Where to with reserve selection and conservation planning in South Africa?

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A critical evaluation of the strengths and weaknesses associated with the 'minimal set' approach to designing an optimal reserve network for vertebrate species is offered. Strengths are the rational and efficient manner in which full species representation is achieved, and the planning benefits that can be gained through its flexibility. Weaknesses include the inappropriateness of the 'minimal set' as a framework for a reserve network, and the frequent confusion between top-down relational species criteria and bottom-up site attributes. It is suggested that the distinct 'top-down' relational and 'bottom-up' representation approaches may act synergistically to form the basis of a National Biodiversity Conservation Strategy. These complementary approaches may require different forms of protection and monitoring, but could also be amalgamated to develop a conservation strategy for non-protected areas. Sufficient attention should also be paid to encouraging the free flow of information and to incorporating the principles of taxonomic and environmental uncertainty into future conservation policies.

'n Kritiese evaluasie van die sterk en swak punte van die 'minimum versameling' benadering teenoor die ontwerp van 'n optimale reservaatnetwerk vir vertebraatspesies word uitgevoer. Sterk punte, sluit in die rasionele en effektiewe wyse waarop volle spesie-verteenwoordiging behaal word, sowel as die beplanningsvoordele verbonde aan die buigsaamheid van die proses. Swak punte sluit in die onvermoë van die 'minimum versameling' om as raamwerk vir 'n reservaatnetwerk te dien en die verwarring wat dikwels ontstaan tussen 'bo-na-onder' vergelykende spesieskriteria en 'onder-na-bo' terreinkenmerke. Daar word voorgestel dat die verskillende 'bo-na-onder' vergelykende en 'onder-na-bo' verteenwoordigende benaderings mekaar kan aanvul om die basis te vorm van 'n Nasionale Biodiversiteit-bewaringstrategie. Hierdie komplementêre benaderings mag verskillende vorms van bewaring en monitering vereis, maar mag ook saamgesnoer word om 'n bewaringstrategie vir onbeskermde gebiede te ontwikkel. Aandag moet daaraan geskenk word om die vrye vloei van inligting te verseker, en om die insluiting van die begrippe van taksonomiese en omgewingsonsekerheid in 'n nuwe bewaringsbeleid te verseker.

Introduction

The principal objective of modern protected areas is frequently stated to be the conservation of biodiversity (Joubert 1986). However, this stated objective has little to do with the reasons for establishing protected areas in the first place (Pressey 1994), and considerable disparity may exist between established reserve networks and a hypothetical reserve network which represents all species in the most efficient manner. Although procedures and principles employed to design 'optimal' hypothetical reserve networks are now widely endorsed in the conservation literature (Pressey, Humphries, Margules, Vane-Wright & Williams 1993; Forey, Humphries & Vane-Wright 1994), their practical application is often viewed with some skepticism by conservation planners, managers and conservation biologists (Branch, Benn & Lombard 1995).

The collection of papers published in this volume of the *South African Journal of Zoology* (Volume 30/3) represents an initial attempt to apply explicit conservation evaluation procedures to a variety of vertebrate groups in South Africa. The objectives of this paper are: (i) to critically evaluate what has actually been achieved in this volume, (ii) to offer some thoughts on potential avenues for future scientific development, and (iii) to make suggestions regarding a policy framework for pursuing biodiversity conservation goals in South Africa. The intention of this paper is therefore to assist with the broader interpretation of the principal directions indicated by these reserve selection procedures, as well as their incorporation into a rational biodiversity policy framework. This is particularly important in light of the obligation of contracting parties to the Convention of Biological Diversity to develop a National Biodiversity Strategy and Action Plan (Caldecott, Jenkins, Johnson & Groombridge 1994).

Vertebrate diversity and conservation planning: a review of progress to date

The procedures applied to databases of representative taxa from the major vertebrate classes are summarized in Lombard (1995a) and amount to the identification of a number of areas (15' × 15' grid squares) in South Africa (including Lesotho and Swaziland) which:

(i) represent 'hot spots' of species richness, endemism and red-data species;
(ii) identify a 'minimim set' network representing the species included in the analyses, and
(iii) identify 'hot spots' and 'minimal set' areas unrepresented in the existing national reserve network.

These analyses were performed separately on various vertebrate taxa (Branch, Benn & Lombard 1995; Drinkrow & Cherry 1995; Gelderblom & Bronner 1995; Gelderblom, Bronner, Lombard & Taylor 1995; Mugo, Lombard, Bronner, Gelderblom & Benn 1995; Skelton, Cambray, Lombard & Benn 1995) and collectively (Lombard 1995b) using a rarity algorithm (Rebelo & Siegfried 1992). The distribution of 'hot spots' and 'minimal sets' was compared with the predominant vegetation biomes in order to evaluate the impact of vegetation on taxa distribution (Drinkrow & Cherry 1995; Gelderblom *et al.* 1995; Lombard 1995b; Mugo *et al.* 1995). No evaluations that take phylogenetic rarity in vertebrates into account were attempted, although such attempts have previously been made on sub-Saharan non-passerine birds (de Klerk 1994). The issue of data quality was addressed in two papers (Freitag & van Jaarsveld 1995; Gelderblom & Bronner 1995). The advantages and disadvantages associated with the use of point data and species distribution maps were evaluated by focussing on mammalian richness patterns in the Transvaal region (also see Freitag, Nicholls & van Jaarsveld, in press) and the distribution patterns of South African endemic mammals, respectively.

Taking existing data limitations into account, the observed overlap between 'hot spots' and existing reserve systems for vertebrates was encouraging (Lombard 1995b). However, areas of concern include the low degree of formal protection for tortoise species richness 'hot spots', tortoise, fish, frog and snake endemic 'hot spots' as well as fish, frog and snake red-data 'hot spots' (Lombard 1995b).

Strengths of the 'minimum set' approach

As conservation is now considered a form of land-use that competes with other land-uses (Pressey *et al.* 1993), the major advantage of the iterative approach is the *efficiency* with which it identifies a 'minimum set' of sites that represent all species. This efficiency is achieved using the principle of *complementarity*, i.e. the selection of sites that complement one another in terms of species composition, avoiding the unnecessary duplication of common species (Pressey, Bedward & Keith 1994). The result is a 'minimum set' that represents all species in a small area. Greater or lesser degrees of efficiency can be achieved using more exact methods (Underhill 1994) or altering the initial selection conditions in an algorithm. This can be achieved, for example, by first selecting rare species or unique habitats (Margules, Nicholls & Pressey 1988; Rebelo & Siegfried 1992; Margules, Cresswell & Nicholls 1994; Freitag, Nicholls & van Jaarsveld, in press), species rich areas (Rebelo & Siegfried 1992; Kershaw, Williams & Mace 1994), taxonomically rich sites (Vane-Wright, Smith & Kitching 1994), or regions rich in endemics (Rebelo & Siegfried 1989).

On the other hand, the benefits that can be gained from incorporating the principle of flexibillty into the selection system may outweigh the gains achieved through greater efficiency (Pressey & Possingham unpubl., Pressey, Possingham & Margules unpubl.). The principle of flexibility allows the generation of numerous hypothetical reserve networks which achieve the same conservation objectives to be considered before a final decision is made. When these hypothetical networks repeatedly select a particular site, the site is considered to have a high conservation value. The conservation value, or irreplaceability, of a site can be quantified and is described as the percentage of these hypothetical networks that select a particular site (Pressey *et al.* 1994; Pressey, Johnson & Wilson 1994). Collectively, the principles associated with the 'minimum set' approach provide a rational and scientific basis for achieving full species representation in an efficient manner, while simultaneously incorporating a degree of planning flexibility.

Limitations of the 'minimum set' approach

Minimum sets as frameworks for locating reserve networks

Influential authors in the field of reserve selection and conservation planning have suggested that 'minimum set' networks may be used as frameworks for locating reserve networks (Pressey *et al.* 1993; Rebelo 1994). This implies that once 'minimum set' configurations have been laid down, reserve design criteria can be applied according to the needs of the particular species found in each reserve (Rebelo 1994). Critics suggest that 'minimum set' nodes may be completely unsuitable as the basis for reserves aimed at the conservation of particular species or groups of species (Branch *et al.* 1995). In fact, such nodes may represent marginal or sink habitats (Pulliam 1988) in which it is impossible to establish viable populations, irrespective of reserve size and other design criteria. The importance of distinguishing source from sink habitats cannot be overemphasized when population viability is a conservation goal. A small part of a species' range that acts as a source habitat (positive demographic balance) may, through emigration, compensate for the negative demographic trends in vast sink areas of the species' geographic range (Pulliam 1988). Consequently, attempts to establish reserves and maintain viable populations of species around 'minimum set' nodes may be doomed from the outset. Alternatively, a 'minimum set' aimed at selecting viable populations of species, rather than species representation, may result in a very different spatial configaration (Pressey, pers. comm.).

These limitations do not imply that the 'minimum set' approach is not useful, merely that it should be recognized for what it represents: a very efficient way of sampling regional species diversity (Margules *et al.* 1994). Reserve networks derived from the 'minimum set' approach can, therefore, only be considered representative.

Confusing relational species criteria with site attributes

The principle of weighting species according to criteria of rarity (e.g. phylogenetic rarity, endemism, low density, IUCN category of threat) prior to performing reserve selection procedures is becoming fashionable (for overview see Forey, Humphries & Vane-Wright 1994). The use of this principle for increased efficiency of reserve selection, for improving the degree of flexibility, or to identify irreplaceable units makes intuitive sense. However, when it is simply employed to prioritize species some confusion of scales becomes evident.

If the objective of reserve selection procedures is to 'sample' (represent) regional species diversity (Margules *et al.* 1994), then it is unclear why some species should be afforded a higher rank than others. 'Sampling regional species diversity' is essentially a *bottom-up* approach where all species should carry equal weight in order to achieve a representative regional sample. The inclusion of relational (Cousins 1994) or *top-down* rarity criteria only confuses the objective of regional sampling. Relational criteria are species-specific criteria that are derived from comparisons with other species (Cousins 1994) or from a historical perspective of a particular species (e.g. destined for extinction). In short, the inclusion of relational criteria leads to a confusion between species attributes and site attributes. The latter should be the primary concern in an exercise aimed at sampling regional species diversity.

This does not mean that relational criteria should be abandoned, only that a clear distinction between conservation goals determined from a bottom-up perspective (species diversity sampling) and those using broader top-down or relational criteria should be made. The challenge before us is to develop a rational way of combining the bottom-up (regional sampling) and top-down (relational criteria) approaches in a conservation strategy that can be implemented at various geographical, administrative and political scales.

Relational conservation criteria revisited

A 'hot spot' analysis for South African vertebrates (Lombard 1995b) indicates that vertebrate richness 'hot spots' and red-data 'hot spots' are concentrated in the north-east of the country. However, endemic 'hot spots' are mostly found in the Western Cape region which is most distant from national borders. Does this imply that endemicity is an important consideration for the Western Cape but less so for the northern provinces? Clearly, the influence of the proximity of national boundaries on a particular category of rarity (endemism) does not facilitate a rational approach towards identifying priority species that should be afforded protection on a regional basis. This also raises the question of who should take responsibility for species that transcend political or administrative boundaries and whether South Africa should spend resources conserving species that are largely extra-limital (e.g. north-eastern Transvaal, Siegfried & Brown 1992; Turpie & Crowe, 1994).

The objective should be to develop a rational approach for assigning scarce resources to species of significant relational importance, while simultaneously sampling regional diversity on a regional basis. One approach towards determining regional relational priorities is to develop a ranking system which evaluates the 'relative rarity' of taxa and incorporates various types of rarity, i.e. endemism, area of occupancy, phylogenetic rarity and category of threat (Freitag & van Jaarsveld, in review). This would assist planners, frequently restricted by administrative boundaries or briefs, to objectively determine priorities about which taxa should be afforded special protection or resources under the banner of relational criteria. Species that are prioritized in this manner are likely to be managed for 'population viability' in a classical reserve setting.

Acceptable procedures used for categorizing the degree of threat to species have altered considerably over the last few years and are more quantitative than the subjective evaluations originally used by Smithers (1986). The revised categories of threat now revolve around available population information and the probability of a population/species going extinct, together with the introduction of additional categories (IUCN 1994). Any future attempts to revise the degree of threat to South African vertebrates (e.g. Mugo *et al.* 1995) should attempt to follow these revised guidelines. These revised procedures would, however, require more extensive population information than is presently available for the vast majority of species.

Towards a policy framework for conserving regional biodiversity

When future policy frameworks for the implementation of a National Biodiversity Conservation Strategy are considered we will be faced with a number of challenges. Resources will undoubtedly be limited and priorities will have to be determined in every sphere of conservation. The efficiency with which conservation goals can be achieved will be critical. However, it is important that a rational basis for determining priorities should be employed whenever possible. A short description of such a policy framework is provided. This is based on a natural division of conservation goals derived from the top-down *vs* bottom-up approaches, and the explicit nature of the framework is presented as a basis for future discussion and critical review.

A number of critical issues and conservation approaches are delineated below.

(i) *A system of protected areas will have to be maintained in order to protect unique habitats and species that require special protection under the banner of relational criteria (phylogenetic rarity, endemism, category of threat).*

The objectives of these Parks will be to maintain viable populations of species that require special protection (including metapopulations if required) and to protect unique habitats. The use of relational criteria will be important to establish regional and national priorities at an appropriate scale. In addition, expertise in this field is well developed in South Africa and the use of tools such as population viability analysis (Lacey 1993) and population persistence analysis (Nicholls, Viljoen, Knight & van Jaarsveld, in press) will be invaluable.

(ii) *A network of conservation areas that complement protected areas and ensure regional species representativeness.*

These complementary conservation areas could be subjected to various forms and intensities of resource use (McNeely 1994); however, it is critical that species persistence should be intensively monitored in such areas. It is unlikely that there will be sufficient resources to determine whether all such species are viable, although the number of species representations in a network could be increased (Freitag *et al.*, in press). However, it is in maintaining, managing and constantly upgrading this complementary network of conservation areas where the 'minimal set' approach will be most useful. The use of biodiversity technicians to monitor the presence of species in such areas (Oliver & Beattie 1994) could be considered, and the strength of such a complementary conservation network should be its responsiveness to changing species distribution patterns.

(iii) *A conservation strategy for non-protected areas*

The sensible use of non-protected areas for human habitation and economic activity forms an integral part of a national biodiversity conservation strategy. Maximizing future land-use options in the face of planetary change requires the minimization of the immediate impact of human habitation outside protected areas [e.g. environmental impact assessment (EIA) and restoration ecology]. It is outside protected areas that a sensible integration of top-down relational criteria and bottom-up representation criteria is required. This will allow planners the luxury of having site specific conservation values assigned to tracts of land being considered for development or other projects. The tools required for this are, however, still being developed (see Forey *et al.* 1994).

(iv) Planning for uncertainty

Much of existing conservation policy is rooted in the outdated philosophy of 'natural' *vs* 'disturbed' ecosystems and although scientists have now modified or abandoned these models, their policy implications remain enshrined in existing policy frameworks (Reid 1994). A system of National Parks was the most prevalent institutional response to this outdated philosophy. Although National Parks have been very successful at re-aligning their missions, it is unlikely that they will suffice as an adequate institutional framework for conserving regional biodiversity, the principal reason for this being their inability to provide an institutional basis for coping with uncertainty. In essence, there are two kinds of contingent events that biodiversity policy will have to accommodate:

Taxonomic uncertainty. Many animal groups have not been adequately described and this is unlikely to take place in the immediate future. Insect species are an excellent example of this uncertainty (Chown & McGeoch 1995; Scholtz & Chown 1993). As more information becomes available, particularly on invertebrate distribution patterns, the results will have to be assessed and integrated with botanical and vertebrate patterns.

Environmental uncertainty. The unpredictable behaviour of ecological systems and our insufficient understanding of their predictable elements suggests that we may be unable to ensure that the planet maintains its capacity to support life, including humanity. As a result it has been suggested that the principal goal of ecological management should be social, and be aimed at maximizing 'human capacity to adapt to changing ecological conditions' (Reid 1994). In essence, this means maximizing the options that are available to future human generations, and "planning for uncertainty" should therefore be a philosophy permeating conservation policy, decision making and institutional frameworks.

(v) Freedom of information principle.

It is unlikely that any of the above objectives will be achieved if the restricted flow of information still prevalent in South African society and in the scientific community is maintained. Linkage between the implementation of a Biodiversity Conservation Strategy and the establishment of a freedom of information principle should therefore be actively sought (Van Jaarsveld & Lombard 1995).

Conclusion

The collective analysis presented in Lombard (1995b) underscores our ability to assess the representation of species, either within reserve networks and/or in regions. This 'minimum set' approach towards conservation planning represents a 'bottom-up' conservation evaluation approach that strives to achieve full species representation within a protected area network. This is in sharp contrast to the manner in which many existing reserves were established, where the emphasis was on conserving and representing viable populations of species considered to be rare, at risk of extinction or phylogenetically distinct. In the latter case, conservation priorities are determined using top-down relational criteria. Although these two approaches towards determining conservation priorities are distinct, they could act synergistically to form the basis of a National Biodiversity Conservation Strategy. Consequently, the representation approach should not be interpreted as an alternative method to the relational approach for designing reserve networks. Furthermore, it is suggested that the ultimate success of such a Biodiversity Conservation Strategy is likely to hinge on the incorporation of principles of 'uncertainty' and 'freedom of information' into a policy framework.

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