen, 2001; Wilkie et al, 2001). Accurate information on the conservation value of an area (i.e. its contribution to target achievement) and the costs of effectively managing it can help to facilitate the often difficult transition from planning to implementation by allowing scientists, managers, and politicians to evaluate trade-offs between maximizing biodiversity benefits and minimising costs in the design of a reserve system (Pressey and Cowling, 2001). To our knowledge, this is the first study to use specific relationships between protected area attributes and management costs to calculate such recurrent costs. Although this technique does have

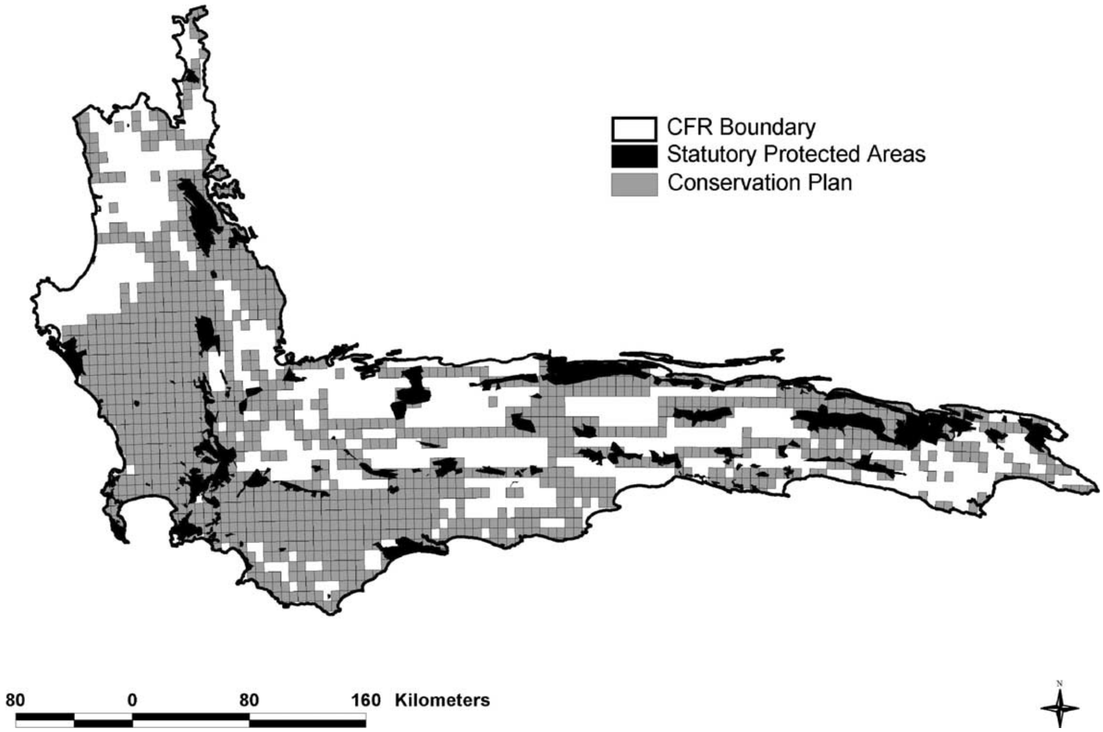

Fig. 1. The Cape Floristic Region showing statutory protected areas and the conservation plan identified by Cowling et al. (1999) to achieve conservation targets for biodiversity pattern (broad habitat units, Cowling and Heijnis, 2001) and the spatial components of ecological and evolutionary processes required to maintain and generate biodiversity. Planning units are sixteenth degree cells. See Section 2.4.1 for details on how the conservation plan was derived.

limitations, it avoids any bias that may result from the application of a fixed cost per unit area for estimating annual management costs (James et al., 1999a, 2001).

Specifically, this study addresses the following questions:

1. What are the annual unit management costs for protected areas based on their physical and biological attributes?
2. What are the costs that will have to be borne by conservation agencies in order to implement actions required to achieve explicit conservation targets (pattern and process)?
3. How do these costs compare with current expenditure on protected areas?

2. Methods

2.1. Study area

The study area comprises the Cape Floristic Region (CFR), delimited by Cowling and Heijnis (2001) as an area of 87,892 km^2 (Fig. 1) which falls within three of South Africa's provinces: Western Cape (most), Eastern Cape and Northern Cape (marginal). The CFR has long been recognised as a global priority for conservation action, owing to its high concentration of endemic taxa (especially plants and invertebrates), and its vulnerability to processes that threaten this unique biodiversity. It has therefore been identified as a biodiversity hotspot of global significance (Myers et al., 2000). Globally, the region is also listed as a Centre of Plant Diversity (Davis et al., 1994), an Endemic Bird Area (Stattersfield et al., 1998) and a Global 200 Ecoregion (Olson and Dinerstein, 1998). The area holds 1406 Red Data Book plant species, the highest known concentration of such species in the world (Cowling and Hilton Taylor, 1994).

Approximately 30% of the CFR is currently transformed by cultivated land (including forestry plantations) (25.9%), urban areas (1.6%), and dense stands of invasive alien trees (1.6%) (Rouget et al., 2003a). 19,350 km^2 or 22% of the CFR is conserved in either statutory reserves (49% of the conservation estate comprising 132 individual areas) or non-statutory reserves (51% in 213 areas) (Rouget et al., 2003b). Statutory reserves (hereafter protected areas) are supported by strong legal and institutional structures and controlled at the national and provincial level (national parks, Department of Water Affairs and Forestry (DWAF) forest nature reserves, and provincial reserves); non-statutory reserves have a lower level of legal and institutional support (Local Reserves, Protected Natural Environments, Mountain Catchment Areas, Conservancies, Natural Heritage Sites, Private Nature Reserves and DWAF Demarcated Forests) (Rouget et al., 2003b). Reserves are biased towards upland areas and this has seriously constrained representation of biodiversity pattern and processes (Rouget et al., 2003b).

2.2. Definitions

2.2.1. Conservation plan

The plan identified by Cowling et al. (1999) to achieve conservation targets for biodiversity pattern and process (see Fig. 1 and Section 2.4.1).

2.2.2. Expanded protected area system

A system of protected areas (see later for definition of these) identified by us for this costing study (see Section 2.4.2).

2.2.3. Operating costs

Non-salary costs[1] i.e. costs allocated to administration, travel, infrastructure maintenance, etc. For the purpose of this study, operating costs exclude the costs of the initial clearing and first two follow-up clearings for removing alien vegetation from a protected area. These costs are calculated separately and, thus, only low-level maintenance clearing was considered as part of operating costs.

2.2.4. Off-reserve contractual areas

Conservation areas falling outside of the expanded protected area system (see Section 2.4.2) but included in the conservation plan. While not formally protected, there are contractual obligations between agencies and landowners to conserve the biodiversity of these areas (Heydenrych et al., 1999; Pence et al., 2003).

2.2.5. Off-reserve conservation areas—other mechanisms

Conservation areas falling outside of the expanded protected area system and contractual areas, but included in the conservation plan, to which other incentive-based off-reserve conservation mechanisms (tax breaks, easements etc.) apply (Pence et al., 2003).

2.2.6. Protected area

A conservation area, termed a statutory reserve by Rouget et al. (2003b), which is formally protected and managed under national or provincial legislation in South Africa (see Section 2.1). They do not include the non-statutory reserves of Rouget et al. (2003b) (see Section 2.1).

2.2.7. Protected area unit

Any discrete portion of a protected area (some protected areas are divided into such units for management purposes).

2.2.8. Total required expenditure

An estimate of the recurrent expenditure (or budget) required for effective management of a given protected area unit. These costs are expressed as annual management costs per ha.

2.3. Modelling management costs

2.3.1. Protected area expenditure

Since recurrent expenditure on protected areas in developing countries is usually inadequate to fulfil conservation objectives (James et al., 1999a; Wilkie et al., 2001)—and this is certainly the case for the CFR (Burgers, 1998)—we did not use existing budgets as a departure point for estimating future budgetary requirements for effective protection. Instead, we conducted a survey of six national parks administered by South African National Parks (SANP) and 56 protected areas administered by provincial agencies (Western Cape Nature Conservation Board (WCNCB) and Department of Economic Affairs, Environment and Tourism: Eastern Cape (DEAET), in order to obtain data on the ideal staffing and operating costs required for effective management of each protected area unit (see www.cabs.conservation.org for a survey questionnaire pro forma). We surveyed only statutory protected areas.

We asked protected area managers to estimate an ideal number of staff within each approved profession category required for management of each protected area unit. We asked regional managers to allocate overhead costs (for scientific research and for head and regional offices) across all of the protected areas under their jurisdiction. For protected areas consisting of multiple units, we asked managers to allocate the percentage time each staff member would spend in each protected area unit under the ideal management scenario. We checked the estimates by comparing them with detailed estimates of salaries for each approved profession category required for each protected area unit in SANP projected budgets and the 1999 WCNCB Work Study Document of ideal staffing levels.

We examined the relationship between staffing and operating costs to derive total required expenditure for the management of each protected area unit. Our analysis showed that since 1998, on average, staff costs account for 65% (range 55–85%) of protected area budgets. Since the variance in the data was not significantly related to either protected area size or habitat class (in the costing model, these two variables account for >90% of the variance in unit management costs (see Section 3.1), we adopted the level of 65% as the proportion of total costs allocated to staff for each protected area unit. We estimated the total required expenditure for each unit as 65% (staffing costs) plus an additional 40% (operating costs).

We excluded from the estimates the costs of tourism development and management in protected areas

[1] Costs are given in 2000 US$ assuming $1 = ZAR 7.5.

because of recent policies within both WCNCB (D. Daitz, personal communication) and SANP (J. van der Merwe, personal communication) to outsource these activities to the private sector. This policy is also likely be adopted by the conservation authority responsible for protected area management in the Eastern Cape in the near future.

We also obtained data on current levels of annual expenditure on the management of protected areas by the four conservation agencies in the CFR, namely DEAET, DWAF, SANP and WCNCB.

2.3.2. Protected area attributes

We used data in a Geographic Information System (GIS) (ArcView 3.2 Environmental Systems Research Institute, Redlands) on the existing protected area system (Rouget et al, 2003b), land classes (broad habitat units (BHUs) (Cowling and Heijnis, 2001), land transformation (Lloyd et al., 1999; Rouget et al., 2003a), and remaining natural (untransformed) habitat (Rouget et al., 2003a) to measure physical and biological attributes that were likely to influence protected area management costs. These attributes were:

Size. Small protected areas usually cost more to manage per unit area than larger ones, owing to management complexity and economies of scale (Shafer, 1990; Howard and Young, 1995; Press et al., 1996; Bowers, 1997; Young and Gunningham, 1997; Hoctor et al., 2000). To examine the effect of size on management costs, we computed the size (ha) of each discrete protected area.

Shape. The perimeter-to-area ratio of protected areas influences management requirements: the more complex the shape, the greater the management costs (Diamond, 1975; Shafer, 1990). We used perimeter-to-area ratio as a surrogate for protected area shape.

Dominant habitat class. Management requirements and, hence, management costs are influenced by the mix of vegetation types in CFR protected areas (van Wilgen et al., 1992). We derived habitat classes by grouping the 88 BHUs (land classes that are surrogates for vegetation type; Cowling and Heijnis, 2001) in the study area. The classification and categorization of corresponding management requirements (Table 1) were based the knowledge of protected area managers captured at workshop in November 2000 and via a questionnaire. We determined the extent of each habitat class in each protected area unit and assigned as the dominant class that which exceeded 60% coverage. For two protected area units, the dominant class (dry mountain fynbos) covered $<60\%$; however, in both cases the subordinate class was karoo, which has similar management requirements (Table 1). Therefore, we assigned dry mountain fynbos as the dominant class.

Surrounding land cover. The management costs of a protected area are influenced by the land use in its vicinity (Laurance and Yensen, 1991; van Wilgen et al., 1992; D'Amico, 1998). We explored this by using a thematic map of transformation of natural habitat by urban development, agriculture, high- and medium-density woody alien plant infestation (species of *Acacia*, *Pinus*, *Hakea*, *Eucaluptus* and *Leptospermum*), and areas of industrial-scale afforestation (mainly *Pinus* spp.) (Lloyd et al., 1999). We calculated the proportional coverage of each transformation class within a 5-km radius of each protected area unit, taking the combined extent of these as a surrogate for threatening processes (Rouget et al., 2003a) that might influence management costs.

Impact of tourism. While we did not include in the analysis tourism-related expenditure, we anticipated that management activities that were shared between conservation management and tourism (e.g. trail maintenance) might influence management costs. Consequently, we explored the relationship between management costs and the number of annual visitors to each protected area unit.

2.3.3. Model development

We used data from 58 of the 62 protected area units in the analysis to produce a model for predicting management costs. We eliminated three protected areas because they comprised multiple discrete areas for which the management effort could not be readily distinguished. We excluded another protected area—an outlier that had a strong influence on the model outputs identified using Cook's Distance measures on the residuals (Chatterjee and Hadi, 1988). We also excluded four protected areas in the Eastern Cape since the extent of surrounding transformation could not be determined with the existing GIS thematic maps. However, when surrounding land cover did not emerge as a significant variable in the model using the 54 protected area units, we included these four units for deriving the final model ($n=58$). The raw data on protected area management costs and attributes are available at www.cabs.conservation.org.

We used multiple regression analysis (Statistica 3.0; StatSoft, Inc., 1999) to explore the relationships between total required expenditure per ha (response variable) and the protected area attributes (explanatory variables) for the protected area units. Dominant habitat class in each protected area unit was represented as a categorical variable in the regression. Management costs and the continuous explanatory variables were log-transformed to achieve normality. Only significant explanatory variables were included in the final model, which we called the long-term management cost model (LTMCM). We validated the model by assessing the relationship between the model outputs and actual expenditure per protected area unit. We also compared its

Table 1
Habitat classes and associated management requirements for protected areas in the Cape Floristic Region

Habitat class	Primary BHUs represented[a]	Secondary BHU codes[b]	Management requirements			
			Control of invasive alien species	Wildfire control	Prescribed burning	Ecological monitoring requirements
Coastal	Dune Pioneer, Fynbos/Thicket Mosaic, Strandveld	1–4, 6–9, 83, 96	High	High	Medium	High
Lowland	Sand Plain Fynbos, Limestone Fynbos, Grassy Fynbos, Fynbos/Renosterveld Mosaic, Coast Renosterveld, Inland Renosterveld	5, 10–14, 18–22, 24–38, 42–44	High	Medium	Medium	Medium
Forest and thicket	Afromontane Forest, Indian Ocean Forest, Mesic Succulent Thicket	93–94, 100–102	Medium	Low	Low	High
Wet mountain fynbos	Mountain Complex	47–48, 50–60, 63–65, 69, 71–72, 74	Medium	Medium	Medium	Medium
Dry mountain fynbos	Inland Renosterveld, Mountain Complex	39–41, 45–46, 49, 61–62, 66–68, 70, 73	Low	Low	Low	Low
Karoo	Vygieveld, Broken Veld, Xeric Succulent Thicket	76, 78, 81, 86–89, 97	Low	Low	Low	Low

[a] BHUs are the broad habitat units described by Cowling and Heijnis (2001). BHUs are described in a two-tier hierarchy. Thus, the primary BHU "Mountain Fynbos Complex" comprises 30 secondary BHUs.
[b] As given in Cowling and Heijnis (2001).

outputs to two fixed cost-per-unit-area estimates: (1) the current South African average protected area management costs of \$18 per hectare (James et al., 1999b), and (2) a simple extrapolation of a management cost of \$71 per ha, derived by summing the required costs per ha of all protected area units, and dividing this by the number of units ($n=58$). This comparison enabled us to assess the effects of using fixed and non-fixed unit management cost on estimates of the total management costs.

2.4. Estimating the costs of conservation

The conservation goal for the CFR (Lochner et al., 2003) will not be achieved by expanding the protected area system only (see also Binning, 1997); off-reserve conservation mechanisms will also be required to achieve conservation targets (Gelderblom et al., 2003; Pence et al., 2003). These include contractual reserves and other incentive-based off-reserve mechanisms such as tax breaks and easements (Heydenrych et al., 1999; Pence et al., 2003). Below we describe how we allocated different parts of the CFR identified in the Cowling et al. (1999) conservation plan to these three conservation mechanisms. Then we explain how we estimated the costs of conserving the expanded reserve system. We assumed that the costs of expanding and establishing (i.e. initial clearing of alien vegetation and creation of off-reserve arrangements) the reserve system to be one-time costs distributed over the proposed 20-year implementation period for the CAPE strategy (Younge and Ashwell, 2000; Gelderblom et al., 2003).

2.4.1. The conservation plan

Using the principles and practices of systematic conservation planning (Margules and Pressey, 2000), Cowling et al. (1999) produced a conservation plan for the CFR (Fig. 1) that achieved targets for BHUs and the spatial components of ecological and evolutionary processes (see also Pressey et al., 2003). They used a reserve selection algorithm in C-Plan, a GIS-based decision support system (Ferrier et al., 2000) to identify a notional system of reserves that achieved all targets. This plan, which is one of many possible configurations that would achieve the conservation targets, covered 43% of the CFR and 61% of its remaining extant habitat.

More recently Cowling et al. (2003a) have identified another conservation plan for the CFR using a similar approach. However, in addition to achieving targets for BHUs and processes, this plan also achieved targets for species of Proteaceae, lower vertebrates (freshwater fish, amphibians and reptiles) and medium- and large-sized mammals. Nonetheless, the overall outcomes of the two plans are very similar. The Cowling et al. (2003a) plan covers 67% of the extant area of the CFR. The difference between the Cowling et al. (1999) plan and this or any other one that uses the same biodiversity features and planning approach is unlikely to have a major impact on the conservation costing estimates derived in this study.

2.4.2. Configuration of an expanded protected area system

Using the outcomes of the Cowling et al. (1999) conservation plan, a significant expansion of the existing reserve system is being undertaken through acquisition of new protected areas, and off-reserve conservation mechanisms (Gelderblom et al., 2003; www.capeaction.org). There are as yet no spatially explicit recommendations on the distribution of these three forms of conservation mechanisms across the region. Therefore, we identified for this study an expanded reserve system, comprising both protected areas and areas allocated to off-reserve mechanisms. We based our configuration on the assumption that the reserve system would be expanded out from existing protected areas and would incorporate existing non-statutory reserves. This is consistent with the configuration of a ''wishlist'' of additional reserves identified by protected area managers in the CFR (Cowling et al., 2003b) who identified protected area consolidation and boundary rationalisation as important criteria for the inclusion of areas in the wishlist.

We created an enlarged protected area system by expanding the existing system by 5 km from its boundary (Fig. 2). The expansion zone incorporated all non-urbanised (i.e. restorable) habitat included in the Cowling et al. (1999) conservation plan. The system thus expanded achieved targets for 32 (36%) of BHUs; however, it achieved $<10\%$ of the target for 18 (20%) BHUs (Fig. 3). The expanded system also covered the entire wishlist and included 70% of extant habitat in high-priority lowland BHUs (those BHUs for which all extant habitat was required to achieve the conservation target). We stress, however, that our expanded system is one of many options that would contribute to target achievement in the CFR. It merely provides a realistic configuration for this costing exercise. We do not necessarily recommend it as a design for implementation.

2.4.3. Configuration of an off-reserve conservation system

We identified two off-reserve conservation mechanisms for those areas of restorable habitat outside of the expanded protected area system but included in the conservation plan (Fig. 2). These were:

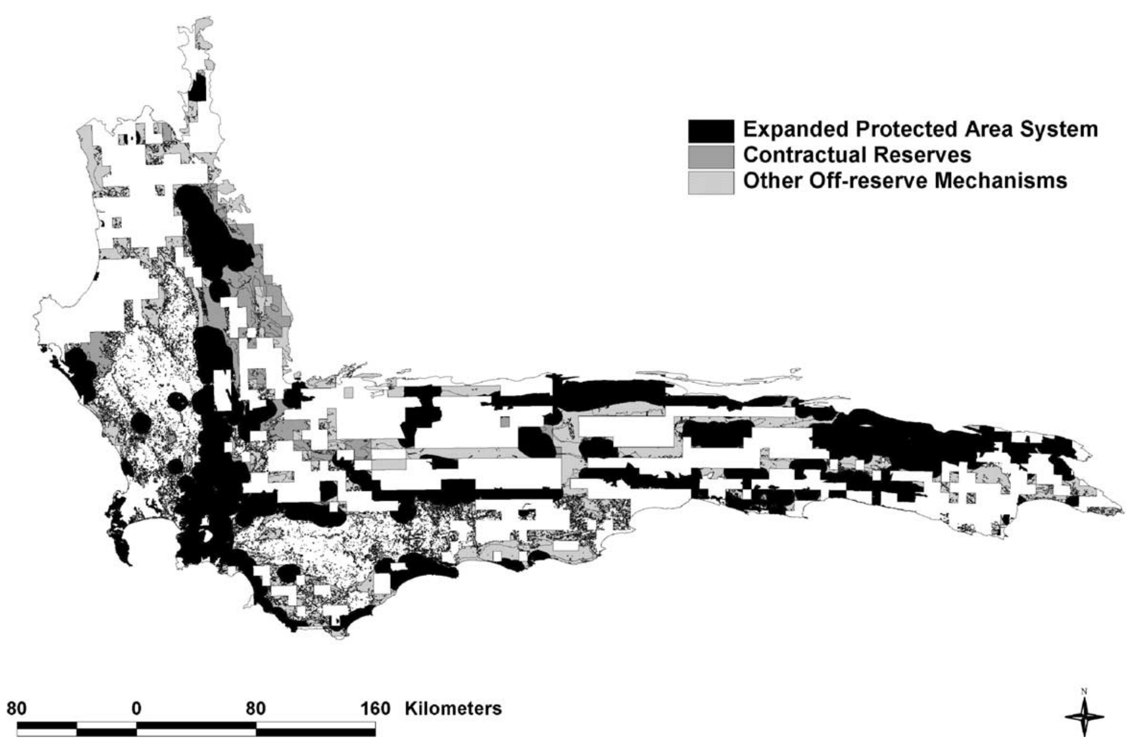

Fig. 2. The expanded reserve system for the Cape Floristic Region used for the costing exercise. The system includes three components: (1) a protected area system comprising existing protected areas and a 5-km buffer around this system of restorable habitat (i.e. excluding urbanised areas) included in the Cowling et al. (1999) conservation plan (see Fig. 1); (2) contractual reserves comprising non-statutory reserves (Rouget et al., 2003b) included in the conservation plan; and 3) the remaining restorable area of the conservation plan allocated for other off-reserve conservation mechanisms (see text). Small fragments of habitat in the light grey parts of the map are also allocated for other off-reserve conservation mechanisms.

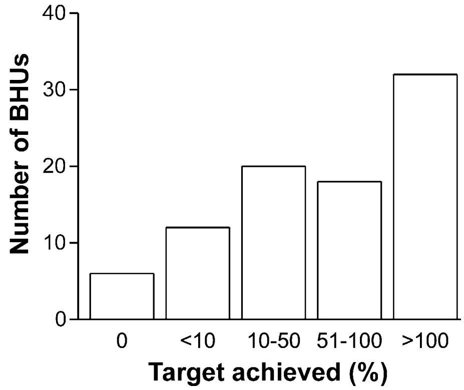

Fig. 3. Frequency of broad habitat units (BHUs) in relation to categories of target achievement under an expanded protected area system comprising a 5-km buffer around existing protected areas. Target achievement includes the contribution of the existing protected area system.

1. contractual reserves (see Section 2.2) that we allocated to the non-statutory reserves described by Rouget et al. (2003b);
2. other off-reserve mechanisms (tax breaks, conservation easements, etc.) that we allocated to all of the remaining area.

2.4.4. Costing the expanded protected area system

We estimated land acquisition costs on a per ha basis from consultations with experts (J. Vlok, private consultant; M. Botha, Botanical Society of South Africa; S. Bekker, WCNCB) and the literature (Clark, 1997; CSIR, 2000). We calculated acquisition costs as follows:

- Average price per ha was calculated for each habitat class from at least four values.
- Owing to inflated prices associated with resort development potential, any land located within 5 km of the coast was assigned a premium price per ha, five times greater than the average (range throughout the CFR from parity to 10 times non-coastal land value).
- To accommodate for the costs of land preparation and agricultural potential, any land already under some form of cultivation was assumed to have a price twice that for undeveloped land (J. Vlok, personal communication) (range throughout the CFR from parity to three times non-agricultural and non-coastal land value).
- Since new legislation will require landowners to clear their land of invasive alien plants, we assumed that owners of land with high-density infestations would be willing to sell at a discounted rate. Pence et al. (2003) show that >60% of farms in the Agulhas Plain area in the south-western CFR have estimated land values less than the total costs of clearing alien plants from their holdings. Therefore, we estimated prices for land currently infested at high densities to be conservatively discounted by 10% from the price of land in its natural state.

Eradication and control of invasive alien plant infestations is the single largest management challenge facing protected area managers in the CFR (van Wilgen et al., 1992; Higgins et al., 1999). We used a map of the distribution of aliens throughout the CFR (Lloyd et al., 1999), information on the composition of invasive species in the Western Cape (Versveld et al., 1997), and specific costs for clearing stands of invasive *Pinus, Eucalyptus, Acacia,* and *Hakea* spp. (Marais, 1998), to calculate an average clearing cost for low, medium, and high density alien plant stands throughout the study area. We mapped the low-medium-high density rankings of Lloyd et al. (1999) as the corresponding rankings of Marais (1998): 5–25%; 25–75%; 75–100%. These rankings correspond to 8.6, 11.9 and 28.2 person days to clear, at a cost of $14.4 per person day (Marais, 1998).

Follow-up treatments are essential for long-term control of alien plant infestations (Higgins et al., 1999; Marais, 1998). According to protected area managers, only the first two follow-up treatments incur costs additional to other annual management costs. We estimated follow-up costs from clearing efficiency probabilities calculated for various densities, given the known proportions of different alien species within the CFR (Marais, 1998).

We used the LTMCM to estimate the total required annual expenditure for the long-term management of the existing and expanded protected area system.

2.4.5. Costing the off-reserve conservation system

Off-reserve conservation mechanisms distribute costs across conservation agencies, local government, and private landowners (Pence et al., 2003). Thus, a management agreement for a contractual reserve may require a conservation agency to bear the responsibility for clearing invasive alien plans, while the private landowner incurs the cost of infrastructure maintenance. In this analysis, we report only on off-reserve costs borne by the conservation agencies (see Pence et al., 2003, for a detailed analysis of the distribution of off-reserve costs for a fine-scale conservation plan). We costed the two kinds of off-reserve mechanisms as follows:

- contractual reserves: 80% of alien plant clearing costs including two follow-up treatments, legal fees, management plans, and staff extension for annual monitoring;
- other off-reserve mechanisms: 80% of alien clearing costs, and staff extension for annual monitoring.

We estimated the costs of alien plant control as for the expanded protected area system (Section 2.4.4). We

Table 2
Derivation of extent (ha) of off-reserve conservation system that can be monitored by one district service officer (DSO) in the Cape Floristic Region

WCNCB[a] Regions	Population per region	Extant natural habitat in off-reserve system (ha)	Recommended No. of DSOs[b]	Average No. ha per DSO
Southwest	1,825,000	106,925	22	4860
Breede River	449,000	219,443	9	24,382
NorthEast/Gouritz	433,900	141,122	13	10,855
Western	375,852	521,924	6	86,987

[a] Western Cape Nature Conservation Board.
[b] From 1999 WCNCB Work Study Document of ideal staffing levels.

assigned a cost of \$0.80 per ha to cover the costs of negotiating legal agreements and developing joint management plans for proposed contractual reserves. Provincial conservation agencies are responsible for monitoring off-reserve conservation areas. Location, regional population, and the amount of extant habitat in off-reserve conservation areas influence the number of district service officers required for such monitoring; data are provided in 1999 WCNCB Work Study Document of ideal staffing levels. These data enabled us to calculate the recommended number of district service officers for the off-reserve system (Table 2). We assigned additional operating costs in accordance with the estimate for total required management costs, but at a value half that of the typical required expenditure of 40% overhead, since district service officers tend to spend only half their time in the field (S. Bekker, WCNCB, personal communication).

3. Results

3.1. Predicting annual management costs

There were strong relationships between total required expenditure per ha and some of the physical and biological attributes of protected areas. In the multiple regression that included all explanatory variables (adjusted $R^2=0.899$; $F=69.59$; d.f.$=53$; $P<0.0001$), increasing area significantly reduced management costs (Table 3, Fig. 4). This relationship was non-linear: the unit costs of management escalated dramatically at protected area sizes smaller than 580 ha (i.e. the Δy (cost)/Δx (area)>1 for any reserves smaller than this area, and <1 for reserves larger than this area).

Protected area shape and surrounding land cover did not emerge as significant variables, nor did number of tourists per year. Size and shape were strongly correlated ($r=-0.90$, $P<0.0001$,) as were size and % transformed land in the buffer ($r=-0.56$, $P<0.0001$).

For the habitat classes, reduction in management costs, relative to forest and thicket—the default dummy variable—was greatest for dry mountain fynbos, followed by wet mountain fynbos and then lowland habitats. The relationship for coastal habitats was marginally non-significant. No protected area unit was dominated by the karoo habitat class.

The final model (LTMCM) (Table 4), which excluded non-significant explanatory variables and included the four Eastern Cape protected area units that lacked surrounding land cover data, accounted for 91% of the variance in management costs of which protected area size contributed 83% (adjusted $R^2=0.910$; $F=110.0$; d.f.$=57$; $P<0.0001$). The equation for the LTMCM is as follows:

Table 3
Results of a multiple regression analysis for modelling the relationships between total required expenditure per ha in protected areas ($n=54$) in the Cape Floristic Region and a range of explanatory variables

Explanatory variable	Coefficient	P-value
Area	−0.587	<0.001
Forest and thicket[a]	0.000	
Lowland	−0.832	0.010
Wet mountain fynbos	−1.017	<0.001
Dry mountain fynbos	−1.464	<0.001

[a] Default dummy variable.

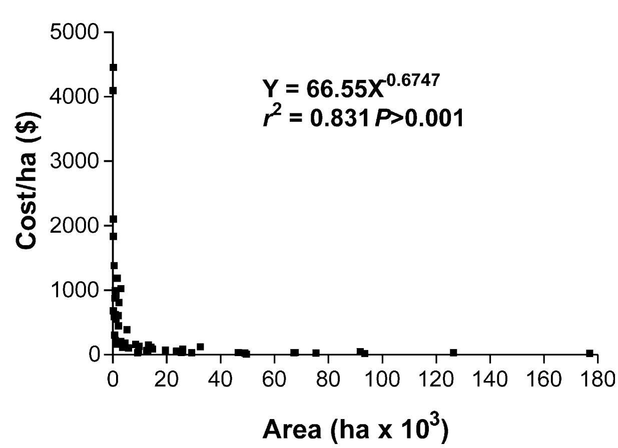

Fig. 4. Relationship between annual required expenditure per ha and protected area size in the Cape Floristic Region.

Table 4
Regression statistics for the final long-term management costs model (LTMCM) for predicting total required expenditure per ha in protected areas ($n = 58$) in the Cape Floristic Region

	Coefficient	SE	*P*-value
Intercept	10.845	0.344	<0.001
Ln area	−0.528	0.040	<0.001
Coastal	−0.636	0.264	0.020
Lowland	−0.833	0.247	<0.001
Wet mountain fynbos	−1.198	0.237	<0.001
Dry mountain fynbos	−1.841	0.275	<0.001

$$\ln(\text{costs/ha}) = 10.845 - 0.528(\text{ln\_area}) - 0.636(\text{coastal}) - 0.833(\text{lowland}) - 1.198(\text{wet mountain fynbos}) - 1.841(\text{dry mountain fynbos})$$

The model residuals were normally distributed ($P < 0.0001$; Kolmogorov–Smirnov test).

There was a highly significant relationship between the annual costs of management (total required expenditure) for each protected area predicted by the LTMCM and the empirical management costs derived from the survey results for each of the 58 protected area units (Fig. 5). The difference in annual management expenditure between the empirically derived value and that predicted by the LTMCM was only 8% (Table 5). This suggests that the model is reasonably reliable for predicting the annual management costs of the expanded protected area system. However, the two estimates based on average unit costs, which do not take into account economies of scale, overestimated the costs relative to the empirically derived value (Table 5).

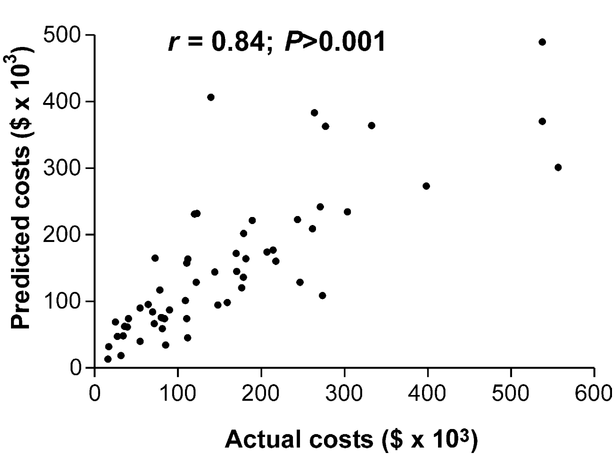

Fig. 5. Relationship between annual required expenditure predicted from the long-term management costs model (LTMCM) (see text) and empirical expenditure, derived from survey results, per protected area in the Cape Floristic Region.

3.2. Costs of conservation

3.2.1. Costs of establishing and managing the expanded protected area system

The costs of acquiring all remaining extant habitat in the CFR amounts to some \$948 million; that of acquiring all extant land in the conservation plan is about \$622 million; and that of acquiring all extant land within the expanded protected area system identified by us is about \$224 million (Table 6). However, effective conservation will require the acquisition of transformed land that is potentially restorable (i.e. non-urbanised land), in order to achieve pattern targets for some features and maintain the biological processes that will ensure the long-term persistence of biodiversity, especially in fragmented landscapes (Cowling et al., 2003a; Pressey et al., 2003). Including in the protected area system land transformed by agriculture, plantation forestry and dense stands of invasive alien plants, increased the total amount of land to be acquired, relative to extant land only (Table 6), by 21% to approximately 1.5 million hectares (Table 7). Nonetheless, some 80% of the land required comprised extant habitat, most of which is in relatively non-threatened mountain and inland basin landscapes (Rouget et al., 2003a). About 8% of the required area was on the coastal forelands that include several highly fragmented and high-priority BHUs where the conservation target exceeds the area of remnant natural habitat (Cowling et al., 1999), all of which is highly vulnerable to further transformation (Rouget et al., 2003a). Of the land targeted for acquisition that is either cultivated or covered in

Table 5
Comparison of the empirically derived costing estimate with other available estimates for conservation management costs in the Cape Floristic Region

	Annual management costs for the known sample of the existing protected area system (\$)	Difference from empirical total required expenditure (%)
Empirically derived expenditure[a]	10,764,331	
LTMCM[b]	9,937,457	−8%
Average cost of \$18 ha^{-1} [c]	22,133,743	106%
Average cost of \$71 ha^{-1} [d]	87,514,362	781%

[a] This value is derived by summing the expenditures, derived from survey results, for each of the 58 protected area units in the CFR for which costs and total area were available.

[b] Long-term management cost model using the Preferred Expenditure Levels (based on the same sub-set of CFR protected areas sampled).

[c] From James et al. (1999b) and applied uniformly across the sampled protected areas.

[d] Average over all protected areas derived from this study and applied uniformly across the sampled protected areas.

Table 6
Costs of acquiring extant habitat under three conservation scenarios in the Cape Floristic Region. See text for methods for deriving acquisition costs

Habitat class	All remaining extant habitat[a] in the CFR		Remaining extant habitat in the conservation plan[b]		Remaining extant habitat in the expanded protected area system	
	Area (ha)	Cost ($)	Area (ha)	Cost ($)	Area (ha)	Cost ($)
Coastal	214,421	183,020,916	121,217	112,287,991	35,648	33,434,889
Lowland	1,660,142	634,509,691	1,029,135	439,354,864	301,558	64,431,476
Dry mountain fynbos	897,859	23,942,899	482,423	12,864,604	217,536	2,712,120
Wet mountain fynbos	1,230,471	55,348,180	758,248	35,406,199	499,979	43,994,586
Karoo	1,053,936	28,104,955	350,210	9,338,924	101,704	54,455,482
Forest and thicket	153,465	22,805,756	81,187	12,534,346	60,450	24,610,752
Total	5,210,294	947,732,396	2,822,418	621,786,928	1,216,875	223,639,303

[a] Land not transformed by agriculture, urbanisation and dense stands of invasive alien plants (see Rouget et al., 2003a).
[b] From Cowling et al. (1999).

high-density alien plants, 43% occurred on the coastal forelands. While important for conservation, including transformed land in the protected area system comes at a substantial price as it nearly doubles the cost of acquisition (Table 6 cf. Table 7).

The costs of controlling invasive alien plants in the expanded protected area system were substantial. Initial clearing costs were $68.9 million of which $3.9 million was required to clear aliens from the existing protected area system. The net present value of the cost of two follow-up treatments was $7.2 million. This brings the total cost of combating alien vegetation in the expanded system to $76.1 million.

The LTMCM predicted an estimated a total required expenditure per annum of $15.4 million for the expanded protected area system. Owing to the economies of scale, this was only $2.4 million higher than what the model predicted for the existing system.

3.2.2. Costs of establishing and monitoring the off-reserve conservation system

The overall costs for establishing contractual reserves for all existing non-statutory reserves in the expanded system amounted to $240,000. The cost of clearing alien plants from these areas was $5.6 million for the initial clearing and $36,700 for the two follow-up treatments. Alien plant eradication from the other off-reserve conservation areas incurred a cost of $28.8 million with follow up treatments amounting to $385,000. Ninety-one district service officers were required to monitor and provide extension services for this off-reserve conservation system; their salary and operating costs amounted to $1.5 million per annum.

3.2.3. An estimate of the overall costs of conservation

In addition to the expenditures already presented, the overall costs of conservation in the CFR (Table 8) include overhead costs for scientific research and for head and regional offices. These we assumed to be 10, 7 and 8%, respectively, of the annual management cost for each protected area unit to reflect the ideal budget distribution of the largest conservation authority (WCNCB) operating in the CFR (S. Bekker, WCNCB, personal communication). Given the increase in management responsibilities for off-reserve areas, we allocated a higher overhead cost for the regional than head offices.

Amortizing the initial acquisition and establishment costs of the expanded reserve system (Table 8) over a 20-year implementation period with a discount rate of 6%, yielded an annual payment of $45.6 million for one-off costs; the annual expenditure on management, monitoring and overhead costs was $24.4 million (Table 8). The latter are an overestimate since they reflect the expenditure on a fully implemented reserve

Table 7
Distribution of different types of land cover and corresponding costs of acquisition for the area required for the expanded protected area system in the Cape Floristic Region

Land cover	Area required for the expanded protected area system (ha)	% Expanded protected area system	Cost ($)
Extant: mountains and inland basins	1,101,544	72	117,642,224
Extant: coastal forelands	115,331	8	105,997,079
Agriculture	241,970	16	185,833,742
Forestry plantation	40,227	3	0[a]
High-density alien plants	36,863	2	7,626,953
Total	1,535,934	100	417,099,998

[a] State-owned plantation holdings in the CFR will be transferred gratis to conservation agencies (C. Burgers, WCNCB, personal communication).

Table 8
Overall costs of implementing an expanded protected area and off-reserve conservation system in the Cape Floristic Region

	One-off costs ($)	Annual costs ($)
Expanded protected area system		
Land acquisition	417,099,998	
Alien plant control		
Initial clearing	68,852,268	
Follow-up[a]	7,240,356	
Annual management costs[b]		15,436,996
Off-reserve system		
Establishing contractual reserves	239,701	
Alien plant control		
Initial clearing	28,853,369	
Follow-up[a]	385,285	
Annual monitoring costs		1,446,498
Overhead		
Head offices		2,959,133
Regional offices		2,451,179
Scientific services		2,071,393
Total	522,670,978	24,365,199

[a] Net present value.
[b] Preferred required expenditure.

system. However, without information on the rate of implementation, we were not able to estimate variation in the annual management costs over the implementation period.

3.2.4. Shortfalls in current expenditure on the existing protected area system

Current (2000) annual expenditure (excluding tourism-related costs) on management of existing protected areas in the CFR is approximately $6.7 million, broken down as follows: provincial reserves (DEAET and WCNCB: $4.7 million, SANP: $1.6 million, and DWAF contributions to forest reserves $400,000). The annual management cost predicted by the LTMC model for the existing system is $13.0 million, representing a shortfall of 48%. The corresponding value for the expanded protected area system was 57%. Clearly, conservation agencies will need to increase their budgets substantially in order to effectively manage the protected area system in the CFR, although the marginal increase for the expanded system is relatively low, given the increase in area (Table 7).

4. Discussion

4.1. Predicting management costs based on protected area attributes

Much research has focused on the relationships between protected area attributes and their effectiveness in the long-term maintenance of biodiversity. The results of this research are routinely incorporated into design recommendations for expanding reserve systems. However, much less attention has been given to the relationships between protected area attributes and unit management costs. In reality, cost issues are more likely to be considered by cash-strapped conservation agencies than considerations that focus exclusively on biodiversity representation and persistence (Prendergast et al., 1999). Therefore, a predictive understanding of management costs in relation to protected area attributes can enable conservation authorities to trade-off cost implications and biodiversity conservation when designing an implementation strategy. To our knowledge, ours is the first study to undertake a systematic and comprehensive analysis of the relationships between protected area attributes and management costs in a biological hotspot. In the section below, we explore the implications of our results for expanding the reserve system in the CFR.

Size emerged as the most important predictor of management costs of protected areas in the CFR. At areas of below about 600 ha, unit management costs increased markedly. Not only are small protected areas expensive to manage relative to larger reserves, they are also not able to support species with extensive habitat requirements (Noss and Cooperrider, 1994; Terborgh et al., 1999; Kerley et al., 2003), are too small to maintain many ecological and evolutionary processes (Pickett and Thompson, 1978; Balmford et al., 1998), and are vulnerable to biodiversity loss as a result of both stochastic and deterministic processes (Diamond, 1975; Shafer, 1990). Indeed, in a pioneer assessment of protected area requirements for the CFR, Kruger (1977) recommended protected area sizes of 10,000–100,000 ha in order to accommodate effectively the region's biodiversity patterns and processes. However, more recent research has shown that plant and invertebrate species diversity, and a subset of processes, can be maintained in reserves smaller than 600 ha provided appropriate fire regimes are maintained (Bond et al., 1988; Cowling and Bond, 1990; Kemper et al., 1999; Donaldson et al., 2002; see also Pressey et al., 2003). Forty-nine percent of the CFR's protected areas are smaller than 1000 ha and 21% are smaller than 100 ha (Rouget et al., 2003b). Despite their high management costs, additional small reserves will be required to conserve at least the biodiversity pattern in the highly fragmented lowland landscapes of the CFR where all available extant habitat is required to achieve BHU targets (Cowling et al., 1999; 2003a; Gelderblom et al., 2003; Pressey et al., 2003). Implementing these reserves will represent a major financial challenge to the conservation agencies. Off-reserve mechanisms, whereby landowners contribute via incentive schemes to reserve management, will probably be the most cost-effective approach (Pence et al., 2003), assuming off-reserve mechanisms are as effective as protected areas in promoting the persistence of biodiversity.

Protected area shape and surrounding land use did not emerge as significant predictors of management costs since these variables were strongly correlated with protected area size. Small protected areas have more complex shapes and tend to have a higher proportion of transformed land in their surrounds than large protected areas. In another study, protected area managers in the CFR consistently cited boundary rationalisation as a justification for expanding the existing system (Cowling et al., 2003b), presumably because of the high costs of managing protected areas with complex perimeters. The extent of transformed land surrounding protected areas will also influence management costs for at least two reasons: these surrounding areas often include stands of alien plants which provide a source of propagules for invasion (Richardson et al., 1992); and protected areas that abut on urban and agricultural land require more intensive management to prevent fire damage to infrastructure and crops, than those in a matrix of natural habitat (van Wilgen et al., 1992).

Habitat class was an important determinant of management costs although the variance explained was relatively low, probably because of collinearities between habitat and protected area size and surrounding land use: many of the smaller reserves occur in mesic lowland areas supporting habitats that are expensive to manage. As anticipated by managers (Table 1), montane habitats, especially dry mountain fynbos, had a greater effect on depressing management costs than lowland habitats. Montane habitats are generally freer of alien plants than lowland ones (Rouget et al., 2003a) and require less intensive fire management (van Wilgen et al., 1992).

It is important to realise that these relationships between management costs and protected area attributes may not have been discernable had existing expenditure been used instead of estimates of total required expenditure. Substantial effort was made during the survey process to ensure that the latter were accurate representations of the costs required for effective conservation management.

We anticipate that relationships between protected area attributes and unit management costs are a widespread yet largely undocumented phenomenon. Estimates that apply average costs uniformly across existing or expanded protected area domains (Culverwell, 1997; James et al., 1999a, 2001; Myers et al., 2000) are likely to be inaccurate since they do not take into account the ways in which unit costs change with different protected area attributes. Although these factors may average out at global scale, the results of this study show that at a regional scale, assuming a fixed management cost per unit area may overestimate total required expenditure.

4.2. Conserving the Cape Floristic Region— a conservation "bargain"?

Conserving the CFR will not be cheap. The one-off costs of acquiring the land for the expanded protected area system ($417 million) and controlling alien plants on- and off-protected areas ($105.2 million), are substantial. Controlling alien plants is an expensive exercise (see also Versveld et al., 1998; Marais, 1998). However, alien plant control is a cost-effective intervention that yields many benefits in addition to biodiversity conservation, especially the sustained delivery of water from CFR mountain catchments (van Wilgen et al., 1996; Higgins et al., 1997). At $24.4 million, the annual management and monitoring costs of implementing the overall conservation plan are similarly substantial. This figure ($24.4 million) is only slightly higher than the $20 million per annum estimated by Myers et al. (2000), but lower than that which would be predicted using the South African average cost per hectare recommended as the ideal by James et al. (1999a). The judicious allocation of finances for effective management is essential for the persistence of biodiversity in the expanded system (cf. Cabeza and Moilanen, 2001; Wilkie et al., 2001).

To what extent are the costs of conserving the CFR justified by the benefits they yield, and how do these costs compare with other regional estimates? Our estimate $45.6 million (one-off cost) for establishing an expanded reserve system plus an annual expenditure of $24.4 million for management and monitoring, is small in comparison with the estimate by Turpie et al. (in press) of $1100 million per annum (assuming the exchange rate used in this study) for the direct and indirect value derived from the CFR's terrestrial ecosystem goods and services. In the absence of conservation interventions, the potential of the CFR to deliver these services will undoubtedly be compromised (Higgins et al., 1997).

When compared to conservation investments elsewhere, conserving the CFR is indeed a bargain (see Balmford et al., submitted for publication). In northern California, $3 million was spent to purchase 15 ha of sand hills habitat that conserved 78 plant and 13 locally rare mammal species (Press et al., 1996). For less than this amount, about 70,000 ha could be purchased to consolidate a mega-reserve in the Baviaanskloof region of the CFR (Clark, 1997), thereby providing an opportunity to conserve about 1400 plant species, a wide range of steep climatic gradients, a riverine corridor, and opportunities to conserve or establish viable populations of almost all of the CFR's 46 species of medium- and large-sized mammals (Boshoff et al., 2000). Kautz and Cox (2000) estimated a cost of $8200 million to purchase 1.56 million ha of strategic non-reserved habitat in Florida in order to achieve conservation targets for 179 rare taxa, 105 globally rare plants and four natural plant communities; annual management costs were estimated to be $122 million. To acquire almost exactly the same area of land for our expanded protected area system will cost 20 times less and will achieve >50% of the targets for 70 of the CFR's 88 BHUs as well as conserving many thousands of threatened and endemic plant species. Annual management costs for the CFR system (including existing protected areas) are some five times lower than the Florida example.

4.3. Financing conservation in the Cape Floristic Region

Currently, conservation agencies are not spending enough to effectively manage the CFR's existing protected area system. How then are they going to cope with the additional financial burden that an expanded system will incur?

Owing largely to the economies of scale that we have demonstrated, the marginal costs of expanding the protected area system are not substantial. Thus, the costs of conserving the CFR are warranted from both a biodiversity and economic perspective. The funds required for implementing the CAPE conservation strategy (Gelderblom et al., 2003; Lochner et al., 2003) will come from both local and global sources. All of the three major conservation agencies (DEAET, SANP and WCNCB) are parastatal institutions with financial autonomy. This financial autonomy has provided great benefits for conservation elsewhere in Africa with more than 15 times more spent by parastatal agencies than comparable government agencies (James, 1999). WCNCB, the major conservation agency in the CFR and the principal implementing authority for the CAPE strategy, aims to cover at least 30% of annual expenditure through tourism revenue, and 50% through appeals to government to maintain annual costs (S. Bekker, WCNCB, personal communication). With the investment in biodiversity surveys and conservation planning already completed, only the cost of creating an effective protected area system and the remaining 20% of the annual costs will need to be raised from outside sources. The CAPE Project has provided the scientific expertise, the political support, and the inter-agency cooperation required to effectively implement this comprehensive strategy and may be one of the few hotspots where effective conservation can be achieved rapidly.

However, we do not wish to paint too rosy a future for conservation implementation in the CFR. The national and provincial governments continue to cut budgets allocated to conservation agencies, arguing that these should be generated largely from tourism revenue. Even with innovative agency-private sector partnerships, tourism is unlikely to generate the requisite funds; more research, however, is required to assess this. Furthermore, international donors, mainly the Global Environment Facility, and the Critical Ecosystem Partnership Fund, have made available $3.5 million per annum as a contribution to implementing the first 5-year phase (2002–2007) of the CAPE project. None of this funding is available for land purchases and much of it will be devoted to activities other than protected area and off-reserve management (www.capeaction.org.za). Furthermore, there are costs of off-reserve conservation—mainly associated with incentive schemes—additional to those that will have to be borne by conservation agencies. For example, Pence et al. (2003) estimate that municipal authorities on the Agulhas Plain in the south-western lowlands of the CFR, will have to bear a reduction in the rates base of between $89,000 and $179,000 per annum, depending on the incentive mechanisms applied over a 124,000 ha reserve system. It remains to be seen whether local authorities—hard-pressed to provide social delivery—will be willing to bear these costs.

4.4. Conclusion

Howard and Young (1995) observed that conservation is not cheap: significant funds are required for acquisition and effective management of protected areas. Our study has shown that an expanded reserve system comprising both protected areas and off-reserve conservation mechanisms, and which achieves both biodiversity pattern and process targets derived from a systematic conservation planning process, is indeed costly to implement and expensive to manage. However, it requires only marginally greater recurrent costs than a well-managed existing system, which does a poor job in conserving the CFR's biodiversity (Rouget et al., in press b). Therefore, investing in the expanded system greatly increases the likelihood of maintaining the region's biodiversity in perpetuity at a relatively low additional recurrent cost. Furthermore, the overall cost of establishing and managing the expanded conservation system is very low in comparison with the economic benefits derived from CFR ecosystems as well as corresponding costs for much less biodiverse areas in the developed world (see also Balmford et al., submitted for publication). In other words, the CFR is an investment bargain. The challenge is to persuade local and global institutions to make these investments soon. The heroic efforts of local stakeholders to prevent ongoing biodiversity loss on shoestring budgets and sheer commitment will not prevent the cascade of extinctions predicted for the Cape hotspot (Nott et al., 1995).

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