The protection of biological diversity in South Africa: profiles and perceptions of professional practitioners in nature conservation agencies and natural history museums

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Two hundred professional natural scientists (those with biological degrees) employed by official nature conservation agencies (148 persons) and natural history museums (52 persons) in South Africa were surveyed for their opinions on matters affecting the protection of biological diversity (= biodiversity). The respondents rated Freshwater/Wetland ecosystems as being most in need of special protection in South Africa. Terrestrial vascular plants were considered to be the group of wild alien species posing the greatest threat to indigenous biodiversity. Despite there being a broad range of specialized taxonomic knowledge amongst the scientists, relatively few of them have contributed to the compilation of species lists for nature reserves, or have published research reports dealing with aspects of biodiversity. The components of conservation biology for which the respondents felt most in need of additional training were geographic information systems, mathematical modelling, minimum viable populations, time-series analysis and decision analysis. The respondents also expressed a greater need for further training in socio-economic influences and environmental impact assessments than for other options.

Tweehonderd professionele natuurwetenskaplikes (diegene met biologiese grade) in diens van amptelike natuurbewaringsinstansies (148 persone) en natuurhistoriese museums (52 persone) in Suid-Afrika het deel uitgemaak van 'n meningsopname m.b.t. sake wat die beskerming van biologiese diversiteit (= biodiversiteit) beïnvloed. Die proefpersone het Varswater/Vleiland ekosisteme geëvalueer as dié ekosisteme met die grootste behoefte aan spesiale beskerming in Suid-Afrika. Terrestriële vaatplante is as dié groep wilde uitheemse plante beskou wat die grootste bedreiging vir inheemse biodiversiteit inhou. Ten spyte van 'n wye spektrum van gespesialiseerde taksonomiese kennis onder die wetenskaplikes, het betreklik min van hulle 'n bydrae gemaak tot die opstel van spesieslyste vir natuurreservate of navorsingsverslae m.b.t. aspekte van biodiversiteit gepubliseer. Die komponente van bewaringsbiologie waarvoor die deelnemers die meeste nodigheid vir verdere opleiding ag is geografiese inligtingsisteme, wiskundige modellering, minimum lewensvatbare bevolkings, tyd-reeksanalise en besluitnemingsanalise. Die proefpersone spreek ook 'n groter behoefte uit vir opleiding in sosio-ekonomiese invloede en omgewingsimpakstudies as vir ander aspekte.

Keywords: Biodiversity protection, conservation biology training, priority ecosystems, scientists' perceptions

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Introduction

South Africa contains extraordinarily high levels of biological diversity (= biodiversity), in terms of species richness and local endemism (Siegfried 1989). Hence, South Africa has an important position and a practical role to play in the protection of global biodiversity.

Here we report on the results of part of an investigation designed to yield an overview of what is being done to promote the protection of biodiversity in South Africa. More particularly, we focus on the biographical profiles and perceptions of a body of professional natural scientists in South African official nature conservation agencies and natural history museums, scientists who are most concerned with the protection of biodiversity. The data collection took three months, and was completed in January 1992.

Methods

South Africa is taken here to mean the Republic of South Africa, including the now defunct so-called 'self-governing' or 'independent' territories (see Siegfried 1989). Southern Africa is here taken to mean South Africa (as defined above), Lesotho, Swaziland, Botswana, Namibia and the sea (including off-shore islands) within 200 km of the shore. Zimbabwe, Angola and Mozambique are not included. The term, 'nature reserve' has been used to encompass national parks and protected areas.

A questionnaire form was drawn up in consultation with prominent conservation biologists (see Acknowledgements section). Copies of the form (in English and Afrikaans) were sent to the directors of the 16 official (public sector) nature conservation agencies and the 13 natural history museums in South Africa, requesting that they ask their professional staffs of scientists holding biological degrees from universities to respond. The difficulty of identifying academic biologists involved in state-funded biodiversity research led to their being excluded from this study.

The questionnaire contained a section devoted to a biographical profile, but focused on the respondents' perceptions and qualifications relating to: natural systems most in need of biodiversity protection; alien threats to indigenous biodiversity; taxonomic knowledge; contributions to species lists; scientific journals read most frequently; reference works used most frequently; recommended publications on biodiversity; expertise and training needs in components of conservation biology and environmental science; reactions to two issues arising out of conservation biology; and actions necessary to promote biodiversity protection in South Africa.

The data takes the form of frequencies arranged in categories. Normality cannot be assumed, and it is consequently necessary to use a non-parametric test. The chi-square test has been used when looking to establish statistical significance.

Results and Discussion

Two hundred scientists (148 and 52 in nature conservation agencies and natural history museums, respectively) responded to the questionnaire before the cut-off date for statistical analysis of the results presented at the IUCN's IV World Congress on National Parks and Protected Areas, held in Caracas, Venezuela, in February 1992. Calculating a response rate is problematical, because certain of the directors of institutions restricted the recipients of questionnaires to those scientists involved in research (by omitting, for example, those in administrative positions, even if they had the appropriate academic qualifications for participation). Moreover, a suite of three questions asking respondents to report their unaided taxonomic knowledge, probably affected the returns. Several recipients felt that these questions could serve to disparage them and they were unhappy about answering them. The overall response rate is estimated to be over 70% of the total body of scientists surveyed.

Biographical profile

Most (87%) of the respondents were males. This gender imbalance may be typical of groups of scientists in similar institutions in many parts of the world. Similarly, the language split (64% English speaking) does not reflect the national profile. Less than 10% of all South Africans have English as a home language (based on data from the South African Central Statistical Services, 1992).

The mean (and median) age of the respondents was 40 years, with a range between 24 and 78 years. Respondents had a mean of 12 years of employment in nature conservation agencies/natural history museums, with a median period of nine years and a range between 0 and 48 years. Personal communication with most of the directors of the institutions concerned suggested that turnover of staff is low (despite relatively poor salaries, there is a great deal of prestige and job satisfaction), and that an increase in the number of posts devoted to scientific services had occurred in recent years. There is, thus, a relatively large amount of mature experience underpinning the scientific services of these institutions.

The personal education levels were correspondingly high. It is remarkable that 93% of the respondents have a post-graduate qualification: 38% and 31% of the respondents having doctoral or masters degrees, respectively. This confirms the high academic standards required to obtain employment in these institutions. The respondents' highest qualifications were obtained an average of 10 years ago, although 21% had obtained their highest degree in the last three years. The Universities of Pretoria (24%), Natal (16%), Cape Town (11%), Witwatersrand (9%) and Stellenbosch (9%) conferred most of these degrees, with 11% being conferred by overseas universities. Of the respondents, 57% extended their professional interests by being voluntary members of conservation societies.

Respondents were asked where they would place themselves on a five-point generalist-ecologist to specialist-scientist continuum. There was a fairly even spread across the continuum, with a slight shift to the specialist side (36% saw themselves to be on the generalist-ecologist side, 22% in the middle, and 42% on the specialist-scientist side). Most of the museum scientists were on the specialist-scientist side, whereas more scientists from the nature conservation agencies were on the generalist-ecologist side. Given the range of requirements of nature reserve staff, and the known specialist inclinations of museum staff, this appears to be a well-balanced spread of expertise.

Most of the respondents were employed in research positions (71%), or in the administration of research. Of the respondents, 17% worked for the Sea Fisheries Research Institute of the Department of Environment Affairs; 15% for the National Parks Board; 30% for the four (former) provincial (Cape, Natal, Orange Free State, Transvaal) nature conservation agencies; 12% for (former) 'homeland'/'independent state' conservation agencies, and 26% for museums (including 7% for the National Botanical Institute).

Only 13% of the respondents had attended an international (here taken to mean outside southern Africa) conference specifically dealing with biodiversity during the last five years. Of these, 2% had attended two such conferences. Of the respondents, 45% had attended local conferences dealing with biodiversity (21% of these having attended more than one conference on the subject). This is, in part, a reflection of the limited number of conferences dealing with biodiversity that have been held in southern Africa during the last five years.

What is more surprising is that only 14% of the respondents have had one or more scientific publications on biodiversity published in refereed journals during the last five years. Of the respondents, 10% have had a popular publication on biodiversity published during this period. It may be an indication that this subject is not the specific focus of most of the research undertaken by the scientists. (However, it should be borne in mind that the scientists may have been producing unpublished reports on aspects of biodiversity. Furthermore, the difficulty of separating a biodiversity component from more general nature conservation publications must be acknowledged.)

Of the respondents, 39% did not indicate that they had had any scientific papers published during the past five years. (The mean number of refereed papers by the respondents that were published during this period is 4,35, which translates to 7,13 for the 61% who had at least one paper published during this period.) Even fewer respondents (46%) had had one or more popular articles published during this period.

More respondents (43%) work in the Savanna system than any other, consistent with the popularity of 'big-game' nature reserves for tourists. Grassland, too, is well served (33%), whereas Fynbos — arguably, on an international scale, South Africa's most important biodiversity biome — languishes at the bottom (only 9% working in the system). This is likely to be a reflection of the fact that most of the first and biggest nature reserves were established to conserve big game, and this legacy still means that there are imbalances in the distribution of the scientists working for nature conservation agencies. (See Table 1 for list of biomes and biotopes.)

Biotic systems most in need of additional protection

Based on previous experience (e.g. Breen & Begg 1989; Siegfried 1989), it was expected that, among the biomes and biotopes, Fresh-water/Wetlands would be given the highest rating, followed by the Karoo biome. The Karoo biome has been identified repeatedly as the richest centre for endemic taxa of several vertebrate classes, taxa which are not represented in the region's nature reserve system (Siegfried 1989, 1992; Siegfried & Brown 1992). Straddling the list of biomes and biotopes, the South African montane grasslands and their associated wetlands are being transformed extensively as a consequence of a rapid expansion of commercial forestry.

The high rating obtained for Fresh-water/Wetlands in the survey (Table 1) agrees with the preceding expectation, but the relatively low ratings given to Montane, Grassland and especially Karoo elements do not. Also at variance is the high rating given to the Forest biome, probably the best protected system in the South African nature reserve system (Siegfried 1989). The Savanna system is also well protected by the nature reserve system and, as expected, it features low down in the respondents' ratings. Curiously, these ratings are very similar to the ratings for humid tropical Indonesia (Prins & Wind 1993).

When asked which one particular system they considered to be most in need of additional protection, the respondents rated Fresh-water/Wetlands (38%) well ahead of any other system. Estuaries/Lagoons (14%), Grassland (14%), Forest (13%) and Fynbos (13%) were the only other systems to attract substantial support. The Karoo system was mentioned by only 2% of the respondents, whereas the Montane system was not mentioned by any respondent.

A cross-tabulation of the mean ratings of the biotic systems most in need of protection by those scientists who work, or have worked, in each system is presented in Table 2. Those who work, or have worked, in a system typically rate the need for protection of that system as lower than do those who have not worked in the system. This is particularly true of those who work/have worked in the Marine, Rocky Shores and Beaches/Dunes systems, while the exceptions to this tendency are those who work/have worked in the Karoo, Fresh-water/Wetlands and Montane systems. It is difficult to speculate on this tendency to rate less familiar biomes as being more in need of additional protection. It may be influenced by popular articles and programmes on these systems, which might accentuate perceptions of problems — as opposed to the influence of outside opinion on their perceptions of the systems in which they work.

The ratings of systems by those who work, or have worked, in the system thus show a different sequence to the overall ratings — Grassland leap-frogs over Beaches/Dunes systems; Karoo and Montane systems overtake Rocky Shores, and Savanna edges in front of Marine systems. With the exception of the last-mentioned change, the differences are statistically

Table 1 Need for biodiversity preservation in ecological systems in Southern Africa

Question 2 – How important do you consider the following systems to be for biodiversity preservation action? Please rate each on a scale of 0 to 10, where 10/10 means that this system is critically in need of biodiversity preservation action, while 0/10 means that sufficient action to preserve biodiversity in the system is being taken. Please leave blank those systems that you feel you cannot rate.

Which one system do you consider to be most in need of biodiversity preservation action?

[Note: n = 176 in column titled 'Most'.]

	1a: Ratings by all respondents			1b: Ratings by those who work, or have worked, in each system	
System	Mean	Most	*n*	Mean	*n*
Fresh water/wetlands	8,96	38	164	9,03	92
Estuaries/lagoons	8,51	14	153	8,41	44
Forest	7,73	13	146	7,63	62
Fynbos	7,72	13	130	7,15	30
Beaches/dunes	7,14	5	127	6,31	33
Grassland	7,06	14	137	6,82	65
Rocky shores	6,44	1	116	5,44	34
Karoo	6,39	2	115	6,65	48
Montane	6,16	0	118	6,16	56
Marine	6,11	1	121	4,98	51
Savanna	5,26	1	130	5,21	111
Desert	4,91	1	105	4,27	37

The first three columns (1a) refer to the mean ratings by all 200 respondents. The last two columns (1b) give the mean ratings by those respondents who work, or have worked, in the system in question.

Table 2 Alien threats to biodiversity in Southern Africa

Question 3 — Which of the following groups of wild alien species would you say pose the greatest threat to biodiversity. Please rate each group of alien species on a scale of 0 to 10, where 10/10 means that this group is having a critical impact, and 0/10 means it is having no negative impact, on biodiversity in Southern Africa. Note that the figures are percentages (e.g. 40% of the respondents gave Terrestrial vascular plants a rating of 10/10).

System	Mean	10	9	8	7	6	5	4	3	2	1	0	*n*
Terrestrial vascular plants	8,17	40	12	20	11	8	3	1	3	1	2	1	179
Aquatic vascular plants	6,36	10	5	25	11	13	17	8	4	3	1	3	158
Aquatic vertebrates	5,30	7	6	13	12	11	17	6	8	9	6	6	162
Aquatic non-vascular plants	4,79	6	1	9	10	13	15	13	9	15	5	4	128
Terrestrial invertebrates	4,62	4	1	9	8	13	20	14	8	15	4	5	144
Terrestrial vertebrates	4,58	8	3	6	7	9	16	11	13	18	8	3	160
Aquatic invertebrates	4,22	2	1	8	8	11	17	13	8	17	8	7	143
Terrestrial non-vascular plants	4,08	6	2	10	6	7	11	12	12	16	9	11	122

significant ($p < 0{,}005$).

The greatest variation in the respondents' perceptions of the need for protection by system were for the Grassland, Montane, Desert, Rocky Shores and Marine systems. Respondents who work/have worked in Beaches/Dunes, Rocky Shores, Marine, Estuaries/Lagoons, Fynbos, Karoo and Grassland systems were more at variance with the overall ratings than those who work/have worked in the other systems.

The ratings in Part B of Table 2 thus tend to support the authors' contention that the overall (Part A of Table 1) ratings given to Montane, Grassland and especially Karoo systems are an under-estimation, relative to the ratings of the other systems listed.

Alien threats to biodiversity

The respondents' rating of wild alien species posing the greatest threat to biodiversity accorded with the opinion of Macdonald (1989). Terrestrial Vascular Plants were seen to be the most significant alien invaders, followed by Aquatic Vascular Plants and Aquatic Vertebrates (Table 3). The category of Terrestrial Vertebrates was somewhat problematical, since some respondents appear to have included domestic livestock in the definition, despite the question referring to 'wild' invasive aliens. Other respondents may not have thought of including translocated natives in this category, such as the nyala *Tragelaphus angasii* reducing understory vegetation and, consequently, impacting blue duiker *Cephalophus monticola* populations (Howard & Marchant 1984).

The very high mean score (8,17/10) given to Terrestrial Vascular Plants is an indication of the seriousness with which the scientists viewed the impact that these invasive aliens are having on biodiversity in the region. It raises the question of whether sufficient emphasis is being given to the control of invasive aliens by the authorities (see Richardson *et al.* 1992).

Respondents' taxonomic knowledge

Respondents were asked to indicate how many species in various groups of indigenous plants and animals they were able to identify without reference books and/or museum specimens (Appendix 1 and 2). We had hoped to get a benchmark by which we could measure over time any changes in taxonomic knowledge, and any changes in emphasis between these groups of indigenous plants and animals.

A number of respondents were critical of the question, finding it difficult to estimate the number of species by group that they could identify unaided. (It was clear from the answers that certain respondents made no attempt to answer the question in full, thereby compromising the results.) Others questioned whether scientists should try to identify specimens without reference books and/or museum species. In truth, the results are not particularly informative. Perhaps the most important aspects are that:

— there is a depth of expertise that exists within most of the organizations in the identification of higher-order animals;

— there is a discernible emphasis on mammals (and most particularly ungulates and carnivores), birds and tortoises — perhaps to be expected, since they are relatively easy to identify, and tourist demands would exacerbate this tendency;

— it appears that more of the respondents are comfortable with the unaided identification of species of animals than with species of plants — perhaps indicative of a bias in favour of animals in the appointment of scientists to the institutions concerned (bearing in mind, too, that the plant-specific line of work of the National Botanical Institute would strongly boost the overall averages for recognition of plant species).

Respondents' contributions to species lists for nature reserves

Given the level of taxonomic knowledge within the nature conservation agencies and natural history museums, the relatively low contributions to species lists for nature reserves by the respondents is surprising. Of the respondents, 13% have been responsible for one or more species lists for Birds; 12% for both Mammals and Plants, followed by Reptiles (8%), Amphibians (7%), Fishes (5%) and Invertebrates (5%). Of the respondents, 31% have contributed towards one or more species lists for Plants, 27% for Birds, 24% for Mammals, followed by Reptiles (14%), Amphibians (12%), Invertebrates (11%) and Fishes (10%). To put this into perspective, Siegfried (1989) found that South Africa (as defined here) has 576 publicly-owned nature reserves, as well as many private nature reserves. It would appear that this is an aspect where more might be done, since the stronger the inventory the better the options for reserve management. What was not asked of respondents was their contributions to the bird and other atlases that are now being developed in southern Africa (e.g. Harrison 1989).

Scientific journals read most thoroughly

Of the respondents, 9% said that the *South African Journal of Wildlife Research* is the journal that they read most thoroughly, followed by the *South African Journal of Marine Science* (8%), *Koedoe* (7%) the research journal of the National Parks Board of South Africa, *South African Journal of Botany* (6%) and *Journal of the Grassland Society* (6%). Thirty respondents did not answer the question, and the remaining 85% named a total of 61 different journals. Two aspects should be noted: first, the choice of journals is parochial; secondly, one should consider publishing in the aforegoing journals when wanting to communicate with the group of scientists involved in this survey. Moreover, given the prominence accorded to the *South African Journal of Wildlife Research,* it is remarkable that this journal publishes almost nothing dealing primarily with the protection of biodiversity (see Siegfried & Brooke, MS.). Among the respondents who do read the literature, it is remarkable how few read *Biological Conservation* (5%) and *Conservation Biology* (1%) which are in the forefront of the modern literature dealing with the protection of biodiversity.

Reference works used most frequently

The three reference works most frequently used by the respondents were Smithers (1983) on mammals (24% of the respondents), Maclean (1985) on birds (17%) and Palgrave (1983) on trees (16%). These works were followed, after a gap, by Smith & Heemstra (1986) on marine fishes (7%), Zar (1984) on statistics (6%), Gibbs Russell *et al.* (1990) on grasses (6%) and Scholtz & Holm (1985) on insects (5%).

In total, 235 reference works were mentioned by the 200 respondents. The prominence of works of identification with summaries of biological knowledge indicates that biodiversity considerations are a component of the day-to-day work of these professional scientists. Works with specific reference to plants, too, are prominent. This may indicate the respondents' greater familiarity with animals that emerges from earlier questions, and a greater need to consult books with a special reference to plants.

It is noteworthy that the book *Biotic Diversity in Southern Africa* (Huntley 1989), the product of the country's first symposium on biodiversity, is mentioned by only 1% of the respondents. It is also of interest that Fuggle & Rabie's (1985) *Environmental Concerns in South Africa*, a holistic perspective of broad environmental issues in the country, is mentioned by only 2% of the respondents.

Recommended publications on biodiversity

Respondents were asked to list the three publications dealing with biodiversity that they would recommend to a new professional scientist joining their institution. The focus of the question was on biodiversity publications, rather than the general publications of the previous question (see Reference works used most frequently). The respondents recommended 202 publications. The most recommended publications were Huntley's (1989) *Biotic Diversity in Southern Africa* (17%), and Soulé's (1986) *Conservation Biology: the science of scarcity and diversity* (7%).

Two aspects of these results should be noted: first, the high proportion (34%) who did not care to answer the question; secondly, the lack of overlap between the reference works listed here and those in the previous question. Only 62 of the 437 works listed, i.e. 14%, in either set of answers were common to both sets. The conclusion to be drawn is that the reference works on biodiversity advocated by these professional scientists are typically not those general reference works that they themselves use most frequently. This may imply that biodiversity protection is not a specific priority in the day-to-day work of a number of these scientists. (Of course, others may not need to refer to the books that they would require a new scientist to consult.)

Expertise in components of conservation biology

Respondents were asked to rate their expertise in components of conservation biology, and in broader environmental aspects. Monitoring Techniques, Population Demography/ Dynamics, Community Ecology and Sustainable Utilization of Resources topped the list, significantly ($p < 0,01$) ahead of other components (Appendix 3). Whereas a broader meaning was originally meant by Sustainable Utilization of Resources, it is likely that certain of the respondents limited their responses to the utilization of resources within nature reserves.

Appendix 3 lists the respondents' ratings of their expertise in components of conservation biology. The respondents' ratings were generally low, with Time-series Analysis (83% saying Poor or Not adequate), Mathematical Modelling (81%), Geographical Information Systems (GIS) (81%), Population Genetics (80%), Decision Analysis (78%) and Environmental Law (72%) the components that received the worst self-ratings.

The respondents indicated that they were most in need of training in GIS (47%), Mathematical Modelling (44%), Minimum Viable Populations (40%), Decision Analysis (39%) and Time-series Analysis (39%). Socio-Economic Influences (38%) and Environmental Impact Assessment Skills (36%) were (marginally) the highest of the broader environmental aspects.

An attempt was made to contrast the results of the question on the components in which the respondents felt a need for further training with the views of experts in conservation biology (Appendix 4). Only three such experts — senior lecturers in conservation biology at the University of Cape Town — were questioned. Although this means that the results should be viewed cautiously, it is nevertheless interesting that the experts rated Minimum Viable Populations, Disturbance Ecology, Community Ecology and Decision Analysis as components in which they felt that the respondents would most need training. Moreover, whereas the respondents rated GIS as the component in which most (47%) felt a need for further training, the experts ranked it in seventh position in terms of what they predicted the respondents would say, and last (12th) in terms of what they felt the respondents really needed. The respondents rated Mathematical Modelling (44%) second in terms of their training needs; the experts ranked it in 11th position in terms of what they predicted the respondents would say, and in 10th position in terms of what they felt the respondents really needed. Time-series Analysis, Monitoring Techniques and Population Genetics are other components where there were marked differences in the rank orders by the respondents and experts.

Preserving biodiversity: two issues

Of the respondents, 57% said that, where practicable, the principles derived from island biogeography theory should be used to select areas for nature reserves. Practical concerns should temper any criticism here. For example, using island biogeography theory principles to select areas could have greater environmental costs than benefits, were this to result in the forced removal of people. This concern is thought to be behind the 35% 'uncertain' answers. Of the respondents, 8% did not feel that the principles derived from island biogeography theory should be used to select areas for nature reserves.

The questionnaire asked whether the world's last known remaining source of the smallpox virus should be destroyed or not. The majority of the respondents (69%) showed appropriate concern in opposing the eradication of the smallpox virus. Biochemistry is in its infancy, and to kill off an agent of such influence on the biochemical make-up of humans would be short-sighted. Again, the practical concerns of those saying 'Yes' (14%) and 'Uncertain' (16%) should be borne in mind (e.g., the virus's potential for biological warfare).

The most important actions needed to protect biodiversity

Respondents were asked what single particular action should be taken to promote the protection of biodiversity in southern Africa. Grouping the responses, Environmental Education (29%) was ahead of Habitat Protection (23%), human Population Control (14%), Environmental Planning (9%), Political/ Administrative Action (9%), Socio-economic Action (8%)

and Scientific Action (7%). The faith in Environmental Education deserves comment. Preston & Fuggle (1986) remarked 'Environmental education is often proposed as a panacea for environmental ills. This will only be true if very much more effort, more resources, and — above all — more ingenuity are applied to its practice'. The diversity in the answers of the respondents is a comment on the difficulties facing those charged with protecting biodiversity in the region. We did expect a need for better coordination of biodiversity protection efforts of the various conservation bodies in the region to have been mentioned more frequently than it was.

Conclusions

There is a considerable body of skills among the professional scientists in South African nature conservation agencies and natural history museums. This bodes well for the protection of South Africa's biodiversity, provided that the scientists' work is more closely focused to this end. Among the means needed to achieve this, it will be necessary to increase scientists' expertise in particular aspects of conservation biology. It will also be necessary to direct their attentions to the most critical biomes, and to conservation problems within them.

The very different perceptions of practitioners and the experts in conservation biology consulted on what aspects are weakest amongst practitioners shows that there is a need to harmonize perceptions and practice in South Africa. This is made more difficult by the existence of no less than 16 nature conservation agencies in South Africa. Increasing convergence of responsibilities and policies among the nature conservation agencies is desirable, as well as greater concentration on the protection of biodiversity. It is clearly difficult to divorce biodiversity protection from other aspects of conservation practice. Nonetheless, biodiversity protection requires being more than a by-product of such conservation activities.

There is a marked need for floral and faunal (not only vertebrate) surveys of all large and moderately sized (> 1000 ha) nature reserves. The potential contribution of people other than professional scientists in nature conservation agencies and museums is important in the compilation of inventories. The bird and Proteaceae atlas projects in southern Africa illustrate the potential of this resource (Harrison 1989; Rebelo 1988).

The Biodiversity Convention at the Rio Earth Summit calls for the development of national, regional and local strategies for the protection of biodiversity. South Africa appears to be well placed to address this challenge, given a greater degree of co-operation between the 16 nature conservation agencies, and between these agencies and museums, universities and other interested groups. Any such strategies should be integrated into a regional strategy for southern Africa.

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Appendix 1 Unaided taxonomic knowledge of Southern African animals and plants

Question 4 – Please indicate your taxonomic knowledge of species within the following groups of animals — *i.e.* the number of known species indigenous to Southern Africa within each group that you are currently able to identify without reference to books/museum specimens? We have given rough estimates of the number of described species within each group, to help you to assess what number you are able to identify. (Please fill in the number, not the percentage.)

The 'known' column lists the approximate number of species within each group that are known to occur in Southern Africa. The 'know' column is the average number of species within each group that the respondents can identify unaided, followed by the standard deviation, minimum number and maximum number. The '50% +' column indicates the percentage of respondents who are able to identify 50% or more of the known species in the groups.

	Known	Know	*S.D.*	Min	Max	50% +
Mammals:						
Ungulates	44	32	12	0	44	76%
Carnivores	35	23	10	0	35	74%
Insectivores	39	11	10	0	39	16%
Bats	74	6	11	0	74	3%
Rodents	120	16	20	0	120	4%
Marine mammals	43	11	9	0	43	11%
Birds:						
Birds	900	215	214	0	850	15%
Reptiles:						
Snakes	160	26	31	0	160	8%
Lizards	230	15	34	0	230	2%
Tortoises/ terrapins/turtles	23	6	6	0	23	16%
Amphibians:						
Amphibians	93	11	16	0	93	5%
Fishes:						
Fresh-water	250	18	29	0	200	2%
Marine/estuarine	2200	60	153	0	1000	0%
Invertebrates:						
Marine invertebrates	5 000	67	156	0	1000	0%
Spiders	4 000	11	19	0	150	0%
Scorpions	180	4	13	0	150	1%
Insects	80 000	80	166	0	1000	0%
Butterflies	700	16	54	0	680	1%
Beetles	17 000	25	107	0	1000	0%
Grasshoppers/ locusts/crickets	900	6	17	0	200	0%

Note: 120 is the number of species of rodents used in the questionnaire: it is undoubtedly too high.

Appendix 2 Unaided taxonomic knowledge of Southern African plants by biome, and by genera

Question 5 – Please indicate your taxonomic knowledge of plants within the following biomes – *i.e.* the number of known species indigenous to each biome that you are currently able to identify without reference to books or museum specimens? We have given rough estimates of the number of described plant species within each biome, in order to help you to assess what nu mber you are able to identify. (Again, please fill in the number, not the percentage.)

Question 6 – Approximately how many of the +2000 plant genera indigenous to Southem Africa are you able to identify without reference to books/museum specimens?

The 'known' column lists the approximate number of plant species within each biome that are known to occur in Southem Africa. The 'know' column is the average number of species within each biome that the respondents can identify unaided, followed by the standard deviation, minimum number and maximum number. The '25% +' column indicates the percentage of respondents who are able to identify 25 % or more of the known species in the biomes.

	Known	Know	*S.D.*	Min	Max	25% +
Savanna	5800	222	529	0	4500	4%
Forest	1300	79	162	0	1300	5%
Fynbos	7300	101	436	0	4000	2%
Desert	1000	39	98	0	800	4%
Karoo	5000	103	429	0	4000	2%
Grassland	3800	134	337	0	3000	4%
Marine	1100	29	107	0	1000	2%
Plant genera	2000	200	298	0	1800	15%

See next page for Appendices 3 and 4

Appendix 3 Components of conservation biology — expertise

Question 11a - Please would you rate your expertise in each of the following components of conservation biology.

[The mean scores are derived merely by weighting the Very Good, Good, Fairly good, Not adequate, and Poor headings by 5, 4, 3, 2 and 1, respectively, and dividing by the number of respondents.]

	Mean	Very good	Good	Fairly good	Not Adequate	Poor
Monitoring techniques	3,07	8	27	38	18	9
Population demography/ dynamics	2,87	3	23	43	19	13
Community ecology	2,73	3	20	36	29	12
Ecology of invasive alien species	2,46	3	8	37	36	16
Disturbance ecology	2,38	3	9	30	39	19
Landscape ecology	2,28	4	12	24	28	32
Minimum viable populations	2,19	1	7	26	42	24
Population genetics	1,96	0	6	14	50	30
Decision analysis (eg Expert Systems)	1,84	1	4	17	34	44
Geographic Information Systems	1,82	1	4	14	38	43
Mathematical modelling	1,77	1	4	14	33	48
Time-series analysis	1,70	0	3	14	33	50
and						
Sustainable utilization of resources	2,68	2	22	33	28	15
Environmental impact assessment (e.g. IEM)	2,47	5	9	36	29	20
Environmental education techniques	2,27	1	14	24	34	26
Socioeconomic influences	2,16	1	7	26	39	27
Environmental law	1,94	1	5	22	31	41

Appendix 4 Components of conservation biology — training needs

Question 11b — Would you also please indicate in which of these components you feel a need for training to improve your skills.

[Note that the table shows the percentage of respondents indicating a need for further training; the rank order of their rating (excluding the broader environmental issues); the experts' prediction of how the respondents would rank the components, and the experts' ranking of what the respondents need.]

	Percentage indicating need for training	Respon-dents' rank order	Experts' prediction of respondent's ranking	Experts' perception of respondent's needs
Geographic Information Systems	47	1 (1)	7	12
Mathematical modelling	44	2 (2)	11	10
Minimum viable populations	40	3 (3)	1	1
Decision analysis (e.g. Expert Systems)	39	4 (4)	6	6
Time-series analysis	39	4 (4)	10	9
Population demography/ dynamics	34	6 (9)	4	2
Ecology of invasive alien species	34	6 (9)	3	4
Monitoring techniques	33	8 (13)	2	8
Population genetics	32	9 (14)	4	7
Disturbance ecology	30	10 (15)	8	3
Community ecology	28	11 (16)	8	5
Landscape ecology	23	12 (17)	12	11
and				
Socio-economic influences	38	– (6)	–	–
Environmental impact assessment (e.g. IEM)	36	– (7)	–	–
Environmental education techniques	35	– (8)	–	–
Sustainable utilization of resources	34	– (9)	–	–
Environmental law	34	– (9)	–	–