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Securing Protected Areas in the Face of Global Change

Lessons Learned from the South African Cape Floristic Region

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A Report by the Ecosystems, Protected Areas and People Project

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Cover: A view of the Kogelberg Biosphere Reserve (Photo: Amida Johns)

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Executive Summary

The Ecosystems, Protected Areas and People Project, supported in part by the UNEP-GEF, has developed a Protected Areas Learning Network (PALNet), to enable organisations responsible for protected area policy and management to share the lessons they are learning in coping with global change factors. One project component is a network of Field Learning Sites.

The South African Cape Floristic Region (CFR) was identified as a Field Learning Site where theoretical and applied science and practical implementation are being combined, with the involvement of appropriate stakeholders, to derive innovative responses to anticipated climate change. This report summarises relevant lessons learned in the CFR and South Africa in general during this process.

The CFR is recognized as the smallest of the world’s six floral kingdoms – and the only one to be found entirely within one country. The CFR covers a total land area of 87 892 km^2 at Africa’s southern tip. Fynbos, the predominant vegetation type in the CFR, occurs only in South Africa, and is an evergreen, fire-prone shrubland mainly characterized by three plant families: shrubby Proteaceae and Ericaceae, and grassy Restionaceae. The region has been recognised as a global priority for biodiversity conservation, and is characterized by exceptionally high levels of plant diversity and endemism at all taxonomic levels (being home to some 9030 species of vascular plants, of which nearly 70% are endemic). Thus far, work in the CFR has mostly explored regional climate change and biotic response modelling and systematic conservation planning for climate

change. Much remains to be done to allow detailed guidelines to be fully implemented by all stakeholders on the ground.

As a background to this work, the report summarises information on the current situation in the CFR with respect to the distribution and efficacy of protected areas, and the ancillary threats facing biodiversity, such as invasive alien plants and agricultural activity. It concludes that the protected areas system in the CFR is faced with many challenges even without climate change. The existing protected areas system performs relatively well for biodiversity processes such as species migrations along upland-lowland and macroclimatic gradients in the uplands, owing to spatial connectivity of current protected areas in the uplands. The spatial components of many other processes, for example riverine corridors and macroclimatic gradients in the lowlands, however, are poorly represented. Furthermore, not one of the protected areas has the appropriate size, composition and configuration of habitat types to sustain viable populations (at least 50 individuals) of all of the herbivores and carnivores that occupied the region in pre-European times. Finally, the achievement of these conservation targets will likely require restoration of large tracks of land, requiring incentives and other instruments for private landowners.

An appreciable amount of work has explored the potential impacts of climate changes on the CFR. Climate change projections for the CFR for the year 2050 suggest generally warmer and drier conditions with an increase in mean annual temperatures of about 1.8 ºC under a scenario of doubled atmospheric CO_2 concentrations, although in some areas the direction of change in rainfall is still uncertain. The general future warming and drying, most likely unprecedented in the past 20 000 years or more, will intensify the already significant water stress across the region and impact

on biodiversity and people in many ways. These changes might impact on species distributions, community composition and configuration, ecosystem functioning, services and states, and disturbance regimes. At worst extinctions of species that are not able to adapt to rapidly changing climates may result. Consequently, many protected areas are likely to lose species through extinctions and migrations. Dispersal limitations and a hostile landscape matrix might, however, prove to be key obstacles for species migrations in response to climate change. Indigenous freshwater species and ecosystems, already severely impacted on by invasive alien species, are at risk from future drying. At the same time, climate change is likely to aggravate the problem of invasive alien species, which further affects critical water resources and fire regimes. Some coastal lowlands are also threatened by sea level rise, which will further reduce the remaining natural buffer between the ocean and human developments at the expense of coastal species and ecosystems.

In the opinion of local experts, it is critical to provide concrete and credible evidence of climate change and its impacts on biodiversity and people to the public, planners, managers and policy-makers. Some stakeholders do not yet see climate change as an important threat to biodiversity compared to more tangible threats such as habitat transformation and fragmentation. The uncertainty associated with climate change and its impacts further adds to the problem.

On the other hand, climate change presents opportunities for researchers, planners and managers in the region. First, it has raised important questions about the vulnerability and adaptability of species, ecosystems and human systems in the CFR. To find answers in time, new national and international collaborative research projects are initiated, and increased and improved baseline data collection, mapping and monitoring is already underway. The climate change impacts anticipated in the CFR have also attracted considerable attention by global donors leading to additional funding. Furthermore, the climate change issue has resulted in increased environmental awareness by the public. This leads, in turn, often to greater public support for conservation action. A sense of urgency among the public, planners, managers and policy-makers may also speed up the implementation of conservation plans. At the same time, climate change may render some agricultural areas unsuitable for agriculture in the future, which may thus become available for biodiversity conservation. Finally, successful response strategies to climate change may ultimately result in an enlarged and enhanced protected areas system and better land management within and outside protected areas.

The report closes with a listing and discussion of lessons learned and response options and guidelines for stakeholders that have been developed in the light of the many challenges facing this region, ranging from on-the-ground planning responses to considerations of national and international funding limitations.

Contents

Foreword

The Ecosystems, Protected Areas and People (EPP) Project, supported in part by the UNEP-GEF, has developed a Protected Areas Learning Network (PALNet), to enable organisations responsible for protected area policy and management to share the lessons they are learning in coping with global change factors[1]. The project will continue to develop the capacity of government agencies, NGOs, local and indigenous communities that have responsibility for managing protected areas to enact policies and manage protected areas adaptively in the face of global change, to protect them against imminent and long term threats, while capturing new opportunities to make areas more sustainable and effective in social, economic and ecological terms. The project consists of five components:

1. A PALNet Website (www.parksnet.org) to facilitate the exchange of experience among and promote interaction between those responsible for protected area policy and management;

2. A network of Field Learning Sites (FLS) where managers and communities are actively experimenting with innovative and creative options for addressing the challenges and opportunities brought by global changes;

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[1] Global change is a broad term that refers to the myriad of factors, primarily human driven, which alter our biological, social, and institutional environment. Some examples are: (a) Biophysical changes (climate change, sea level rise, invasive alien species, and fragmentation of forest cover/change in land use); (b) Socio-economic changes (human population growth, demographic changes and urbanization, growing demand for food and fiber, new technologies, and the impacts of globalization on biodiversity, culture and social values); and, (c) Institutional changes (access to information, participation, decentralization, and cooperative arrangements for area management).

3. A series of face-to-face regional training workshops for engaging primary project stakeholders in the continuing improvement and expansion of PALNet, in learning to utilize its features, and in gathering, synthesising, and sharing the lessons being learned;

4. A series of brief publications that make “hard copy” reports available on the guidelines and lessons being learned, specifically designed for those stakeholders not engaged through the electronic knowledge management system; and

5. Five technical working groups[2] of experts that analyse lessons learned from literature, case examples, and the learning sites, prepare initial guidelines and options for adapting to global change that will reach primary stakeholders through the web site, and assist in drafting reports on this topic.

The network[3] of FLS has been selected on the basis of ongoing pioneering work being done at those locations in response to one or more factors of change. Governments, universities, NGOs, and communities are already experimenting with innovative options for adapting their management approaches to one or more of the biophysical, socio-economic, and institutional changes. At each of these FLS the project engages local NGOs or other stakeholders as local partners who work with the local managers to articulate the lessons they are learning from their innovations and testing of ideas and methods. Thus, it is a cooperative

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[2] Dealing with (i) Understanding Global Change; (ii) Building the System; (iii) Equitable Protected Areas; (iv) Capacity to Manage; and (v) Management Effectiveness.

[3] The FLS include: Apo Island and Dauin Sanctuaries in the Philippines; Terai Arc Landscape in Nepal and India; Socotra Islands in Yemen; Cape Floristic Province and Kruger National Park in South Africa; Congo Basin Network in Cameroon; Zapata Swamp National Park in Cuba; and Yasuni National Park in Ecuador. An additional site to cover capacity building in the protected areas system in Costa Rica is under discussion.

programme with local stakeholders for the purpose of building on, articulating, analysing, sharing and promoting replication of lessons being learned from work already funded and ongoing.

The South African National Biodiversity Institute (SANBI) is the local partner of the EPP project in respect of the Cape Floristic Province in South Africa. This publication documents the first year's report on the lessons that have been learnt at the site in responding to climate change impacts on biodiversity, protected areas and their management. The EPP project will track the progress being made and the lessons being learned in the process of dealing with these impacts at the Cape Floristic Province site over the coming years and document them for sharing over PALNet for use by the global protected areas community that might be interested in the specific management issues.

1. Introduction

The South African **Cape Floristic Region** (CFR) (Figure 1.1) has been identified as a Field Learning Site (FLS) where researchers, planners, managers and other stakeholders are experimenting with innovative and creative options for addressing the challenges and opportunities brought by **climate change**. This report seeks to share relevant lessons that have been learnt over several years in the CFR and South Africa in general. Thereby we hope to encourage and enable others who might be facing similar situations to cope with climate change.

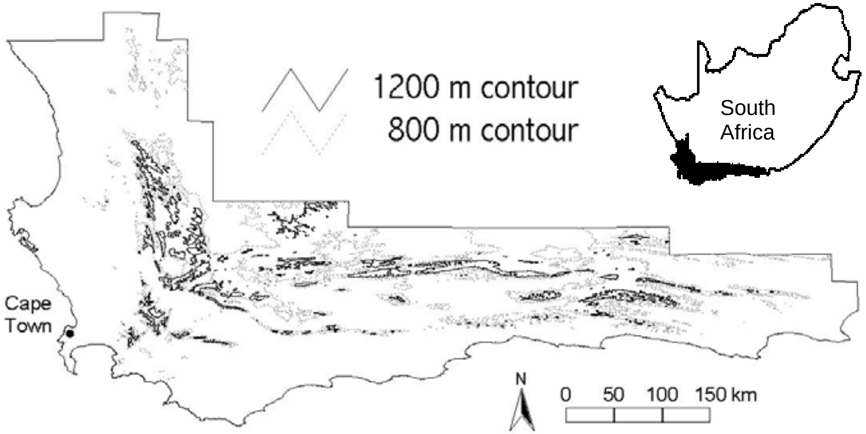

Figure 1.1. The Cape Floristic Region and the Cape Fold Mountains

This report is a first attempt to draw together lessons learned from early efforts to plan and implement adaptive responses to climate change. The report does not aim to prescribe. We are not promoting a single best practice to address the challenges and opportunities brought by climate change, although we subscribe to the published principles of climate change-integrated **conservation strategies** (Hannah et al. 2002b). We aim to offer lessons learned and guidelines that may be useful in southern Africa and beyond, not to provide a manual. It is important to note that to date the pioneering work in the CFR has mostly dealt with

- **regional climate change and biotic response modelling and**
- **systematic conservation planning for climate change,**

and that it is still a long way to go until the outcomes of this work will be fully implemented by all stakeholders on the ground.

Recognising that climate change could indeed be one of the major future threats to biodiversity in the CFR, conservation agencies, organisations and universities in the region have increasingly begun developing response strategies. In this context, it is encouraging to see these strategies cautiously being converted from modelling and planning activities to monitoring and management initiatives, and that they also address various projected climate conditions – because climate change is more than just “global warming”. Furthermore, it is increasingly realised that climate change will interact with other stresses to ecosystems, such as habitat transformation and fragmentation, invasive alien species and overexploitation. Realistic response strategies to climate change cannot ignore these ancillary threats.

2. The Field Learning Site

2.1 The national context of the Cape Floristic Region

South Africa has an extensive system of formally protected areas. There are 950 terrestrial protected areas covering nearly 6% of the total land area of South Africa (Rouget et al. 2004). The goal is to enlarge the system of formally protected areas steadily from 6% to 8% by 2010 and later to 10% and to ensure that all significant vegetation types are included (DEAT 2003). Since 1994, national and provincial governments and their conservation agencies have acquired some 360 000 ha in new and/or expanded reserves. These efforts are ongoing and changes in the protected areas system are taking place every year.

National protected area legislation in South Africa has recently been reformed. A new Protected Areas Act was passed in 2003. It proposes a new system of protected areas comprising special nature reserves, national parks, nature reserves (including wilderness areas) and protected environments (DEAT 2003). Eventually this will result in an interlocking system of conservation areas that explicitly encourages the cooperation of private landowners through conservation stewardships. In addition to the Protected Areas Act (Act 57 of 2003), there are a number of other pieces of national legislation in South Africa that establish terrestrial protected areas (Cowan et al. 2003), for example:

- Mountain catchment areas (declared in terms of the Mountain Catchment Areas Act, Act 63 of 1970) and

- Forest nature reserves and forest areas (declared in terms of the National Forests Act, Act 84 of 1998).

In addition to this national legislation, each of the nine provinces in South Africa is responsible for provincial legislation relating to protected areas.

Of the 950 terrestrial protected areas, 479 are so-called Type 1 protected areas, including 20 national parks covering some 3.6 million hectares (Table 2.1.1), and 471 are Type 2 protected areas (Rouget et al. 2004). The distinction between Type 1 and Type 2 protected areas is made based on the degree of biodiversity protection provided.

Table 2.1.1. National parks in South Africa (SANParks 2005)

National park	**Proclaimed**	**Current size (ha)**
Addo Elephant	1931	74 339
Agulhas	1999	5 690
Augrabies Falls	1966	41 676
Bontebok	1931	2 786
Golden Gate Highlands	1963	11 633
Kgalagadi Transfrontier (formerly Kalahari Gemsbok)	1931	959 103
Karoo	1979	77 094
Knysna National Lake Area	1985	15 000
Kruger	1926	1 962 362
Mapungubwe (formerly Vhembe-Dongola)	1998	28 000
Marakele	1993	50 726
Mountain Zebra	1937	24 663
Namaqua	1999	72 000
Richtersveld	1991	162 445
Table Mountain (formerly Cape Peninsula)	1998	24 310
Tankwa-Karoo	1986	43 899
Tsitsikamma	1964	63 942
Vaalbos	1986	22 697
West Coast	1985	36 273
Wilderness	1985	10 600
Total	**-**	**3 689 238**

Type 1 protected areas are state-owned and supported by strong legal and institutional structures with clear mandate of biodiversity protection, whereas Type 2 protected areas represent various degrees of protection and have legal and institutional structures that are consistently weaker (Rouget et al. 2003b). Type 1 protected areas include national parks, provincial nature reserves and local authority nature reserves, while Type 2 protected areas include wildlife management areas, national heritage sites, private nature reserves and mountain catchment areas.

South Africa is party to a number of international agreements relating to protected areas. These include the Convention on Biological Diversity, the Convention on Wetlands of International Importance, the Convention on Migratory Species, the World Heritage Convention and UNESCO’s Man and the Biosphere Programme. In terms of these agreements South Africa has designated 17 Wetlands of International Importance (Ramsar Sites), six World Heritage Sites and four Biosphere Reserves (Cowan et al. 2003). South Africa has also established three Transfrontier Conservation Areas (TFCAs) and is in the process of establishing a further three with its neighbouring countries.

A number of national and provincial agencies manage South Africa’s protected areas (Cowan et al. 2003). At national level, South African National Parks (SANParks) is responsible for the national parks and national lake areas. The Department of Water Affairs and Forestry (DWAF) is responsible for state forests and mountain catchment areas, but several state forests have been delegated to SANParks or to provincial agencies, and all mountain catchment areas have been delegated to provincial agencies. Finally, the Greater St Lucia Wetland Park Authority manages the Greater St Lucia World Heritage Site. At provincial level, South Africa has five provincial departments, for example in the Northern Cape and Eastern Cape, and five statutory boards, for example the Western Cape Nature Conservation Board (WCNCB).

Clearly, there is a need to further consolidate, expand and rationalize South Africa's protected areas system and its management. This need is well documented, for instance, in the 1997 White Paper on the Conservation and Sustainable Use of South Africa's Biological Diversity and the 2001 policy statement "A bioregional approach to South Africa's protected areas" by the Department of Environmental Affairs and Tourism (DEAT). Innovative systematic conservation planning exercises such as the Cape Action Plan for the Environment (CAPE), Succulent Karoo Ecosystem Plan (SKEP) and Subtropical Thicket Ecosystem Plan (STEP) are dealing with the consolidation and expansion of South Africa's protected areas system. The experience gained in these planning exercises has in fact made the country a world leader in the field of systematic conservation planning (Balmford 2003). The new Protected Areas Act is also a first major step in rationalization in protected area legislation, but it will take much more to make South Africa's protected areas fit for the future.

In keeping with the requirements of the Convention on Biological Diversity, South Africa is currently preparing a National Biodiversity Strategy and Action Plan (NBSAP). The NBSAP, which is led by DEAT, has several components (Driver 2004). The biodiversity conservation component of the NBSAP includes a conservation plan for the whole of South Africa, called the National Spatial Biodiversity Assessment, which is led by SANBI. The National Spatial Biodiversity Assessment is using systematic conservation planning methods to identify priority areas within the country (Rouget et al. 2004). One of its products is a list of threatened

ecosystems across South Africa. It also provides an important national context for conservation plans at the sub-national scale. The NBSAP will finally develop an action plan for each identified priority area, which will then be reviewed and revised every five years.

2.2 The local context of the Cape Floristic Region

The CFR covers a total land area of 87 892 km^2 in the Western and Eastern Cape provinces of South Africa at the southern tip of Africa (see Figure 1.1). Fynbos, the predominant vegetation type in the CFR, occurs only in South Africa, and is an evergreen, fire-prone shrubland mainly characterized by three plant families: shrubby Proteaceae and Ericaceae, and grassy Restionaceae (Cowling et al. 1997).

The CFR has been recognised as a global priority for biodiversity conservation. The CFR is characterized by exceptionally high levels of plant diversity and endemism at all taxonomic levels. The region is home to some 9030 species of vascular plants, of which nearly 70% are endemic, mainly from the three characteristic Fynbos families (Goldblatt and Manning 2002). The CFR is recognized as the smallest of the world's six floral kingdoms – and the only one to be found entirely within one country.

The global significance of the CFR is, for instance, reflected in its listing as one of 25 terrestrial Global Biodiversity Hotspots, as a Global 200 Ecoregion and as a Centre of Plant Diversity (see Cowling et al. 2003). It is also a centre of diversity and endemism for mammals, other vertebrate groups (freshwater fish, amphibians and reptiles) and many invertebrate groups. Consequently, in recognition of the outstanding plant diversity and endemism and associated biological and ecological processes, the CFR was recently added to UNESCO's World Heritage List (Box 2.2.1).

Box 2.2.1. The CFR: A recent addition to UNESCO's World Heritage List


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Eight protected areas, covering 553 000 ha, were added, as a serial site representative of the CFR, to UNESCO's World Heritage List on July 1, 2004, for the following reasons (see http://whc.unesco.org): The CFR is one of the richest areas for plants in the world. It represents less than 0.5% of the area of Africa but is home to nearly 20% of the continent's flora. The site displays outstanding ecological and biological processes associated with the Fynbos vegetation, which is unique to the CFR. Finally, the outstanding diversity and endemism of the Cape flora are among the highest worldwide.

Biodiversity conservation in the CFR is, however, faced with many exceptional challenges. There are about 1400 Red List, or threatened, plant species, one of the highest known concentrations of such species in the world (Cowling and Hilton-Taylor 1994). Furthermore, there is a high proportion of plant species with very small species ranges and/or population sizes in the Cape flora, and plant species are neither uniformly nor randomly distributed, but concentrated in smaller nodes highly vulnerable to threats such as future land use change and climate change.

At present more than 75% of the total area of the CFR is in private landownership and about 20% lies in formally protected areas. About 30% of the region has already been transformed by agriculture, urbanisation or high- and medium-density stands of invasive alien shrubs and trees (Rouget et al. 2003c): agricultural areas (including forestry plantations) cover 26% of the CFR, whereas dense stands of invasive alien plants and urban areas cover 2.6% and 1.6%, respectively. The remaining 70% of the region is currently classified as natural vegetation free of woody aliens or with low-density stands of invasive alien shrubs and trees.

Agricultural areas are much more evenly distributed across the region than dense stands of invasive alien plants and urban areas. Invasive alien plants have more severely affected lowland habitats than upland habitats, and urbanisation has severely impacted only a few habitat types in the lowlands, whereas agriculture has affected many habitat types both in the lowlands and uplands (Rouget et al. 2003c). It is not known yet how much more of the region has been degraded by overgrazing, which is common in many lowland and semi-arid habitat types. Disturbingly, land use models predict that at least 30% of the currently remaining natural vegetation could be transformed by agriculture, urbanisation and invasive alien plants in the future (Rouget et al. 2003c).

The 259 formally protected areas in the CFR cover 16 420 km^2 or nearly 20% of the total land area (Figure 2.2.1).

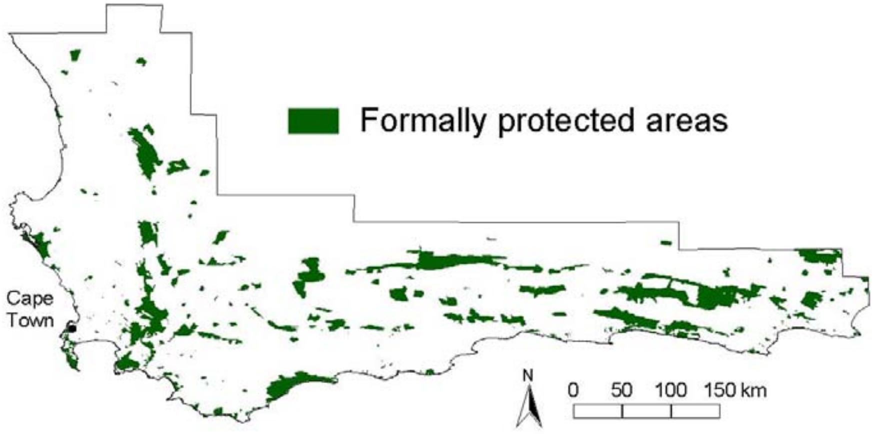

Figure 2.2.1. Formally protected areas in the CFR (see Rouget et al. 2003b)

The 163 Type 1 protected areas comprise 60% and the 96 Type 2 protected areas 40% of the total area under conservation (Table 2.2.1).

Table 2.2.1. Formally protected areas in the CFR (see Rouget et al. 2003b)

Class	Type	Number of sites	Current size (km^2)
Type 1	National parks	16	527.8
	Provincial nature reserves	96	8 924.3
	Local authority nature reserves	44	285.5
	DWAF forest nature reserves	7	118.0
Type 2	National heritage sites	37	226.8
	Private nature reserves	23	82.6
	Mountain catchment areas	14	5 802.1
	DWAF demarcated forest areas	17	246.9
	Private demarcated forest areas	2	33.6
	Protected natural environments	3	172.0
Total	**-**	**259**	**16 419.6**

NB: Number of individual sites does not correspond to total number of protected areas in each type. For example, 16 individual sites comprise 8 national parks within the region.

The system of formally protected areas in the CFR does not seem to be overly fragmented since the 259 formally protected areas, together with 30 existing conservancies, comprise 189 contiguous blocks (Rouget et al. 2003b). Overall, 60% of these protected areas occurs in 4 blocks larger than 100 000 ha and 90% in 22 blocks larger than 10 000 ha. However, invasive alien plants cover currently larger areas in protected areas than in non-protected areas of natural vegetation, which points out a severe shortcoming in protected areas management.

The formally protected areas in the region are managed mainly by two organisations: SANParks is responsible for national parks and national lake areas and the WCNCB is responsible for provincial nature reserves. Up-to-date information on the various research and recreation facilities in these protected areas can be obtained from both organisations online (see Internet Resources). In general, research and recreation facilities in the formally protected areas are excellent, as a result of a long history of scientific and tourist activity in the region.

A recent gap analysis highlighted the reservation bias in the system of formally protected areas in the CFR and the inadequate representation of many biodiversity patterns and processes (Rouget et al. 2003b). As in other parts of the world, this is a consequence of "*ad hoc* reservation" in the past (Pressey 1994), where protected areas have been established largely in remote and rugged landscapes that were not useful for other land uses, without considering explicit conservation targets for the representation of biodiversity patterns and processes. Consequently, the formally protected areas in the CFR are located largely in areas topographically or climatically unsuitable (or only marginally suitable) for agriculture, i.e. in the mountains, where they were proclaimed primarily to protect water catchments.

The geographic bias of protected areas affects their effectiveness in conserving biodiversity patterns and processes. Using habitat diversity as surrogate for biodiversity patterns, some habitat types appear to be over-represented whereas others appear to be under-represented in the existing protected areas system (Rouget et al. 2003b). While the system encompasses areas of all but three of 88 habitat types occurring in the CFR, 40 habitat types have less than 10% of their original area protected. In some lowland habitats, protected areas make up less than 5% of the land and more than 80% of the natural vegetation has been lost to agriculture, urbanization or invasive alien shrubs and trees (Rouget et al. 2003b, Rouget et al. 2003c). Prescribed conservation targets for biodiversity patterns (see Pressey et al. 2003) have been achieved for only 25 habitat types, whereas for 33 habitat types less than 20% of the conservation targets have been achieved. Disturbingly, most of the habitat types for which targets have not been achieved occur in the lowlands highly threatened by future land use change and climate change.

The existing protected areas system is ineffective not only in protecting biodiversity patterns but also in protecting biodiversity processes, although overall it encompasses 8% or more of each related spatial surrogate (Rouget et al. 2003a, Rouget et al. 2003b). Spatial surrogates, or components, of large-scale biodiversity processes (50 – 50 000 ha) were identified that, if protected, would enable the persistence of plant lineage diversification, species migration, and resistance and resilience to climate change (Table 2.2.2) (Cowling and Pressey 2001, Pressey et al. 2003).

Table 2.2.2. Examples of spatial components of relatively large-scale ecological and evolutionary processes (see Rouget et al. 2003a)

Spatial component	**Process**
Edaphic interfaces (spatially fixed)	Ecological diversification of plant lineages
Riverine corridors (spatially fixed)	Migration of biota (e.g. in response to climate change)
Upland-lowland interfaces (spatially fixed)	Ecological diversification of plant lineages
Upland-lowland gradients (spatially flexible)	Ecological diversification of plant and animal lineages, migration of biota (e.g. in response to climate change)
Macroclimatic gradients (spatially flexible)	Geographic diversification of plant and animal lineages, migration of biota (e.g. in response to climate change)

The existing protected areas system performs relatively well for biodiversity processes such as species migrations along upland-lowland and macroclimatic gradients in the uplands, owing to spatial connectivity of current protected areas in the uplands. The spatial components of many other processes, for example riverine corridors and macroclimatic gradients in the lowlands, are, however, poorly represented. Furthermore, not one of the protected areas has the appropriate size, composition and configuration of habitat types to sustain viable populations (at least 50 individuals) of all of the herbivores and carnivores that occupied the region in pre-European times (Kerley et al. 2003).

Although Type 2 protected areas and conservancies do not guarantee long-term protection, their contribution to pattern and process representation in the CFR is substantial (Rouget et al 2003b). Some habitat types are largely protected by Type 2 protected areas, and highly threatened lowlands are at present more protected in Type 2 protected areas than in Type 1 protected areas. Furthermore, Type 2 protected areas and conservancies provide important linkages among Type 1 protected areas, thus potentially enabling species migrations, for example. Therefore, incentives and other instruments (see Pence et al. 2003) to secure their protection status, or at least to ensure biodiversity-friendly land use, are urgently needed. They are also needed to secure large tracks of land required to meet the conservation targets for some relatively large-scale biodiversity processes (see Pressey et al. 2003). Finally, the achievement of these conservation targets will also require restoration of large tracks of land, and this, in turn, will themselves require incentives and other instruments for private landowners.

As indicated above, the reservation bias in the system of formally protected areas in the CFR reflects typical historical "*ad hoc* reservation" (Rebelo 1997). Rouget et al. (2003b) summarise the history of the protected areas system as follows. In the 1940s, five protected areas, all in mountain areas, were advocated to preserve the Cape flora. Emphasis was placed on upland habitats since they are home to the greatest plant diversity and endemism. Rapid protected area expansion also happened from the 1950s to mid 1970s, after most of the lowland habitats had been transformed by agriculture, thus limiting options for protecting them. After the mid 1980s, conservation agencies inherited large state-owned mountain catchment areas, which were later proclaimed as protected areas. However, they were primarily intended for water production and protection, and there was thus no explicit consideration given to their conservation value. Since the 1980s, management considerations (especially in respect of managing fire) have further reinforced the reservation bias. Because it is practically easier to manage one contiguous block than several scattered blocks, protected areas have been expanded by purchasing adjacent areas and thus enlarging the proportion of mountain areas already over-represented in the existing protected areas system, adding to its geographic bias.

In conclusion, the protected areas system in the CFR is faced with many challenges even without climate change. For example, it needs to become representative in terms of both biodiversity patterns and processes, and it needs to be managed more efficiently and effectively for both biodiversity and people. Clearly, with climate change the challenges will be exacerbated, and protected areas planners and managers will require additional resources to rise successfully to these challenges.

3. Global Change Factor Affecting the Site

Anthropogenic climate change is expected to be a major future threat to the biodiversity in the CFR (Midgley et al. 2002, 2003) – in addition to past, present and future habitat transformation and fragmentation, invasive alien species and overexploitation. Climate change could impact on species, ecosystems, human systems and protected areas in many ways, and some impacts of climate change are already apparent. These impacts present not only considerable challenges but also opportunities for protected areas planners and managers in the region.

Anthropogenic atmospheric change causes climate change in the same ways as natural atmospheric changes have done for millennia. Atmospheric change impacts on biodiversity in two ways. First, it directly affects the biosphere through increased atmospheric CO_2 concentrations, decreased stratospheric O_3 concentrations, which lead to increased UV-B radiation at the earth's surface, increased tropospheric O_3 concentrations and increased atmospheric N deposition. Second, it indirectly affects the biosphere through altering the natural greenhouse effect, through changing atmospheric concentrations of greenhouse gases such as CO_2, CH_4 and N_2O. These gases trap heat in the earth's atmosphere and, thereby, cause climatic changes such as changes in global temperature, precipitation and atmospheric circulation patterns.

Surprisingly little is known about the direct effects of atmospheric change on the Cape region. Mooney et al. (2001) suggest that increased atmospheric CO_2 concentrations are expected to change community composition because of the highly variable CO_2 response of different plant species. Due to elevated CO_2, which can improve the water use efficiency of plant species, some species may have competitive advantages, others competitive disadvantages. Stock and Midgley (1996) argue, however, that limiting nutrient availability would suppress Fynbos species responses to elevated CO_2. – a finding confirmed for some Proteaceae by Midgley et al. (1995, 1999). Furthermore, because fire in Fynbos generally limits the extent to which mature individuals compete for resources, CO_2 effects on growth are not likely to have a major impact on ecosystem functioning.

Increased UV-B radiation, caused by decreased stratospheric O_3 concentrations, could affect plant reproductive systems in the region. For some annual species in the arid Succulent Karoo, damaging UV-B effects may accumulate over time in the genome (Midgley et al. 1998). Several Fynbos species delay flowering and decrease flower, pollen and seed production when exposed to elevated UV-B expected for a 20% decrease in stratospheric O_3 concentrations. However, Wand (1995) showed that high flavonoid concentrations in the leaves of Fynbos species is likely to afford them protection from direct UV-B effects on photosynthesis and growth.

Increased tropospheric O_3 concentrations may be expected to change community composition because of the highly variable response of different plant species to damage by photochemical pollutants – but pollution levels in most Fynbos landscapes is trivial. Elevated O_3 could be especially damaging to Fynbos plants with future urban expansion, warming and drying – especially drought has been shown to further increase species sensitivity to damage by photochemical pollutants.

Increased atmospheric N deposition affects community composition by favouring weedy, fast-growing species over slow-growing species and decreasing overall biodiversity, not the least because many endangered species grow in N deficient habitats. However, N deposition probably does not have a notable effect on the CFR where air masses move onshore predominantly from vast stretches of ocean.

Much more is known about the indirect effects of atmospheric change on the Cape region – the impacts of climate changes themselves. Climate change projections for the CFR for the year 2050 suggest generally warmer and drier conditions with an increase in mean annual temperatures of about 1.8 ºC under a scenario of doubled atmospheric CO_2 concentrations (Midgley et al. 2003), although in some areas the direction of change in rainfall is still uncertain. The general future warming and drying, most likely unprecedented in the past 20 000 years or more, will intensify the already significant water stress across the region and impact on biodiversity and people in many ways.

In general, climate change might impact on species distributions, community composition and configuration, ecosystem functioning, services and states, and disturbance regimes (see Box 3.1) (Hannah et al. 2002a, 2002b). At worst it might result in extinctions of species that are not able to adapt to rapidly changing climates. Consequently, many protected areas are likely to lose species through extinctions and migrations.

Box 3.1. Potential climate change impacts on biodiversity

1) Species distributions

Individualistic species responses in latitudinal and altitudinal directions
Individualistic species responses to warmer/cooler and drier/moister conditions
Geographic variation in the magnitude of species responses to the changing conditions
Species range shifts/losses due to range expansions, contractions and eliminations
Species range shifts relative to reserve boundaries: net loss/gain of species in reserves
Local, regional and global extinctions of species due to the changing conditions
Spread of invasive alien species and/or pathogens and parasites

2) Community composition and configuration

Changes in presence/absence and relative/absolute abundance (evenness/richness)
Formation of non-analogue communities (new species assemblages)

3) Ecosystem functioning, services and states

Changes in phenology (the timing of events such as flowering)
Changes in nutrient cycling and natural resource supply (e.g. water)
Changes in predator-prey, parasite-host, plant-pollinator and plant-disperser relationships
Changes in ecosystem services such as pest control, pollination and soil stabilization
Ecosystem switches following changes in ecosystem functioning and disturbance regimes

4) Disturbance regimes

Changes in the intensity, frequency and seasonality of periodic and extreme events such as fires, floods, droughts and other extreme weather events
Changes in human land use pressures (global change synergies)

In the CFR, a winter rainfall region at present, climate change impacts will strongly depend on how rainfall seasonality, frequency and intensity will change. Changes in rainfall will, in turn, affect critical water resources and fire regimes with potentially devastating effects for biodiversity and people. In particular changes in the complex interaction of indigenous and invasive alien plants, fuel loads, fire seasonality, frequency and intensity, local wind and weather patterns and water balance will play a key role in changing biodiversity patterns and processes (Mooney et al. 2001). At the same time, climate change will affect agriculture, in particular the flourishing flower, fruit and wine industries, and the equally important ecotourism industry – through changes in biodiversity.

Overall, both the Cape flora and fauna stand to lose species, in particular where there is little scope for latitudinal or altitudinal range adjustments, for example in the heavily transformed and fragmented coastal lowlands. Clearly, species with good dispersal abilities will be better off than those with poor dispersal abilities when rapid species range shifts are required to keep up with changing climates. However, species that occur currently on mountain-tops might have no place to go with future warming, and habitat-specialist species might suffer greater impacts relative to habitat-generalist species. The many threatened, rare and fire-sensitive plant species in the region are equally at risk as the many highly specialized plant-pollinator and plant-disperser interactions. Climate change could interrupt these vulnerable mutualisms and prompt cascading extinctions caused by loss of mutualist partners (Bond 1994).

Future warming and drying could, overall, lead to the retreat of Fynbos plants to higher, cooler elevations, resulting in a contracted Fynbos biome. Due to the geographically isolated location of the Fynbos at the southern tip of Africa there is no refuge lying at more southern latitudes of the continent. With significantly warmer and drier conditions, Fynbos plants can only retreat to higher mountain areas or suitable micro-refugia. The topographic complexity of the mountain areas in the CFR could provide refugia for climate change-sensitive species on mesic south-facing slopes and higher elevations, for instance, but they would disappear from lower elevations and arid north-facing slopes (Mooney et al. 2001). Translocation experiments with species of the three characteristic plant families of the Fynbos biome showed early on that members of the Restionaceae and Proteaceae are the most sensitive functional groups, whereas Ericaceae were the least sensitive and survived when transferred to lower, warmer elevations (Euston-Brown 1995). Dispersal limitations and a hostile landscape matrix might, however, prove to be key obstacles for species migrations in response to climate change. In contrast to the Fynbos biome, which covers lowlands and uplands at present, the adjacent Succulent Karoo, the only arid biodiversity hotspot in the world, covers lowlands along the west coast of southern Africa. Due to the lack of topographic refugia, the entire Succulent Karoo is severely threatened with “extinction”, as was shown by Rutherford et al. (1999a).

Indigenous freshwater species and ecosystems, already severely impacted on by invasive alien species, are at risk from future drying. At the same time, climate change is likely to aggravate the problem of invasive alien species, which further affects critical water resources and fire regimes. Some coastal lowlands are also threatened by sea level rise, which will further reduce the remaining natural buffer between the ocean and human developments at the expense of coastal species and ecosystems.

In summary, biodiversity patterns and processes in the CFR might change over landscape scales over time frames as short as decades. These dynamic biotic responses to climate change present considerable conservation challenges (Hannah et al. 2002b). With species range shifts and losses, the traditional concept of sustaining species through static protected areas may be fundamentally flawed, since climate change will affect protected areas as much as other areas. According to Rutherford et al. (1999b), four out of five protected areas in South Africa are predicted to lose roughly between 10-40% of their plant species by the year 2050. Nonetheless, species and ecosystems in protected areas are expected to benefit from the higher degree of protection against other human pressures in their struggle to adapt to rapidly changing climates.

Not all protected areas are expected to be equally sensitive to climate change. But what makes a protected area particularly sensitive? Shafer (1999) pointed out some common characteristics of “reserves at risk” under climate change (see Box 3.2). Some examples are given of protected areas in the CFR that potentially meet his criteria. In addition, protected areas that are poorly planned or managed in respect of climate change impacts are expected to be particularly sensitive.

Box 3.2. Examples of “reserves at risk” in the CFR (see Shafer 1999)

Small reserves	Bontebok National Park, Robberg Nature and Marine Reserve
Reserves with rare or threatened species with restricted habitats or home ranges	Table Mountain National Park, Cape Flats Nature Reserves, Kogelberg Nature Reserve
Reserves with high-altitude environments	Cape Fold Mountain Catchment Areas, Swartberg Nature Reserve
Reserves with low-altitude environments	West Coast National Park, Cape Flats Nature Reserves
Reserves with species at the limits of their latitudinal or altitudinal range	Table Mountain National Park, Tsitsikamma National Park, Swartberg Nature Reserve
Reserves with abrupt land use transitions outside their boundaries	Table Mountain National Park, Cape Flats Nature Reserves
Reserves without usable connecting migration corridors	Table Mountain National Park, De Hoop Nature Reserve, De Mond Nature Reserve
Reserves with rare or threatened species near the coast	Knysna National Lake Area, Langebaan Ramsar Site, Wilderness Lakes Ramsar Site
Reserves with interior wetlands	Wilderness National Park, Goukamma Nature Reserve

When asked which impacts of climate change are already apparent in the CFR, local experts cite changes in nutrient cycling and resource supply, especially water resources, changes in ecosystem services, changes in disturbance regimes, especially fire regimes, and changes in species distributions. However, there is still a deficit across disciplines in the systematic detection of early warning signs of climate change.

Gaps in our knowledge of climate change are still a major challenge in the CFR. The lack of long-term weather station data complicates regional climate change modelling in some areas to such an extent that even the direction of changes in rainfall is still uncertain. Without a better understanding of the nature of the expected changes it is, however, difficult to respond to them. Species distributions, especially of sister species, are not yet fully understood, which poses problems for biotic response modelling. Monitoring stations and systems, especially for long-term baseline data collection on changes in biodiversity, are still lacking. Yet they are crucial to determine whether or not changes are occurring and climate change is the driving force in these changes. In addition, simple monitoring strategies are needed for adaptive protected areas management.

In the opinion of local experts, it is critical yet challenging to provide concrete and credible evidence of climate change and its impacts on biodiversity and people to the public, planners, managers and policy-makers. Some stakeholders do not yet see climate change as an important threat to biodiversity compared to more tangible threats such as habitat transformation and fragmentation. The uncertainty associated with climate change and its impacts further adds to the problem.

Further challenges include the identification of both climate change-sensitive species and ecosystems within and outside protected areas and appropriate strategies to conserve them with future warming and drying: How to manage rare and threatened species? How to cope with shifting species ranges? How to maintain plant-pollinator and plant-disperser interactions? How to control the spread of invasive alien species? How to manage water resources and fire regimes? Priority areas for biodiversity conservation need to be identified explicitly based on their resistance or resilience to climate change. Furthermore, a hospitable landscape matrix and/or connecting migration corridors will be necessary for species migrations in response to climate change.

Clearly, long-term planning for both the environment and development is required to avoid future land use conflicts. In order to allow

ecosystems and human systems to adapt to rapidly changing climates, the sustainable use of natural resources, especially water resources, needs to be negotiated wisely. Current stocking rates may have to be adjusted to warmer and drier conditions in the future to protect the natural vegetation from overgrazing. Finally, mitigation and adaptation strategies are required for the flower, fruit and wine industries, and the ecotourism industry.

On the other hand, climate change presents opportunities for researchers, planners and managers in the region. First, it has raised important questions about the vulnerability and adaptability of species, ecosystems and human systems in the CFR. To find answers in time, new national and international collaborative research projects are initiated, and increased and improved baseline data collection, mapping and monitoring is already underway. The climate change impacts anticipated in the CFR have also attracted considerable attention by global donors leading to additional funding. Furthermore, the climate change issue has resulted in increased environmental awareness by the public. This leads, in turn, often to greater public support for conservation action. A sense of urgency among the public, planners, managers and policy-makers may also speed up the implementation of conservation plans. At the same time, climate change may render some agricultural areas unsuitable for agriculture in the future, which may thus become available for biodiversity conservation. Finally, successful response strategies to climate change may ultimately result in an enlarged and enhanced protected areas system and better land management within and outside protected areas.

4. The Response Strategy

4.1 Introduction

To date, there has been no unified response strategy to climate change in the CFR, let alone South Africa. Instead, different stakeholders such as researchers, planners and managers of a number of conservation agencies, organisations and universities have started to address the climate change issue in many ways on different spatial and temporal scales. In doing so, some principles and practices have emerged that are now widely applied in biodiversity conservation in the CFR and beyond, in particular in the fields of regional modelling and systematic conservation planning. These principles and practices are being evolved continuously, and it is important to keep in mind that the success of many of them will only be measurable in the future, ultimately by the persistence of biodiversity.

In the following, a brief historical account of the early stages of response strategies is given first, highlighting how climate change was eventually “mainstreamed” in the CFR. Then the principles of climate change-integrated conservation strategies are briefly outlined. The most recent regional modelling and systematic conservation planning efforts are discussed using examples of state-of-the-art studies. Emphasis is placed particularly on how modelling influenced planning in the region, and how the findings can be applied to other regions, where required baseline data might not be available in similar quantity or quality. Finally, important issues relating to regional coordination and local implementation of climate change-integrated conservation plans and programmes are discussed.

4.2 From first steps to “mainstreaming” climate change

In the early 1990s, shortly after the Intergovernmental Panel on Climate Change (IPCC) had published its First Assessment Report, a report by Midgley and O’Callaghan (1993) from the National Botanical Institute investigated, for the first time, potential climate change impacts on South African vegetation from biome to species level. Based only on early regional climate change scenarios and the little information available at the time on vegetation responses to climate change, the report provides a remarkable overview of the range of impacts expected, without using any “modern” bioclimatic models. In the meantime, many of the predictions for the Fynbos vegetation have been confirmed, not only by bioclimatic models.

In the mid 1990s, a University of Cape Town MSc thesis (Euston-Brown 1995) featured first translocation experiments, which gave insights into how species of the three characteristic plant families of the Fynbos biome respond to different climate conditions. Then two separately prepared reports (Hulme 1996, Shackleton et al. 1996), spearheaded by international scientists, investigated potential impacts of climate change in southern Africa, and helped with capacity-building in the region.

In the late 1990s, in keeping with the requirements of the United Nations Framework Convention on Climate Change (UNFCCC), the South African Country Study on Climate Change was carried out by local experts. Above all the assessment of the vulnerability and adaptability of plant diversity (Rutherford et al. 1999a) attracted a lot of attention in the scientific community. Using bioclimatic models at biome and species level, illustrative maps were produced, showing changes in biome and species distributions for different climate change scenarios for the year 2050. These maps were later reproduced in international journals (Hannah et al. 2002a) and helped to develop climate change-integrated conservation strategies. The South African Country Study on Climate Change also resulted in the first publication dedicated exclusively to climate change impacts on protected areas in South Africa (Rutherford et al. 1999b).

The major breakthrough in terms of “mainstreaming” climate change in wider circles than just the scientific community came, however, not before the year 2001. “The Heat is on”, a lively 10-page publication by Midgley et al. (2001), summarized, understandably to all, the findings of the plant diversity part of the South African Country Study on Climate Change (Rutherford et al. 1999a). It communicated effectively the key message to the public, planners, managers and policy-makers: climate change is potentially hazardous to South Africa’s biodiversity and, therefore, needs to be taken into account in sound conservation strategies.

Regional modelling and systematic conservation planning efforts have mushroomed in the new millennium, thanks to the availability of excellent datasets, expert know-how and funding in the CFR. Most recently, Hannah et al. (2005) provided an in-depth overview of the lessons learned in this and other multi-species modelling efforts, with particular reference to the complex consequences of climate change for protected areas.

4.3 Climate change-integrated conservation strategies

The conservation challenges brought by climate change require the development of climate change-integrated conservation strategies to help biodiversity survive climate change (Figure 4.3.1). Important insights about climate change impacts on biodiversity, which ultimately led to the formulation of these strategies, were gained in the CFR. Key elements of these strategies include (see Hannah et al. 2002a, 2002b):

- Regional modelling of climate change and biodiversity responses
- Systematic conservation planning, including systematic reserve-site selection, with climate change as an integral factor
- Management across regional landscapes, including reserves and their surrounding matrix, with climate change as an integral factor
- Regional coordination, across national and provincial borders, and local implementation in cooperation with all stakeholders

In particular in the fields of regional modelling, systematic conservation planning, regional coordination and local implementation pioneering work is being done in the CFR as will be shown in the following.

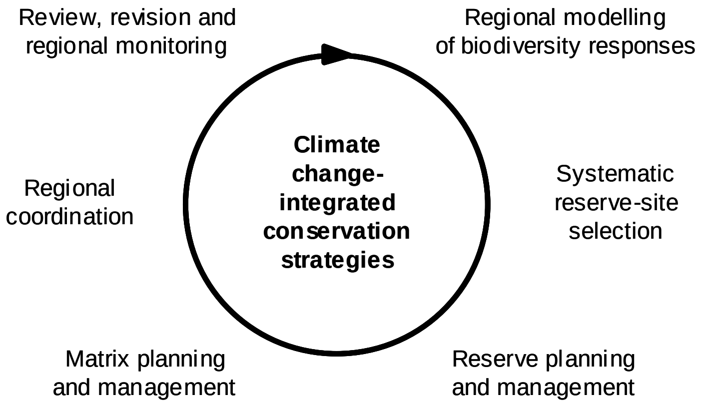

Figure 4.3.1. Key elements of climate change-integrated conservation strategies (see Hannah et al. 2002a, 2002b)

4.4 Regional modelling

A key element of climate change-integrated conservation strategies is regional modelling of climate change and biodiversity responses. Of particular interest to conservation planners and managers are the rates, magnitudes and directions of expected biodiversity response for different species and regions. Most assessments of climate change impacts on biodiversity begin by creating bioclimatic models of a species' present and projected future range. Bioclimatic modelling is based on the idea that known climate tolerances of species can be used to help predict potential future species range shifts. This information can then be used in the design of reserve networks and connecting migration corridors, and for the management of reserves and their surrounding matrix.

Key message (Midgley et al. 2002):

Bioclimatic models need to be temporally and spatially explicit,
to allow planners and managers to plan for maximizing migration potential.
One should also seek to factor in impacts of other threats to biodiversity.

Bioclimatic models describe a species' current climatic niche based on detailed information on its present distribution (Hannah et al. 2005). They may then be used to project this climatic niche into future climates derived from different climate change scenarios. The simplest models create a "bioclimatic envelope" for the species using the maximum and minimum values of various climatic variables found within the species' range. If a few key ingredients are available (see Box 4.4.1) bioclimatic models can nowadays be run on normal desktop computers.

Box 4.4.1. Key ingredients for bioclimatic models (Hannah et al. 2005)

Detailed information on present species distribution

- Modelling should be conducted on species level instead of biome level
- Modelling should be constrained to endemic species or cover the whole species range
- If possible use information on dispersal limitations of species of interest

Fine-scaled present and future data of climatic variables

Fine-scaled present and future data of other environmental variables (e.g. soil)

Bioclimatic models, statistical and technical know-how

In the CFR, all of the key ingredients have been compiled or computed since the 1990s, including the Protea Atlas Project dataset. This exceptional species distribution dataset provides records of presence and absence for some 350 Proteaceae taxa across the region and was prepared over ten years with the help of hundreds of amateurs (Rebelo 2001). Starting from scratch, it might take five to ten years of work before bioclimatic models can be run. However, if the required datasets are available already, or even if herbarium records of species distributions can be digitised, for example, it is possible to complete modelling much sooner. The early stages of response strategies in the CFR have also demonstrated that valuable initial assessments of the vulnerability and adaptability of species, ecosystems, human systems and protected areas do not necessarily require high-end models from the onset.

In South Africa, regional modelling studies have been carried out on the vulnerability and adaptability of plants and animals, for example (see Box 4.4.2 and 4.4.3). It is noteworthy that these are far from being scientific exercises only, but have great practical value for conservation planning and action. With relatively straightforward adaptations of existing systematic conservation planning tools such as reserve-site selection algorithms, those areas can be prioritised for biodiversity conservation that are identified explicitly based on their resistance or resilience to climate change.

The regional modelling studies discussed here are commonly based on climate change scenarios by the South African Committee for Climate Change for doubled atmospheric CO_2 concentrations most likely reached around the year 2050. The most widely applied scenario suggests generally warmer and drier conditions with an increase in mean annual temperatures of about 1.8 ºC in the CFR.

Box 4.4.2. Regional modelling of indigenous plant species

The vulnerability and adaptability of plants to climate change has been modelled in detail both for South Africa and the CFR.

Initially it was assumed that climate change would trigger holistic responses by biotic entities such as biomes, which would shift from unsuitable to suitable bioclimates as a whole. Thus, Rutherford et al. (1999a) modelled regional climate change impacts on South Africa's biomes for the South African Country Study on Climate Change. They found that the Succulent Karoo, the biome northwest of Fynbos, would disappear almost completely from its current range. In contrast, Fynbos was found to be the sole biome that retains much of its current range, due to the buffering provided by steep and large altitudinal gradients.

Subsequent studies, however, painted a bleaker picture for the Fynbos biome: Midgley et al. (2002) established that the bioclimatic envelope of the biome contracts significantly by about 2050 and estimated the overall loss of biome area at 50-65%. Furthermore, they noted a strong latitudinal dependence of biome loss, with the most extensive loss at the northern limits of the Fynbos biome. Their model predicted less than 10% retention of biome area north (equatorward) of 33 ºS. Finally, Midgley et al. (2003) further emphasized the future contraction of the Fynbos biome southward onto the higher altitudes of the Cape Fold Mountains. In contrast, plains and slopes at lower altitudes along the west coast and northern borders of this mountain belt are expected to not retain suitable bioclimates for Fynbos vegetation.

The differences in these projections are due to the different models and scenarios used and assumptions made, which stresses the importance of experimenting eventually with different models and/or scenarios wherever possible.

Nowadays species-level assessments have largely replaced biome-level assessments, following the recognition that species, rather than communities, are the unit of biotic response to climate change. In the CFR, the importance of individualistic responses had already been recognized in the South African Country Study on Climate Change, in which Rutherford et al. (1999a) stressed that species-level approaches are a refinement of the biome-level approach and provide a richer and more realistic picture of projected changes.

Rutherford et al. (1999a) found that the distributions of widespread species of the Fynbos biome contract along the northern limit, but persist along parts of the mountain chains and the southern coastal plateau. According to their projections, other species that are currently concentrated along the coast of the Fynbos biome persist, except at their western and eastern extremities. Subsequent species-level assessments by Midgley et al. (2002, 2003) focused on the Proteaceae endemic to the CFR, using the Protea Atlas Project dataset, and highlighted the individualistic responses of different species.

About 10% of the 330 Proteaceae taxa assessed have ranges restricted to the biome area predicted to be lost by about 2050 and are therefore most likely to go extinct (Midgley et al. 2002). Furthermore, some 30% of the species could suffer complete range dislocations by 2050, which means there is no overlap between their current range and future range. If these species cannot disperse rapidly enough to their future ranges and establish themselves in them, all of them could face extinction. Finally, some 40% of the species could loose up to one third of their current range, whereas only 5% will retain more than two thirds of their current ranges in the CFR.

Mapping the directions and distances of required range shifts is extremely useful for systematic conservation planning. In another study, Midgley et al. (2003) therefore determined the directions of potential range shifts and distances a species must traverse from its current range to its potential future range for 28 Proteaceae taxa in the CFR. Among those species, they found a general southeastward displacement in response to projected climate change, although some species showed large eastward shifts. This information was later used in the systematic conservation planning exercise CAPE, where it assisted in identifying macroclimatic gradients, which would allow species to migrate in response to climate change.

In the real world, climate change acts in concert with other threats to biodiversity and, thus, regional modelling should ideally investigate the combined impacts of them. The simultaneous assessment of multiple threats is, however, still in its infancy.

Midgley et al. (2003) made a first attempt by calculating current and potential future range sizes as well as directions and distances of required range shifts with and without taking into account the impact of current habitat transformation. One of their findings is at first surprising: Under current climate conditions, an average of 55% of the modelled ranges of 28 Proteaceae taxa is transformed, but this figure decreases to below 30% under future climate conditions. This is the result of species ranges shifting to higher altitudes where habitat transformation is minimal at present. The approach taken by Midgley et al. (2003) has one major weakness though: Habitat transformation is an ongoing process and the extent of transformed areas will change with time. Therefore it is desirable to investigate the combined impacts of climate change and habitat transformation using projections for both threats.

Using predictions of both climate change and habitat transformation, Bomhard et al. (2005) recently assessed potential short-term impacts on the Red List status of 227 Proteaceae taxa. From now to 2020, a considerable number of Proteaceae are predicted to be uplisted (become more threatened) by up to three threat categories, and the proportion of threatened vs. not-threatened taxa could rise by up to 16%, depending on the future scenario. Overall, climate change was found to have the most severe effects on the Proteaceae even in the near future.

Interestingly, Proteaceae from different regions or altitudes within the CFR seem to respond differently to the future threats. This type of species-specific, spatially explicit information should be extremely useful for future conservation planning and prioritising species and regions for conservation action in face of climate change.

As indicated above some of these findings have already been applied, if only qualitatively, in the CAPE, SKEP and STEP conservation plans. In addition, a list of the most climate change-sensitive Proteaceae taxa (Bomhard et al. 2005) currently assists SANBI's Threatened Species Programme and its monitoring programme Custodians of Rare and Endangered Wildflowers in picking "plants to watch". Ultimately, it is hoped to establish early warning systems in the CFR, based on both regional modelling and monitoring efforts, which will serve as environmental change detectors and support proactive as opposed to reactive management approaches to climate change.

Box 4.4.3. Regional modelling of indigenous animal species

The vulnerability and adaptability of animals to climate change has not yet been modelled in as much detail as in the case of plants. Van Jaarsveld et al. (1999) did, however, pioneering work in this field for the South African Country Study on Climate Change.

Using bioclimatic envelope models, they investigated climate change impacts on a representative set of some 180 animal species. Some 17% of the species, including some Red List species, showed range expansions. However, 78% of the species showed range contractions ranging from 4%-98% of their current range sizes. Only 3% of the species displayed no or little response in terms of their range size, probably because they are currently distributed in the moister, eastern areas of the west-east aridity gradient in South Africa, the gradient along which species range changes are likely to occur (Erasmus et al. 2002). Finally, four species are predicted to go locally extinct in South Africa following climate change, and they are either habitat specialists with restricted disjointed ranges or occur predominantly in drier, western areas.

In addition to predicted changes in range size, van Jaarsveld et al. (1999) looked at range shifts in changing climates. Unsurprisingly, the majority of predicted range shifts is expected in an easterly direction, again reflecting the east-west aridity gradient across the country. In line with this, species losses will be highest in the west. Combining both range decline and displacement into a single measure, the study identified species in each taxonomic group that are expected to experience an overall range change of more than 50%. For future monitoring, some of these species, particularly if they are Red List species of conservation concern, could be focused on as climate change indicators.

As van Jaarsveld et al. (2002) point out their study may well underestimate the consequences of climate change for animals, because habitat transformation has not been factored into their model, and predicted range shifts into transformed areas may in fact mean local extinction.

Regional modelling of climate change impacts on invasive alien species and disturbance regimes is a critical component of climate change-integrated conservation strategies given their important influence on many ecosystems (Box 4.4.4). Some scientists have long challenged the notion that climate directly determines species distributions and that climate change impacts can therefore be predicted by simply projecting climatic niches into future climates (Bond and Richardson 1990). Instead climate could, at least in some cases, indirectly determine species distributions by changing disturbance regimes or competitive species interactions.

Box 4.4.4. Regional modelling of invasive alien species

Invasive alien species are already a major threat to the indigenous biodiversity in the CFR. This problem is expected to aggravate in the future, in part due to climate change, which could lead to new invaders and changing distributions of established invaders. Biotic response modelling, either on a conceptual basis or with bioclimatic models, should thus be useful to identify potential invasions and appropriate management actions.

Richardson et al. (2000) investigated, for example, how projected climate changes could change distributions of five plant species, each representing an important life form in South Africa's invasive alien flora, with a long history (100-300 years) in the region. According to their bioclimatic models, the five plant species will be affected very differently by climate change. When compared to the substantial climate change impacts on some indigenous species, these invasive alien plants show, however, a generally lesser degree of sensitivity.

Moreover, Richardson et al. (2000) point out an important issue: Many exotic species, especially recent introductions, have yet to reach their equilibrium distributions in South Africa, and care must therefore be taken when applying bioclimatic envelope models because they assume equilibrium distribution. The spread of alien invasive plants might also be strongly dependent on disturbance regimes and competitive species interactions, both of which are certainly affected by climate change (Bond and Richardson 1990).

Higgins and Richardson (1998) developed a model that simulated explicitly the interactions between invasive alien plants and disturbance regimes – yet without climate change impacts. The model enabled them to explore the effects of changing disturbance regimes on invasion dynamics in South Africa. In the Fynbos biome, the increasing number of human ignition events is especially important, leading to more frequent and less intense fires.

Changing disturbance regimes and competitive species interactions of both indigenous and invasive alien species will require adaptive management. Monitoring exotic species already present and screening other potentially invasive alien species, which are so far absent from the region, could, for instance, help to prevent future invasions in the Fynbos biome.

Having looked at some of the regional modelling studies, we will now explore what their findings mean for protected areas planners and managers, and how modelling influenced planning in the region, using some systematic conservation planning exercises as examples.

4.5 Systematic conservation planning

Many of the measures that are now being proposed to ensure or, at least, enhance the resistance and resilience of landscapes and reserves to climate change are not new. Based on common landscape ecological principles (see Dramstad et al. 1996 for instance), they have long been proposed to protect biodiversity in healthy, living landscapes with a high degree of landscape connectivity. In many cases, the explicit consideration of climate change impacts just seems to further stress the importance of these basics of landscape and reserve design. Shafer (1999) provides an overview of options for making reserves fit for changing climates (see Box 4.5.1), and the Addo Elephant National Park, at the eastern edge of the CFR, provides a useful case study for some of these (see Box 4.5.2).

Box 4.5.1. Options for planning and managing reserves (Shafer 1999)

Creating new reserves
Enlarging existing reserves
Creating replicates of existing reserves
Designating “stepping-stone” or corridor reserves
Creating buffer zones of natural habitat around reserves
Increasing habitat heterogeneity within reserves (e.g. altitudinal, latitudinal and topographic)
Restoring, regulating or maintaining disturbance regimes
Removing or reducing invasive alien species
Reducing other environmental stresses
Restoration or rehabilitation of natural habitat
Translocation, reintroduction or introduction of species
Expanding inventory, modelling, monitoring, sensitivity analysis etc.

Box 4.5.2. A case study: Addo Elephant National Park


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For the South African Country Study on Climate Change, Rutherford et al. (1999a) assessed the threat of climate change to plant biodiversity in five key protected areas representing a range of bioclimatic conditions in the country. Only one of the assessed protected areas lies in part in the CFR: Addo Elephant National Park. According to their projections, this reserve faces intermediate bioclimatic shifts, which should allow at least some species’ future bioclimatic ranges to overlap with their current bioclimatic ranges.

Rutherford et al. (1999a) concluded that the extensions to Addo Elephant National Park, proposed at the time of their study, would have the effect of widening the bioclimatic conditions represented in the reserve in the future by decreasing the lower and increasing the upper bioclimatic limits. This would provide a degree of buffering for the species in the protected area against climate change and, in turn, promote the persistence of them.

The Greater Addo National Park (GANP) initiative, founded in the meantime, has promoted the consolidation and expansion of two protected areas, including the Addo Elephant National Park, to form a single larger one (Kerley and Boshoff 2002). In terms of its habitat diversity, the resulting reserve will be the most diverse protected area in South Africa, containing representative areas of six of the seven terrestrial biomes occurring in the country. This is thought to ensure that at least some of these bioclimatic regions will persist there in the face of climate change. In addition, it is expected that the marked altitudinal variation within the proposed protected area will facilitate altitudinal species range shifts as species respond to climate change.

The relative importance of different options in Box 4.5.1 might differ from region to region. In the CFR, local experts stress, for instance, the importance of dealing with invasive alien species and disturbance regimes. Habitat heterogeneity within reserves, buffer zones around reserves and landscape connectivity outside reserves are seen as equally important, and are certainly universal features of climate change-integrated conservation strategies. Furthermore, a sceptic points out that the different options in Box 4.5.1 present win-win solutions for conservation in any case:

> “All of the above options are desirable but are triggered by the desire to conserve the CFR in the face of rampant development and not primarily climate change.”

Using the Protea Atlas Project dataset, Hannah and Salm (2003) recently managed to identify six primary relationships between reserves and a species, and recommended conservation actions (Table 4.5.1). They used the software WORLDMAP for their analysis, a programme that allows selection of reserve sites that contain all species in a minimum-area set, for instance. The relationships they found highlight the importance of locations in which species would persist despite climate change: areas where both present and future ranges overlap (see Figure 4.5.1). And these locations, where no conservation action is required, would ideally form the basis of a climate change-integrated protected areas system.

Table 4.5.1. Primary relationships between reserves and a species with recommended conservation actions (Hannah and Salm 2003)

Relationship between reserves and a species	**Conservation action**
Present and future ranges are both represented in the same existing reserve	No conservation action required
Present and/or future range are both represented in existing reserves; but preferred location representing both present and future ranges in single reserve is unprotected	New reserve is preferred
Either present or future range is represented in existing reserves	New reserve and connectivity are required
Present and future ranges are represented in existing reserves	Connectivity is required
Present and future ranges are represented in existing reserves; but preferred location minimizing distance of connectivity is unprotected	New reserve is preferred and connectivity required
Neither present nor future range is protected	New reserves and connectivity are both required

The summary of recommended conservation actions highlights an asset of this approach (Hannah and Salm 2003): it offers options for optimising and rationalising an existing reserve network for changing climates. Sometimes a single existing reserve will be able to protect both present and future ranges of a species (see Figure 4.5.1: the arrow points at the Kogelberg Biosphere Reserve where both present and future ranges of *Protea angustata* overlap). In other cases, a new reserve will be preferred because it permits protection of both present and future ranges in one location even though existing reserves protect both present and future ranges. Where establishing connectivity between the existing reserves is more costly than establishing a new reserve that protects both present and future ranges, conservation in the single, new reserve may be preferable. New reserves may also be preferred where they substantially shorten (or reduce the cost of) required connectivity, for similar reasons.

For the persistence of species whose present and future ranges do not overlap, such as *Leucadendron thymifolium* (see Figure 4.5.1), the question is: How will they reach their future ranges? Will they be able to migrate fast enough despite dispersal limitations and a hostile landscape matrix? For such a species, integrated planning and managing of reserves and their surrounding matrix is required. Furthermore, translocation from its present range to its future range could be considered as an appropriate conservation action (Rutherford et al. 1999a). In practice, implications for the biodiversity in the target area have to be examined first though, to avoid adverse effects such as the hybridisation of sister species.

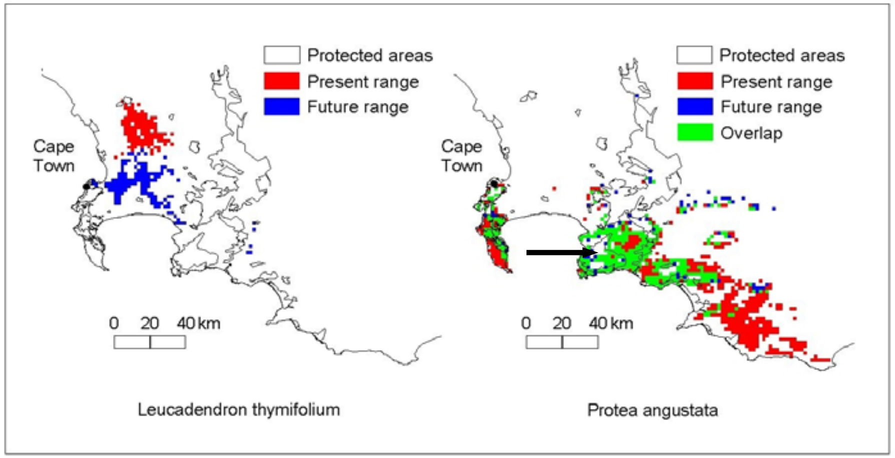

Figure 4.5.1. Present and future ranges of Proteaceae with and without overlap in the Southwest of the CFR showing some protected areas. The arrow points at the Kogelberg Biosphere Reserve.

For the CFR, Hannah and Salm (2003) also stressed the considerable importance of upland conservation in the face of climate change. They found that existing reserves contain sufficient area, especially in the uplands, to accommodate most of the required range adjustments, although these adjustments are complex and often conflicting. However, some new reserves are required to fully represent the Proteaceae in their future ranges, but the area of these new reserves is small relative to the size of the existing reserve network. With climate change, the historical reservation bias towards uplands in the CFR might, for once, be an ally of the region's conservationists – if species can reach their future ranges.

Systematic conservation planning is aimed at both biodiversity representation and persistence. The goal of biodiversity persistence requires the representation not only of biodiversity patterns, but also of the processes that maintain, sustain and generate this biodiversity (Cowling et al. 1999a, Rouget et al. 2003a). Incorporating ecological and evolutionary processes, including those thought to alleviate climate change impacts (see Table 2.2.2), into systematic conservation planning is now common practice in the CFR. Coarse- and fine-scale conservation plans such as CAPE, SKEP, STEP and the Cape Lowlands Renosterveld Project (Von Hase et al. 2003) explicitly target spatial components of biodiversity processes that should enable resistance and resilience to climate change.

Although the explicit consideration of biodiversity persistence and incorporation of both biodiversity patterns and process represents a major advance in systematic conservation planning, in practice only "qualitative" approaches have yet been employed regarding climate change. What do we mean by "qualitative"? In the CAPE, SKEP and STEP conservation plans, the selection of spatial components of biodiversity processes was based on common landscape ecological principles and first indications on the nature of climate change impacts on biodiversity (Cowling et al. 1999b, Rouget et al. 2003c). But it was not based on spatially explicit results from regional climate change and biotic response modelling. In the following, we will introduce three "quantitative" approaches that have recently been developed or demonstrated in the CFR, however they have not yet been employed in any formal conservation plans or programmes.

First, for the prioritisation of limited resources, it should be useful to know where future climate conditions will resemble those suitable for communities and species at present. On the biome level, the South African National Spatial Biodiversity Assessment has identified those areas in the country from which a current biome will not disappear under three different climate change scenarios of doubled atmospheric CO_2 concentrations (Figure 4.5.2) (Rouget et al. 2004). These areas appear to be somewhat resilient to climate change and should therefore be focused on in future conservation planning and action because they are most likely to maintain and sustain biome-specific biodiversity patterns and processes. In the Fynbos biome, these areas extend mainly along the Cape Fold Mountains and south coast, whereas areas along the west coast do not exhibit any resilience to climate change on the biome level. A fundamental flaw of this approach could, however, be the assumption of a holistic, community-level response rather than and individualistic, species-level response to climate change. Therefore, similar studies should also try to identify areas of resilience to climate change on the species level.

Key message (M. Rouget, personal communication):
Areas of resilience to climate change on the community and species level,
with no or little change under various climate change scenarios,
should be identified and prioritised for conservation.

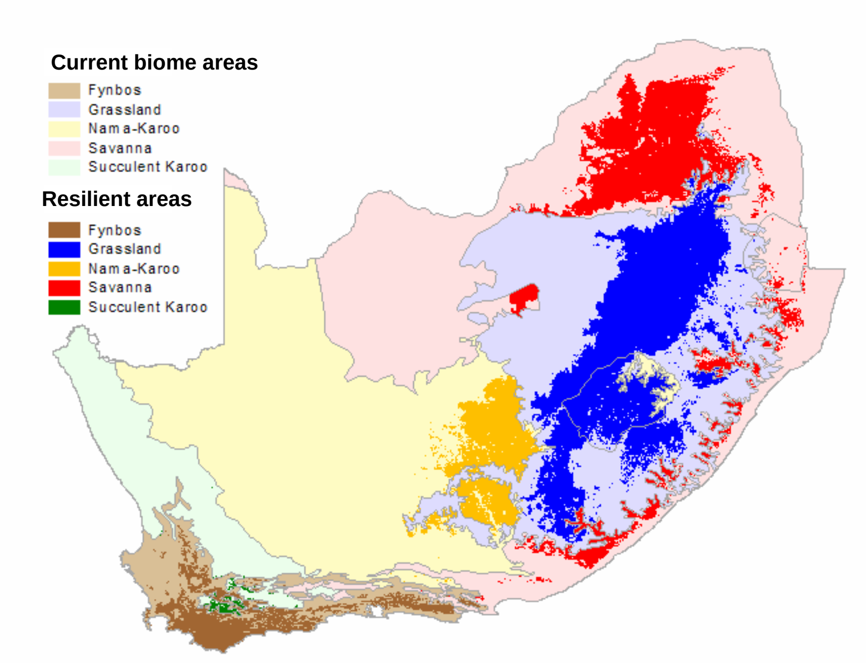

Figure 4.5.2. Areas of biome resilience to climate change in South Africa: i.e. areas where local climate conditions will remain within the current bioclimatic envelope of the biome concerned under three different climate change scenarios (Rouget et al. 2004) (Map provided by M. Rouget)

On the species level, “quantitative” approaches in the CFR still focus on the Proteaceae, due to the lack of similar high-resolution datasets for other species groups, which is certainly a shortcoming that has to be addressed in the future. Two recent studies show methods for identifying priority areas based on multi-species modelling efforts and how their results compare to the CAPE conservation plan (Box 4.5.3 and 4.5.4).

Box 4.5.3. Identifying priority areas for bioclimatic representation

For the species level, Pyke et al. (2005) invented a novel method to identify and prioritise areas based on their value for improving representation of bioclimatic conditions for multiple species with changing climates. They essentially accomplished a bioclimatic gap analysis of the existing protected areas system in the CFR for a single climate parameter (mean annual precipitation) under present and future climate conditions using some 300 Proteaceae taxa.

Their study in a nutshell: First, they evaluated bioclimatic representation across the range of each species for habitat both within and outside protected areas under 2000 and 2050 climates. Then they evaluated the coverage of the existing reserve network for the species using a bioclimatic representation index. This index indicates whether the reserve network, or a single reserve, will be wetter or drier in the future than current CFR-wide climate conditions suitable for the species. Then they applied this new metric as a weighting to the portion of each species' range that is not yet well represented bioclimatically in the protected areas. This helps to identify and prioritise areas where the addition of new protected areas might improve bioclimatic representation. Finally, they aggregated this information for all species and identified priority areas of high value for improving bioclimatic representation.

Under current climate conditions, they found only a modest reservation bias in the existing reserve network. However, if the reserve system is not supplemented, in 2050 it will capture an increasingly skewed sample of climatic conditions occupied by Proteaceae at present. Pyke et al. (2005) recognized at least three areas with high value for multiple species to close the gaps in the existing reserve network in the CFR.

To evaluate the bioclimatic representation value of currently proposed reserves, they also assessed the seven implementation stages of the CAPE conservation plan, both individually and in total. Fortunately, they found that many of the most valuable areas for improving bioclimatic representation coincide with priority areas already earmarked for future conservation action in the CAPE conservation plan.

Furthermore, the soon to be implemented stages 1 and 2 of the CAPE conservation plan, targeted at key biodiversity patterns and processes (see Cowling et al. 2003), will already make the most substantial improvements to bioclimatic representation within protected areas. This seems to indicate that the CAPE planning process was successful in identifying priority areas that are important for alleviating climate change impacts, although the latter were considered only qualitatively rather than quantitatively.

Key message (Pyke et al. 2005):

In biodiversity hotspots with many endemic species that have limited environmental tolerances, bioclimatic representation provides an effective surrogate of direct biodiversity measures when setting conservation priorities.

Box 4.5.4. Identifying priority areas for poorly dispersing species

A climate change-integrated gap analysis can be based on species distributions if spatially explicit information on their required range shifts and dispersal patterns and processes is available. To answer the question how to identify priority areas for poorly dispersing species, which will have to move from formerly suitable areas to newly suitable areas under climate change, Williams et al. (2005) invented a time-slice modelling method for identifying corridors of connectivity for multiple species.

In general, the method seeks to minimise (1) the distances that species are required to disperse across the landscape to accomplish their required range shifts and then (2) the amount of land area required, used as a surrogate for the total cost to society. Williams et al. (2005) applied this method to some 280 Proteaceae taxa in the CFR. In this case, their goal was to provide each species where possible with a viable range size of at least 100 km^2 at any one time between 2000 and 2050 despite climate change. The method differentiates between persistence areas for non-obligate disperses, where species are expected to continue to occur in all assessed time slices, and dispersal areas for obligate dispersers, which form minimum-distance dispersal chains and "stepping stones" across time slices.

According to their models, achieving the goal would require a near-doubling of the total area under conservation in the region. At first sight, this might seem ambitious, but it is still much less than proposed in the CAPE conservation plan, for example. The latter aims at extending conservation management to some 52% of the region. Interestingly, most of the areas identified as corridors of connectivity are already considered totally irreplaceable in the CAPE conservation plan (see Cowling et al. 2003). Yet some areas potentially important for the dispersal of Proteaceae have been missed in the CAPE conservation plan.

Similar to other approaches discussed here, this method is sensitive to the choice of models and scenarios, and to the assumptions about species sensitivity, habitat suitability and dispersal limitations. Furthermore, the question remains whether or not the identified dispersal corridors can ever be expected to actually work for the species. Landscape transformation and fragmentation and the presence or absence of suitable 'micro-refugia' might be at least as important as theoretical dispersal routes in determining the success or failure of relatively coarse-scale dispersal corridors. Finally, it is not clear if the areas identified as important dispersal corridors for Proteaceae will provide dispersal routes for other organism under climate change. Nevertheless, for a large number of species that have to move, using the method described by Williams et al. (2005) to identify corridors of connectivity may be paramount for planning and managing reserves and their surrounding matrix, whereas translocation may be more practical if only a small number of species has to move.

Key message (Williams et al. 2005):

Simply identifying persistence areas could work for some species with dispersal limitations. For other species, especially obligate dispersers, corridors of connectivity, as represented by minimum-distance dispersal chains and "stepping stones" through time, should be identified and prioritised to improve dispersal.

When it comes to advanced modelling and planning for changing climates these two studies show the way: species-level approaches should incorporate different, ideally species-specific, dispersal scenarios. They should not only focus on areas of resilience or persistence areas but also try to identify and prioritise linkages in the landscape such as critical corridors that are likely to be used by many species in response to climate change. Such approaches should also evaluate existing conservation plans and programmes based on their findings, estimate total cost to society of different conservation options, and feed back into land-use planning and decision-making on all scales (see also Driver et al. 2003).

4.6 Regional coordination and local implementation

When designed and managed specifically for climate change, regional reserve networks, landscape connectivity, and transboundary cooperation and coordination in planning and managing reserves and their surrounding matrix are key features in effective climate change-integrated conservation strategies (Hannah et al. 2002a).

For such landscape-based approaches to be effective, regional coordination of land-use planning, decision-making and management will be necessary across political divisions, and intranational and international boundaries (Midgley et al. 2003). In the CFR, this coordination is required within sub-divisions within a single country. The CAPE conservation plan has identified seven implementation stages ultimately leading to a network of conservation areas covering some 50% of the region. Clearly, this requires enormous efforts with regard to regional coordination of on- and off-reserve conservation options. Furthermore, the planning domain of the

CAPE project overlaps partially with those of the SKEP and STEP projects to the north and east of the CFR. This ensures integrated land-use planning, decision-making and management on a trans-regional scale but, at the same time, requires coordination of all stakeholders involved.

With the National Spatial Biodiversity Assessment, there is now for the first time a national context for regional and local conservation plans in South Africa. All of them should be seen as a nested system of plans that complement each other, and all of these plans will eventually address the climate change impacts anticipated in the respective region.

In other cases, coordination across international boundaries will be equally important. TFCAs can in fact make a vital contribution towards conserving migratory species, reducing impacts of climate change through restoring linkages in the landscape that give species space to adjust along critical corridors, and ensuring the maintenance of ecosystem services and ecological and evolutionary processes (Hanks 2003).

Even the most ambitious national and regional conservation plans and programmes need eventually to be implemented at a local level. When it comes to local implementation, the Cape Lowlands Renosterveld Project and its partnership projects show the way (Box 4.6.1). Some of the pioneering approaches should prove invaluable for the local implementation of climate change-integrated conservation plans and programmes. Due to its limited planning domain, the fine-scale conservation plan prepared by the Cape Lowlands Renosterveld Project cannot cater for all of the large-scale ecological and evolutionary processes, for example major range adjustments following climate change. Nevertheless, it seeks to conserve river corridors, which could be important for species migrations in response to climate change. Implementing coarse-scale conservation plans such as

CAPE, SKEP and STEP, which cater for the large-scale ecological and evolutionary processes, will, however, require similar approaches to on- and, especially, off-reserve conservation on the ground.

Box 4.6.1. A case study: Cape Lowlands Renosterveld Project

Following the recognition that planning and implementing conservation action need to be more closely integrated to be successful, the planning process of the Cape Lowlands Renosterveld Project took an implementation-orientated approach, through the consistent involvement of the implementing agency, namely WCNCB, in all stages of the project (Von Hase 2003).

Key outputs of this fine-scale planning project include a 20-year spatial conservation vision for Renosterveld vegetation and a 5-year spatial conservation action plan to guide implementation efforts. The conservation action plan identifies priority areas for inclusion in an off-reserve conservation network. Given that most of the Renosterveld areas are privately owned, successful off-reserve conservation is critical for successful Renosterveld conservation, because on-reserve conservation is socio-economically not practical in most areas.

Taking a new, pioneering approach to conservation on private land, a related partnership project between BotSoc and WCNCB is now addressing the implementation of the off-reserve conservation network: the Conservation Stewardship Pilot Project (Winter 2004).

This project tries to encourage private landowners to take personal responsibility for the natural habitat on their properties. Based on the conservation importance of their properties, landowners are generally provided with three options, ranging from a legally not binding entry option without a defined commitment period to a ‘contract nature reserve’ valid in perpetuity or a minimum of thirty years. In contrast to all other previous off-reserve conservation initiatives, the concept of conservation stewardship provides site security (Winter 2004). This is achieved by attaching a legal contract to the title deed of the property, which is lodged with the deeds office and binds future landowners to adhere to any provisions or restrictions relating to the conservation portion of the property.

Not surprisingly, the Conservation Stewardship Pilot Project, which was also involved in the planning process of the Cape Lowlands Renosterveld Project, is considered crucial for facilitating the transition from planning to implementing conservation action on the ground (Von Hase 2004). Meanwhile, South Africa’s new Biodiversity Act, Protected Areas Act and Property Rates Act contain clauses that will benefit conservation on private land. For example, any property or portion of a property that is declared a ‘contract nature reserve’ will be excluded from rates that are levied by municipalities on rural land.

As Winter (2004) puts it: “This is certainly a victory for conservation!”

Another project between BotSoc and WCNCB aims to ensure that the results of the Cape Lowlands Renosterveld Project are routinely used in land-use planning and decision-making in the Western Cape province (Job

and Driver 2004). This project is aptly named Putting Biodiversity Plans to Work. It will prepare a map in close consultation with each municipality, showing priority sites for biodiversity conservation as well as guidelines for land-use planning, decision-making and management in these priority sites. In addition, it will provide training workshops and support to all relevant parties, track the use of the maps and guidelines in specific land-use plans and decisions, and monitor feedback from users on what works and what does not. By documenting all these efforts, the project hopes to share lessons learned and to assist the creation of similar initiatives.

Finally, a predominantly “north-south” transfer of resources is necessary to underwrite the modelling, planning and coordination efforts, establishment of new and/or expanded reserves, and management of reserves and their surrounding matrix that are essential elements of climate change-integrated conservation strategies (see Midgley et al. 2003). Cooperation among international and national donors has initiated this support for the initial stages of modelling and planning in the CFR. Major new funding mechanisms are, however, called for to extend this support to other essential strategy elements in the CFR and beyond.

5. Lessons Learned and Guidelines

5.1 What has been achieved?

1. Climate change has become part of the public's consciousness and the agendas of researchers, planners, managers and other stakeholders.
2. Regional modelling has highlighted how climate change could impact on species, ecosystems, human systems and protected areas. It identified potential climate change winners and losers, for example, and important issues for researchers, planners and managers.
3. Systematic conservation planning has begun to include climate change explicitly in reserve-site selection on a regional level. Sound response strategies, often in line with common landscape ecological principles in any case, target latitudinal and altitudinal climate gradients and riverine corridors, for instance. These should allow for species migrations in response to climate change.
4. Similarly, national and provincial agencies have begun to include climate change explicitly in their managing, mapping and monitoring activities. Fire management strategies are carefully reconsidered, for example, and potential climate change indicators, both biotic and abiotic, are mapped and monitored to feed back into future modelling and planning activities.
5. To date, climate change has been considered in modelling, planning and managing in a way that does not detract from other pressing environmental issues such as habitat transformation and fragmentation, invasive alien species and overexploitation. In many cases it must be concluded that climate change has actually attracted an increased interest in environmental issues and sound conservation strategies.

On the other hand, there is no unified response strategy to climate change in the CFR yet. Despite early successes in "mainstreaming" climate change, providing a positive message of individual action to the public has been difficult, and different stakeholders still follow different response strategies. Regional and national government departments that could play a coordinating role, have essentially failed so far to take a lead in this regard. Fortunately, modelling efforts such as the South African Country Study on Climate Change and planning efforts such as the CAPE, SKEP and STEP projects happened to coincide so that initial modelling results have been included in planning methods in an intelligent manner. Compared to more tangible threats such as habitat transformation and fragmentation, climate change is, however, still neglected by protected areas planners and, in particular, by managers.

5.2 What are the main lessons that have been learned?

1. Outreach activities and sound communication strategies are critical from the onset to raise environmental awareness for climate change mitigation and adaptation: The South African Country Study on Climate Change and, in particular, "The Heat is on", a lively 10-page publication communicated effectively the key message to the public, planners, managers and policy-makers: climate change is potentially hazardous to South Africa's biodiversity and, therefore, needs to be taken into account in sound conservation strategies.

2. Potential climate change impacts on biodiversity can be identified in various ways: brainstorming, experimental studies in the field and labs, regional climate change and biotic response modelling. Good quality datasets and expert know-how are required for modelling, and partnerships are necessary (public-private, universities, organisations, agencies, overseas) to collect baseline data and species distribution data and mine expert knowledge. Climate change-sensitivity can be estimated using rules of thumb or guidelines such as these by Shafer (1999) (see Box 3.2). A first climate change-sensitivity analysis of all the reserves in a particular region can be done using information on climate change-sensitive species and ecosystems in general. While early broad brush assessments of climate change impacts driven by common sense and a basic ecological understanding may allow ballpark estimates, more detailed modelling reveals many nuances in ecosystem responses and species-specific concerns that are important for conservation planning.

3. Regional modelling can indicate the rates, magnitudes and directions of expected biodiversity response and potential climate change winners and losers. Species with small geographic ranges and poor dispersal abilities are at high risk from climate change. Climate change is likely to reduce the geographic ranges of most indigenous species, with only a few appearing to benefit in terms of range gains (e.g. Hannah et al. 2005). This effect raises the risk of stochastic extinction. The major impact on Fynbos plants is likely to be through the effects of drought (as a result of combined warming and drying and even increased human pressures on water resources). In the CFR, modelling also indicates that climate change impacts could be greater in the lowlands

than in the uplands. Thus, modelling potential climate change impacts is a key element of a response strategy. However, modelling introduces many levels of uncertainty and this need to be explicit. Ongoing assessment of updated climate scenarios is also a priority to gauge when vegetation and species modelling needs updating.

4. Modelling can inform planning despite the uncertainty involved. A strategy of making sure for each vegetation type that a full range of altitudinal and latitudinal environments is captured is sound. Ensuring habitat heterogeneity within reserves (e.g. altitudinal, latitudinal and topographic), buffer zones around reserves and landscape connectivity outside reserves is also sound. The current goal of ocean to mountain corridors applied in the CAPE conservation plan is a sound strategy. To alleviate climate change impacts, riverine corridors, upland-lowland gradients, macroclimatic gradients and habitat connectivity are targeted in the systematic conservation planning exercises in the CFR (Table 2.2.2). On coarse, regional scales, riverine corridors, upland-lowland gradients and macroclimatic gradients are important features for ensuring habitat connectivity (see CAPE, SKEP and STEP projects), whereas on finer, sub-regional scales, habitat connectivity needs perhaps to be defined and determined by other features (see Cape Lowlands Renosterveld Project). In the CFR, the existing and currently proposed reserves could eventually provide reasonable buffering against climate change impacts, according to recent modelling studies. However, the high levels of uncertainty relating to species range shift projections limit the direct application of results to systematic conservation planning.

5. Ancillary human pressures and stresses exacerbate climate change impacts on species persistence and need therefore to be reduced – habitat transformation and fragmentation are clear examples that limit natural adaptation strategies.
6. Based on common landscape ecological principles and first indications on the nature of climate change impacts on biodiversity, healthy, living landscapes with a high degree of landscape connectivity can be designed.
7. Regional coordination of conservation planning is required (e.g. CAPE, SKEP and STEP projects): Initiatives in bioregional planning and management (such as the National Spatial Biodiversity Assessment) are greatly aided by the use of geographic information systems, and can incorporate climate change projections explicitly.
8. Local implementation is required (e.g. Cape Lowlands Renosterveld Project): Regional strategies must be translated to local implementation, and this is greatly assisted by an awareness of how local initiatives have been driven by regionally identified imperatives such as climate change. These imperatives will also assist in motivating both on- and off-reserve conservation efforts (such as conservation stewardships).
9. Research/Management: There are still many unknowns that require further data collection, expert knowledge-mining, and synthesis. For example, we know very little about how fire frequency and intensity might interact with population persistence with climate change. We are also quite ignorant about the interactive impacts of invasive alien species and climate change.

5.3 List of options and guidelines for stakeholders

Before we provide stakeholder-specific options and guidelines we emphasize some guiding principles for all stakeholders (see Box 5.3.1).

Box 5.3.1. Guiding principles for all stakeholders (with options)

1) Start now: doing nothing is no option (see Box 6.1)

Stakeholder workshop and regional framework for action
Baseline data collection, mapping and monitoring
Experimental studies both in the field and labs

2) Think ahead: put it in perspective

Regional modelling of climate change and biodiversity responses (see Box 3.1)
Climate change-sensitive species, ecosystems and reserves (see Box 3.2)
Climate change-integrated site-specific sensitivity analyses
Net loss or gain of species in reserves (see Table 4.5.1)
Ecological and economic impacts

3) Think big: broaden your horizons

Integrated land-use planning, decision-making and management on a trans-regional scale aimed at healthy, living landscapes with a high degree of landscape connectivity
Regional reserve networks that, together with linkages in the landscape such as critical corridors, maintain ecosystem services and ecological and evolutionary processes

4) Think clean: live by example

Reduce greenhouse gas emissions in your field by increasing both the use of renewable energy and efficiency of energy use
Raise environmental awareness for climate change mitigation and adaptation through outreach activities and sound communication strategies

5) Think twice: am I up to date and is my response strategy up to date?

5.3.1 Guidelines for researchers

1. <u>Collaborate with planners, managers and policy-makers</u>
   When part of a response strategy, research should be demand-driven rather than supply-driven. Understanding the needs and wants of

potential users helps to ensure the applicability of research results in land-use planning, decision-making and management.

2. Collect baseline data and species distribution data
   For modelling, planning, monitoring and managing efforts, baseline data and species distribution data are required. If these are not available yet in your region, targeted data collection, for example in collaboration with conservation agencies and organisations, is critical.
3. Carry out experimental studies both in the field and labs
   Particularly if baseline data and species distribution data are not available yet, and modelling is thus not possible, experimental studies such as greenhouse experiments or translocation experiments can help to identify climate change-sensitive species and ecosystems.
4. Carry out regional climate change and biotic response modelling
   Different models and scenarios should be used to identify climate change-sensitive species and ecosystems and the rates, magnitudes and directions of expected biodiversity response for different species and regions. Modelling should also be extended to human systems. Modelling studies should seek to communicate effectively key messages to the public, planners, managers and policy-makers.

5.3.2 Guidelines for planners

1. Consider climate change in systematic conservation planning
   A number of qualitative and quantitative approaches to considering climate change as an integral factor in systematic conservation planning and systematic reserve-site selection are available.

2. Buffer representation targets for biodiversity patterns and processes
   Climate change may alter species distributions, ecosystem functioning, services and states. Buffering representation targets should reduce the risk of protecting not enough areas or the wrong areas.
3. Increase habitat heterogeneity and altitudinal variation within reserves
   New reserves and additional areas for existing reserves should be identified based on regional modelling of climate change and biodiversity responses and common landscape ecological principles.
4. Increase landscape connectivity outside reserves
   Species migrations in response to climate change will require, in many cases, a biodiversity-friendly landscape matrix. Critical migration routes should be secured through both on- and off-reserve conservation.
5. Consider radical solutions for exceptionally threatened species
   It may be necessary to consider translocating species to pre-identified safe habitats in the wild, storing genetic resources in gene or seed banks, or securing species in clone banks or in protected ex-situ conservatories. Each of these strategies needs to be considered in cost/benefit terms.

5.3.3 Guidelines for managers

1. Explore options to increase both the use of renewable energy and efficiency of energy use in your protected area
   Reducing greenhouse gas emissions means reducing the risk of potential climate change impacts. In many cases, more energy-efficient appliances make sense both environmentally and economically.

2. Complete site-specific sensitivity analyses in collaboration with others
   An assessment of the vulnerability and adaptability of your protected area and its management to climate change is critical. Collaboration with conservation agencies, organisations and universities can help with mapping, monitoring and modelling to identify, both within and outside your protected area, potential climate change winners and losers as well as other important issues.
3. Adjust management plans and protocols accordingly
   The management of disturbance regimes, for example fire regimes, and invasive alien species requires adjustments with changing climates. In addition, extreme events might become more frequent and intense with potentially hazardous consequences for the biodiversity and people within and outside your protected area. Therefore, emergency plans and protocols need to be reviewed and revised.
4. Develop simple monitoring strategies to detect early warning signs
   Adaptive protected areas management needs to be able to respond to changes quickly. A set of biotic and abiotic climate change indicators should therefore be monitored continuously. Attempt to link with regional, national and even international early-warning networks.
5. Develop partnerships to link on- and off-reserve conservation
   Human pressures on protected areas are likely to increase. Buffer zones around your reserve, reducing other environmental stresses within it, and landscape connectivity outside your reserve may be critical to allow species to migrate in response to climate change. Partnerships with private landowners could ensure or enhance the persistence of biodiversity within or outside your reserve.

6. Explore options to raise environmental awareness for climate change mitigation and adaptation in collaboration with others
   Both the public and policy-makers need to be informed about the challenges and opportunities brought by climate change. Protected areas provide a unique opportunity to communicate key messages both to local people and tourists. Collaboration with conservation agencies, organisations and universities can help with designing and realising a sound communication strategy.

5.3.4 Guidelines for policy-makers

1. Develop policies and strategies to reduce greenhouse gas emissions
   National and provincial governments and their agencies should lead by example through increasing both the use of renewable energy and efficiency of energy use. Success stories and sound incentive systems may encourage other sectors to follow without requiring sanctions.
2. Develop regional and local policies and strategies for the mitigation of and adaptation to potential climate change impacts
   Even if all greenhouse gas emissions were to stop now, climate change would still impact on species, ecosystems, human systems and protected areas for some time to come. Sound climate change-integrated policies and strategies are critical for all sectors, not the least because, as climate change continues, opportunities for mitigation and adaptation narrow and become more expensive and less feasible.
3. Take into account potential climate change impacts in legislation relating to biodiversity conservation and protected areas
   The implementation of climate change-integrated conservation plans

and programmes requires both on- and off-reserve conservation initiatives. Legal mechanisms such as conservation stewardships are therefore recommended to involve private landowners.

4. Strengthen regional coordination of land-use planning, decision-making and management of biodiversity conservation and protected areas
   The spatial and temporal scales on which climate change operates require measures beyond classic site-level approaches. A regional framework of needs and wants for informed decision-making could help to direct modelling and planning efforts, for instance.

6. Conclusions

Anthropogenic climate change is expected to be a major future threat to the globally significant biodiversity in the CFR. While some impacts of climate change are already apparent, the vast majority of effects such as species migrations and extinctions in response to climate change are still to come. Both experimental studies and regional modelling studies strongly suggest that biodiversity patterns and processes in the region might change over landscape scales over time frames as short as decades. These dynamic biotic responses to climate change present considerable conservation challenges for all stakeholders.

Although there has been no unified response strategy to climate change in the CFR to date, different stakeholders have started to address the climate change issue in many ways on different spatial and temporal scales. In doing so, some principles and practices have emerged that are now widely applied in biodiversity conservation in the region and beyond. Regional modelling and systematic conservation planning for changing climates are commonly recognised as key elements of climate change-integrated conservation strategies. However, regional coordination and local implementation of resulting conservation plans and programmes are equally important to make changes happen on the ground.

Building on the published principles of climate change-integrated conservation strategies and on the pioneering work in the CFR, the following steps should provide a framework for all stakeholders for how to make landscapes and reserves fit for changing climates (Box 6.1).

Box 6.1. Making landscapes and reserves fit for changing climates

1. Consult all stakeholders and coordinate a workshop to determine what is known/unknown about regional climate change impacts and what are the stakeholders' needs and wants
2. Develop a regional framework for modelling, planning, monitoring and managing activities based on what is known/unknown and what is needed and wanted
3. Carry out baseline data collection, mapping and monitoring; experimental studies both in the field and labs; and regional modelling of climate change and biodiversity responses
4. Consider climate change as an integral factor in systematic conservation planning and systematic reserve-site selection and adjust the protected areas system accordingly
5. Consider climate change as an integral factor in reserve and matrix management aimed at healthy, living landscapes with a high degree of landscape connectivity
6. Ensure regional coordination, across national and provincial borders, and local implementation of your response strategy in cooperation with all stakeholders
7. Carry out regional monitoring of climate change, biodiversity responses, and reserve and matrix management, and review and revise your response strategy regularly

In the CFR, we look back on a relatively short history of researching and responding to the climate change issue. Many lessons have, however, been learned already and they should encourage and enable others who might be facing similar situations to cope with climate change. Clearly, doing nothing is no option. At the same time, while our learning process continues, we look ahead to the future, hoping that 1) greenhouse gas emissions and, in turn, the risk of potential climate change impacts will be reduced globally, 2) our growing understanding of regional climate change impacts continues to feed back into land-use planning and decision-making on all scales, and 3) the persistence of the globally significant biodiversity in the CFR will prove our response strategies, which are being evolved continuously, to be ultimately successful.

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Internet Resources

BotSoc Botanical Society of South Africa
www.botanicalsociety.org.za
(e.g., information on Fynbos Forum, and documents for download from Conservation Unit)

C.A.P.E. Cape Action for People and the Environment
(implementation programme of the CAPE conservation plan)
www.capeaction.org.za
(e.g., information on implementation projects and partners, and documents for download)

SANBI South African National Biodiversity Institute
www.sanbi.org
(e.g., information on current research projects and programmes, and Red Lists)

SANBI Protea Atlas Project
protea.worldonline.co.za
(e.g., information on the mapping and modelling of the Proteaceae)

SANParks South African National Parks
www.sanparks.org
(e.g., information on national parks, research and recreation facilities)

WCNCB Western Cape Nature Conservation Board (or Cape Nature)
www.capenature.org.za
(e.g., information on provincial nature reserves, research and recreation facilities)

WCNCB Conservation Planning Unit
cpu.uwc.ac.za
(e.g., map server, and documents for download such as conservation plans)

Abbreviations

BotSoc	Botanical Society of South Africa
CAPE	Cape Action Plan for the Environment
CFR	Cape Floristic Region
CH_4	Methane
CO_2	Carbon dioxide
DEAT	Department of Environmental Affairs and Tourism
DWAF	Department of Water Affairs and Forestry
EPP	Ecosystems, Protected Areas and People
FLS	Field Learning Site
IPCC	Intergovernmental Panel on Climate Change
N	Nitrogen
N_2O	Nitrous oxide
NBSAP	National Biodiversity Strategy and Action Plan
O_3	Ozone
PALNet	Protected Areas Learning Network
SANBI	South African National Biodiversity Institute
SANParks	South African National Parks
SKEP	Succulent Karoo Ecosystem Plan
STEP	Subtropical Thicket Ecosystem Plan
TFCAs	Transfrontier Conservation Areas
UNFCCC	United Nations Framework Convention on Climate Change
UV-B	Ultraviolet-B
WCNCB	Western Cape Nature Conservation Board