National Biodiversity Assessment 2011

An assessment of South Africa's biodiversity and ecosystems

Synthesis Report

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

SANBI
Biodiversity for Life

Acronyms

CBD	Convention on Biological Diversity
CR	Critically endangered
DAFF	Department of Agriculture, Forestry and Fisheries
DEA	Department of Environmental Affairs
EDRR	Early Detection and Rapid Response (programme dealing with invasive alien species)
EEZ	Exclusive Economic Zone
EIA	Environmental impact assessment
EN	Endangered
FEPA	Freshwater Ecosystem Priority Area
IUCN	International Union for Conservation of Nature
KZN	KwaZulu-Natal
LT	Least threatened
METT	Management Effectiveness Tracking Tool for protected areas
METT-SA	Global Management Effectiveness Tracking Tool adapted for use in South Africa
MPA	Marine protected area
NBA	National Biodiversity Assessment
NBF	National Biodiversity Framework
NBSAP	National Biodiversity Strategy and Action Plan
NFEPA	National Freshwater Ecosystem Priority Areas project
NPAES	National Protected Area Expansion Strategy
NSBA	National Spatial Biodiversity Assessment
OMPA	Offshore Marine Protected Area project
PES	Payments for Ecosystem Services
SANBI	South African National Biodiversity Institute
SAPIA	Southern Africa Plant Invader Atlas
VU	Vulnerable
WfW	Working for Water
WMA	Water Management Area

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Synthesis Report

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Foreword

It is a proud moment to present South Africa's National Biodiversity Assessment 2011, a product of high scientific calibre led by the South African National Biodiversity Institute. The NBA was developed in close consultation with the Department of Environmental Affairs and its national partners. Building on the National Spatial Biodiversity Assessment of 2004, the NBA 2011 uses cutting edge science and techniques to provide a comprehensive picture of South Africa's biodiversity and ecosystems across the landscape and seascape, from terrestrial (land) and freshwater to estuarine and marine environments.

This assessment hopes to capture the challenges and opportunities embedded in South Africa's rich natural heritage by looking at biodiversity in the context of social and economic change and recognising the relationship between people and their environment. We are all familiar with the concept of service delivery and the challenges we grapple with in making sure all citizens receive essential services. What we are sometimes less familiar with is the notion that it is not only municipalities that provide services, but also our biodiversity and ecosystems. While we are aware of our built infrastructure like roads, sewers and pylons, and the services they bring to us in our homes, few of us are aware of the services we get from our ecological infrastructure like wetlands, mountains, rivers, coastal dunes and vegetation. These services, called ecosystem services, include basic services like fresh water, firewood and fertile soils for agriculture; but they also include more complex services that regulate water flows and protect us from extreme events associated with climate change, such as floods, droughts and fires. Ecosystem services, like municipal services, play an essential role in supporting social development and economic prosperity.

In relating social and economic concerns to environmental ones, we challenge the notion that there necessarily is a trade-off to be made between faster economic growth and the preservation of our environment. We suggest instead that good environmental management coupled with integrated development planning will allow us to build a low carbon economy that supports resilient ecosystems and economies. Healthy intact ecosystems give us more options for responding to climate change, alleviating poverty and building a green economy. Taking stock of what we have and where we are, allows us to be proactive and make informed decisions about future land-use planning at various scales for South Africa's optimal fast-tracked growth path.

Our message is simple: our vast wealth of biodiversity—our variety of life from genes, species and ecosystems—offers us a suite of natural solutions in the face of unemployment, rising poverty and climate change. This message is relevant for all from rural to urban, rich and poor. We need to step up our efforts to protect our biodiversity to allow it to support South Africans—present and future generations included.

BOMO EDITH EDNA MOLEWA
MINISTER OF WATER AND ENVIRONMENTAL AFFAIRS

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Online resources

This report forms part of a set of six reports on South Africa's National Spatial Biodiversity Assessment 2011, available at SANBI's Biodiversity Advisor website (http://biodiversityadvisor.sanbi.org). The full set is as follows:

Synthesis Report

Driver, A., Sink, K.J., Nel, J.L., Holness, S., Van Niekerk, L., Daniels, F., Jonas, Z., Majiedt, P.A., Harris, L. & Maze, K. 2012. *National Biodiversity Assessment 2011: An assessment of South Africa's biodiversity and ecosystems. Synthesis Report.* South African National Biodiversity Institute and Department of Environmental Affairs, Pretoria.

Technical Reports

Volume 1: Terrestrial Component

Jonas, Z., Daniels, F., Driver, A., Malatji, K.N., Dlamini, M., Malebu, T., April, V. & Holness, S. 2012. *National Biodiversity Assessment 2011: Technical Report. Volume 1: Terrestrial Component*. South African National Biodiversity Institute, Pretoria.

Volume 2: Freshwater Component

Nel, J.L. & Driver, A., 2012. *National Biodiversity Assessment 2011: Technical Report. Volume 2: Freshwater Component*. CSIR Report Number CSIR/NRE/ECO/IR/2012/0022/A. Council for Scientific and Industrial Research, Stellenbosch.

Volume 3: Estuary Component

Van Niekerk, L. & Turpie, J.K. (eds). 2012. *National Biodiversity Assessment 2011: Technical Report. Volume 3: Estuary Component*. CSIR Report Number CSIR/NRE/ECOS/ER/2011/0045/B. Council for Scientific and Industrial Research, Stellenbosch.

Turpie, J.K., Wilson, G. & Van Niekerk, L. 2012. *National Biodiversity Assessment 2011: National Estuary Biodiversity Plan for South Africa*. Anchor Environmental Consulting, Cape Town. Report produced for the Council for Scientific and Industrial Research and the South African National Biodiversity Institute.

Volume 4: Marine Component

Sink, K.J., Holness, S., Harris, L., Majiedt, P.A., Atkinson, L., Robinson, T., Kirkman, S., Hutchings, L., Leslie, R., Lamberth, S., Kerwath, S., Von der Heyden, S., Lombard, A.T., Attwood, C., Branch, G., Fairweather, T., Taljaard, S., Weerts, S., Cowley, P., Awad, A., Halpern, B., Grantham, H. & Wolf, T. 2012. *National Biodiversity Assessment 2011: Technical Report. Volume 4: Marine and Coastal Component*. South African National Biodiversity Institute, Pretoria.

Maps and spatial data from the NBA 2011 are available at SANBI's Biodiversity GIS website (http://bgis.sanbi.org).

A recent publication on South Africa's approach to the management and conservation of biodiversity, titled *Biodiversity for Development: South Africa's landscape approach to conserving biodiversity and promoting ecosystem resilience*, may be of interest to readers of this report. It can be downloaded at www.undp.org/biodiversity/docs/PRIMER.pdf.

Executive summary*

1. Introduction

This report presents the results of South Africa's National Biodiversity Assessment (NBA) 2011, which was led by the South African National Biodiversity Institute (SANBI) in partnership with a range of organisations, involving wide participation from stakeholders, scientists and biodiversity management experts throughout the country over a three-year period. The NBA 2011 assesses the state of South Africa's biodiversity, across terrestrial, freshwater, estuarine and marine environments, emphasising spatial (mapped) information for both ecosystems and species. It synthesises key aspects of South Africa's biodiversity science, making it available in a useful form to policymakers, decision-makers and practitioners in a range of sectors.

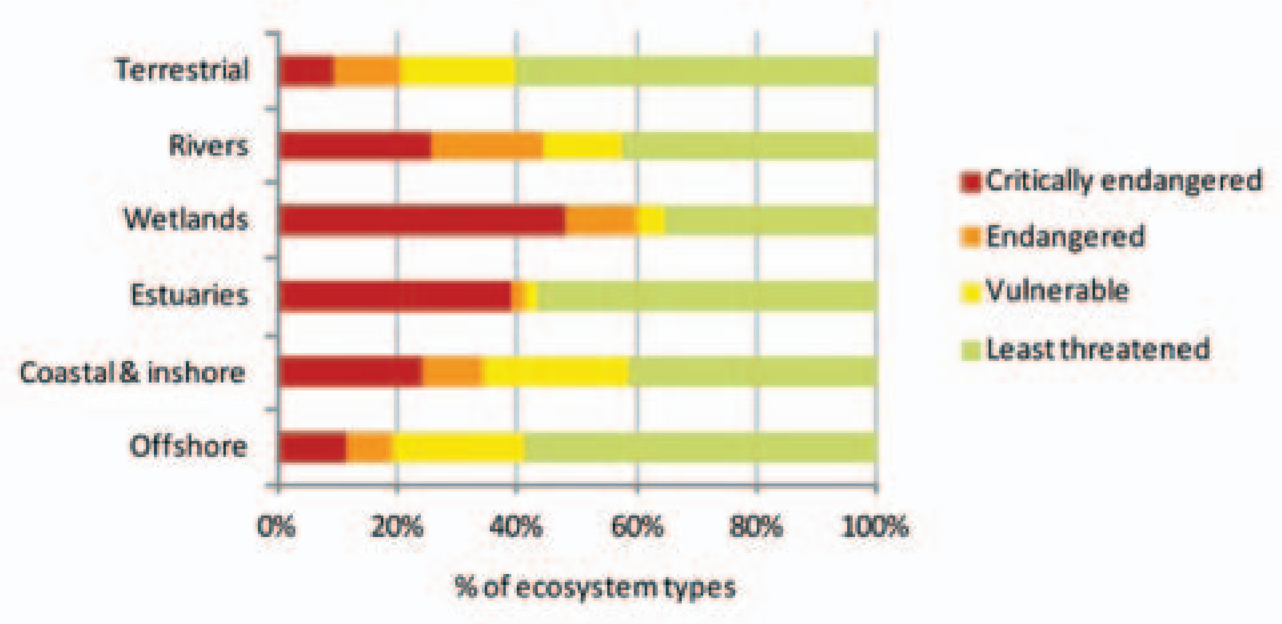
The NBA is central to fulfilling SANBI's mandate in terms of the National Environmental Management: Biodiversity Act (Act 10 of 2004) to monitor and report regularly on the state of biodiversity, and includes two headline indicators that are assessed across all environments: ecosystem threat status and ecosystem protection level. The NBA 2011 also deals with species of special concern and invasive alien species, presents new work on geographic areas that contribute to climate change resilience, and provides a summary of spatial biodiversity priority areas that have been identified through systematic biodiversity plans at national, provincial and local scales.

The NBA 2011 will inform the revision and updating of key national biodiversity policies and strategies, including the National Biodiversity Strategy and Action Plan, the National Biodiversity Framework and the National Protected Area Expansion Strategy. In addition, information from the NBA can be used to streamline environmental decision-making, strengthen land-use planning, strengthen strategic planning about optimal development futures for South Africa, and identify priorities for management and restoration of ecosystems with related opportunities for ecosystem-based job creation.

2. Key highlights

The scope of the NBA 2011 is broad, and the findings discussed in this report are wide-ranging. Twelve of the most important ones are highlighted briefly below. All of these findings should be viewed in the

* References are not provided in the executive summary—please see the relevant chapter in the full report.

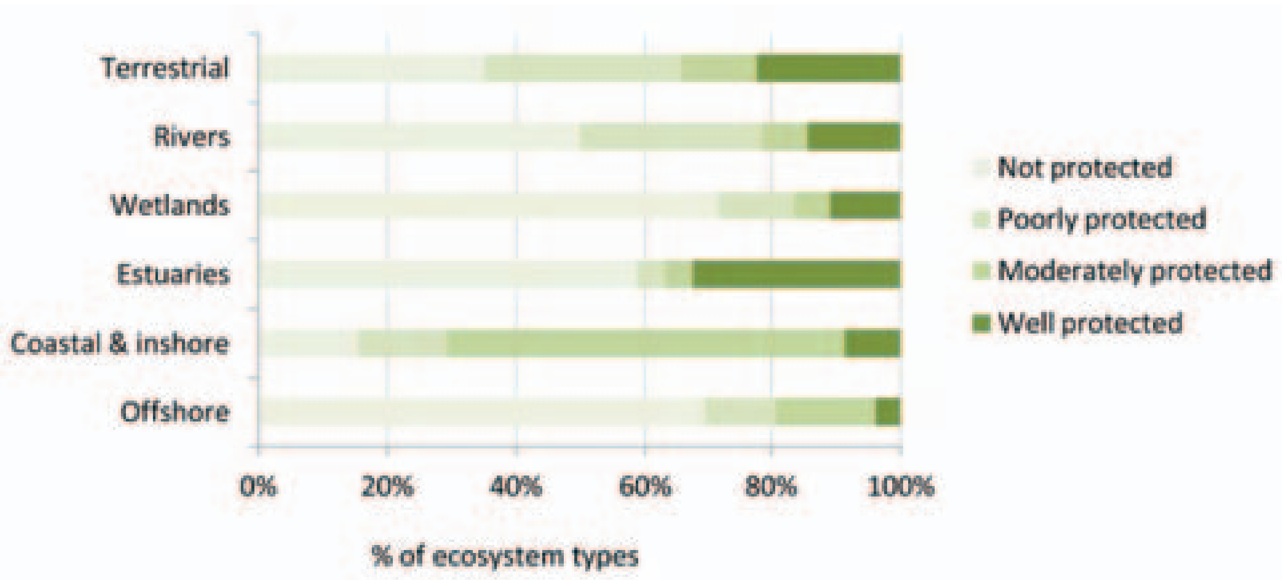


Comparison of ecosystem threat status in the terrestrial, river, wetland, estuarine, coastal and inshore, and offshore environments. Wetlands are the most threatened of all South Africa's ecosystems, with 48% of wetland ecosystem types critically endangered (see highlight #1).

context of South Africa's exceptional endowments of biodiversity assets and ecological infrastructure. On balance, there is immense opportunity to unlock the value of biodiversity and ecosystems in support of the country's development path, especially as the knowledge base on the value of ecosystems and how to manage them effectively expands.

The results of the assessment of ecosystem threat status and protection level, the two headline indicators in the NBA, are summarised for all environments in the graphs below and referred to in some of the highlights. See Section 3 below for further explanation of these headline indicators.

1. Wetlands are the most threatened of all South Africa's ecosystems, with 48% of wetland ecosystem types critically endangered. Wetlands make up only 2.4% of the country's area. This small area represents high-value ecological infrastructure that provides critical ecosystem services such as water purification and flood regulation.



Comparison of ecosystem protection levels in the terrestrial, river, wetland, estuarine, coastal and inshore, and offshore environments. Offshore ecosystems are the least protected of all South Africa's ecosystems, with only 4% of offshore habitat types well protected (see highlight #6).

2. High water yield areas are South Africa's water factories and are of strategic importance for water security. They make up less than 4% of the country's area but only 18% have any form of formal protection.

3. River tributaries are generally in better condition and less threatened than main rivers, which tend to be harder working. Keeping tributaries healthy will help to improve and maintain the quality and quantity of water supplies.

4. Coastal and inshore marine ecosystems are more threatened than offshore ecosystems. Nearly a fifth of South Africa's coast has some form of development within 100 m of the shoreline, placing people and property at risk and compromising the ability of coastal ecosystems to buffer the impacts of climate change.

5. St Lucia, South Africa's flagship estuary, is in a poor state and thus unable to fulfil its role as the most important nursery for marine fish on the southeast African coast. Restoring the health of St Lucia is challenging but feasible, and has been prioritised by the iSimangaliso Wetland Park Authority.

6. Offshore marine ecosystems are the most poorly protected ecosystems of all South Africa's ecosystems, with only 4% of offshore ecosystem types well protected. Offshore ecosystems play a vital role in sustaining fisheries, and spatial management measures including marine protected areas are a key tool in the ecosystem approach to fisheries management.

7. Biodiversity stewardship programmes have been successfully established in the last seven years and are making a significant contribution to meeting national protected area targets, at much lower cost to the state than land acquisition. With modest increases in resources, biodiversity stewardship programmes could make an even larger contribution.

8. Rates of loss of natural habitat are high in some part of the country. For example, in Gauteng, KwaZulu-Natal and North West Province, if current rates of loss were to continue, there would be almost no natural habitat left outside protected areas by 2050. In regions with high rates of conversion of natural vegetation to other land uses, it is especially important to use maps of biodiversity priority areas to guide decisions about where best to locate development.

9. The NBA 2011 provides a new national map of areas that are important for climate change resilience, supporting functional, stable landscapes in the long term. It is important to keep natural habitat intact in these areas.

10. South Africa has over 2 000 medicinal plant species, of which 656 species are traded in medicinal markets. Of these traded species, 54 are threatened. Action is required for threatened medicinal plant species, as well as research and monitoring to ensure that the use of traded species that are currently not threatened is sustainable.

11. The total area infested by invasive alien plants in South Africa doubled between the mid-1990s and 2007, and at least R6.5 billion of ecosystem services are lost every year as a result. There is huge scope to scale up natural resource management programmes such as Working for Water, with coupled job creation and ecosystem service benefits.

12. Since 2004 there has been significant progress in the science of mapping and classifying ecosystems, laying the foundation for more meaningful assessment, planning and monitoring of ecosystems. For example, marine and coastal habitat types and wetland ecosystem types have been identified and mapped for the first time, and the estuarine functional zone has been mapped for the first time for all estuaries.

3. Ecosystem threat status and protection level

The two headline indicators assessed in the NBA are ecosystem threat status and ecosystem protection level, summarised in the graphs above. Each of them is assessed in a consistent way across all environments, enabling comparison between terrestrial, river, wetland, estuarine, coastal and marine ecosystems.

Ecosystem threat status tells us about the degree to which ecosystems are still intact or alternatively losing vital aspects of their structure, function and composition, on which their ability to provide ecosystem services ultimately depends. Ecosystem types are categorised as critically endangered (CR), endangered (EN), vulnerable (VU) or least threatened (LT), based on the proportion of each ecosystem type that remains in good ecological condition relative to a series of thresholds.

Ecosystem protection level tells us whether ecosystems are adequately protected or under-protected. Ecosystem types are categorised as not protected, poorly protected, moderately protected or well protected, based on the proportion of each ecosystem type that occurs within a protected area recognised in the Protected Areas Act.

The ability to map and classify ecosystems into different ecosystem types is essential in order to assess threat status and protection levels and track trends over time. South Africa has an emerging national ecosystem classification system, including vegetation types, river ecosystem types, wetland ecosystem types, estuary ecosystem types, and marine and coastal habitat types, which provides an essential scientific basis for ecosystem-level monitoring, assessment and planning.

4. Terrestrial ecosystems

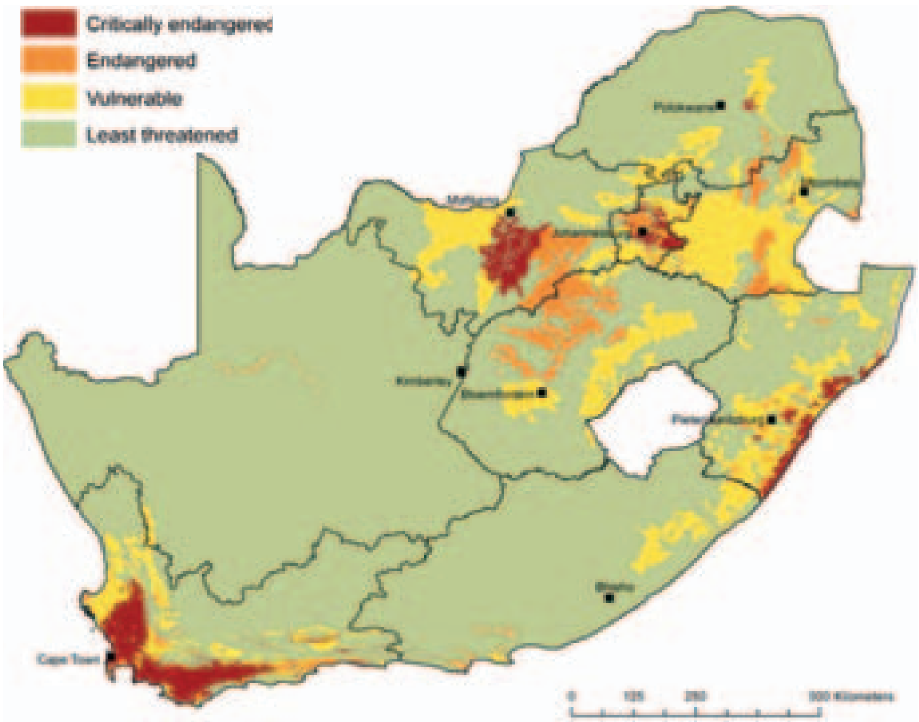
Terrestrial ecosystems are critical for food security, protection from natural hazards, and development of economic sectors such as tourism and the wildlife industry, as well as providing a safety net for rural communities where the cash economy is meagre. Healthy terrestrial ecosystems are vital for healthy catchments, which supply South Africa's water. The main pressure faced by terrestrial ecosystems is outright loss of natural habitat as a result of land cover change through, for example, cultivation, mining, forest plantations and urban expansion.

Forty percent of terrestrial ecosystem types are threatened (9% critically endangered, 11% endangered and 19% vulnerable). The Indian Ocean Coastal Belt, Grassland, Fynbos and Forest biomes have the highest proportions of threatened ecosystem types. Threatened terrestrial ecosystems tend to be concentrated in areas that are hubs of economic production, with the remaining fragments of these ecosystems embedded in production landscapes. The remaining natural habitat in critically endangered and endangered ecosystems makes up less than 3% of the country's area.

The threatened terrestrial ecosystems reported in the NBA 2011 are the same as the national list of ecosystems that are threatened and in need of protection published in December 2011 by the Minister of Environmental Affairs in terms of the Biodiversity Act.

Summary of results for ecosystems in each environment

Terrestrial ecosystems	• Ecosystem threat status: 40% of ecosystem types threatened • Ecosystem protection level: 22% of ecosystem types well protected, 35% not protected • Key ecosystem services: grazing, pollination, ecotourism and the wildlife industry, medicinal plants • Key pressures: cultivation, urban sprawl, overgrazing, invasive alien plants
River ecosystems	• Ecosystem threat status: 57% of ecosystem types threatened • Ecosystem protection level: 14% of ecosystem types well protected, 50% not protected • Key ecosystem services: fresh water • Key pressures: abstraction of water and changes in flow, pollution, destruction of river banks, invasive alien plants
Wetland ecosystems	• Ecosystem threat status: 65% of ecosystem types threatened • Ecosystem protection level: 11% of ecosystem types well protected, 71% not protected • Key ecosystem services: water purification, flood regulation • Key pressures: cultivation, urban development, dam construction, changes in water flow, pollution, invasive alien plants
Estuarine ecosystems	• Ecosystem threat status 43% of ecosystem types threatened • Ecosystem protection level: 33% of ecosystem types well protected, 59% not protected • Key ecosystem services: nurseries for fish, recreation, raw materials such as reeds and sedges • Key pressures: decrease in freshwater reaching estuaries, inappropriate land use and development, fishing and bait collection, pollution, invasive alien species
Coastal & inshore ecosystems	• Ecosystem threat status: 58% of ecosystem types threatened • Ecosystem protection level: 9% of ecosystem types well protected, 16% not protected • Key ecosystem services: fishing, recreation, ecotourism, protection from the impacts of storms • Key pressures: fishing, coastal development, decrease in freshwater reaching the coast and sea, invasive alien species
Offshore ecosystems	• Ecosystem threat status: 41% of ecosystem types threatened • Ecosystem protection level: 4% of ecosystem types well protected, 69% not protected • Key ecosystem services: fishing, recreation, trade and transport • Key pressures: fishing, mining (e.g. diamonds, oil and gas), shipping



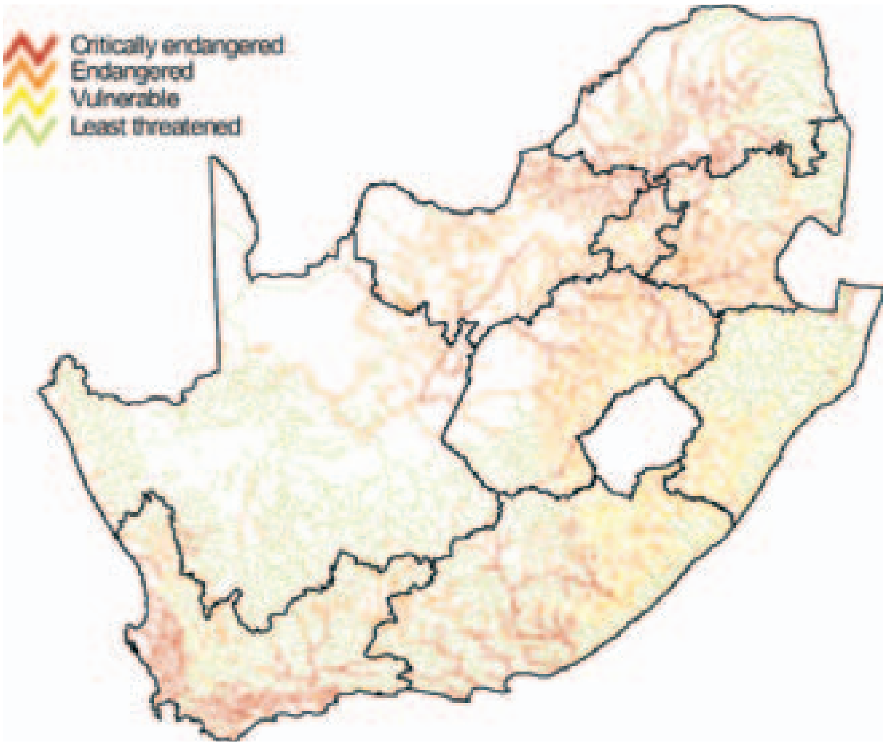
Ecosystem threat status for terrestrial ecosystems, showing original extent of ecosystems. In many of the threatened ecosystems, especially those that are critically endangered or endangered, only small fragments remain.

Twenty-two percent of terrestrial ecosystem types are well protected. However, 35% remain completely unprotected, highlighting that the protected area network does not yet include a representative sample of all ecosystems. The total extent of the land-based protected area network increased from just under 6% in 2004 to 6.5% in 2011, representing an increase of approximately 10% in the extent of the protected area network. Much of this expansion was focused on under-protected ecosystems, with the Succulent Karoo biome in particular benefiting from inclusion of previously unprotected vegetation types in new or expanded protected areas. The National Protected Area Expansion Strategy 2008 identifies spatial focus areas for further expansion of the land-based protected area network.

A major success story for the protection of terrestrial ecosystems over the last seven years has been the establishment of biodiversity stewardship programmes in several provinces, in which contract protected areas are declared on private or communal land. Conservation authorities enter into contract agreements with landowners who retain title to the land and are recognised as the management authority of the protected area. The cost to the state is a fraction of the cost of acquiring and managing land, making biodiversity stewardship a highly cost effective approach to expanding the protected area network. Twenty-four contract protected areas have been declared through biodiversity stewardship programmes to date, totalling over 75 000 ha, with approximately 360 000 ha of additional contract protected areas awaiting proclamation or in negotiation. The limiting factor in declaring further contract protected areas is not lack of willing landowners, but rather lack of human resources in conservation authorities to take advantage of these opportunities, as one biodiversity stewardship officer can support only a certain number of sites effectively.

5. River ecosystems

River ecosystems are vital for supplying fresh water, South Africa's most scarce natural resource. Rivers store and transport water and, combined with manmade storage and transfer schemes, bring water to urban and rural areas, irrigate croplands, take away waste and provide cultural and aesthetic services. Healthy tributaries help to maintain natural flow pulses and flush pollutants from hard-



Ecosystem threat status for river ecosystem types. Critically endangered and endangered ecosystem types are concentrated around major cities and in production landscapes, where pressures on water resources are highest and catchments have lost much of their natural habitat.

working larger rivers, contributing to the quantity and quality of water supplies. Contrary to popular perception, fresh water flowing from rivers out to sea is not wasted but is essential for maintaining healthy ecological infrastructure such as estuaries as well as coastal and marine ecosystems and the societal benefits received from them. The main pressure faced by river ecosystems is the abstraction of water from rivers and other alterations to the timing and quantity of flows, for example as a result of dams or transfer schemes between catchments. In addition, pollution of rivers is a serious and growing problem, often exacerbated by destruction of natural vegetation along river banks which results in irreversible damage to rivers and their ability to provide ecosystem services.

Fifty-seven percent of river ecosystem types are threatened (25% critically endangered, 19% endangered and 13% vulnerable). Tributaries tend to be in better ecological condition than main rivers, so the proportion of threatened river ecosystem types is higher if only main rivers are assessed, with 65% threatened (including 46% critically endangered). The proportion of threatened river ecosystem types is higher among lowland and lower foothill rivers than among upper foothills and mountain streams, reflecting the fact that the intensive agriculture and urban areas are often found in lowlands, as well as the accumulation of impacts on rivers as they flow from source to sea.

Only 14% of river ecosystem types are well protected and 50% are not protected at all. Mountain streams are best protected and lowland rivers have the highest proportion of ecosystem types with no protection. Most land-based protected areas were not designed to protect rivers; however, with some adjustments to their design and management, land-based protected areas could make a much greater contribution to protecting river ecosystems.

High water yield areas are sub-quaternary catchments in which mean annual runoff is at least three times more than the average for the related primary catchment. These areas constitute only 4% of South Africa’s surface area and are the water factories of the country. Currently only 18% of them have any

Photo: Bruce Paxton

form of formal protection. Given their strategic importance for water security, options for formal protection of high water yield areas should be explored, for example declaring them as Protected Environments in terms of the Protected Areas Act.

Because rivers are linear ecosystems and are impacted on by land uses and activities throughout their catchments, protected areas alone will seldom do the full job of protecting river ecosystems. This highlights the importance of integrated water resource management tools provided by the National Water Act, including the ecological reserve, classification of water resources and resource quality objectives, which contribute to the protection of freshwater ecosystems. For all rivers, good land-use practices such as keeping natural vegetation intact along river banks can make a vital difference to their ecological integrity.

6. Wetland ecosystems

Wetland ecosystems are vital for purifying water and regulating water flows, acting as sponges that store water and release it slowly, filtering pollutants and easing the impact of droughts and floods in the process. They also support a rich diversity of species, which have both intrinsic and economic value. The main pressures faced by wetland ecosystems include cultivation, urban development, mining, dam construction and poor grazing management, combined with catchment-wide impacts such as disruption of freshwater flow and pollutants and sediment from surrounding land uses.

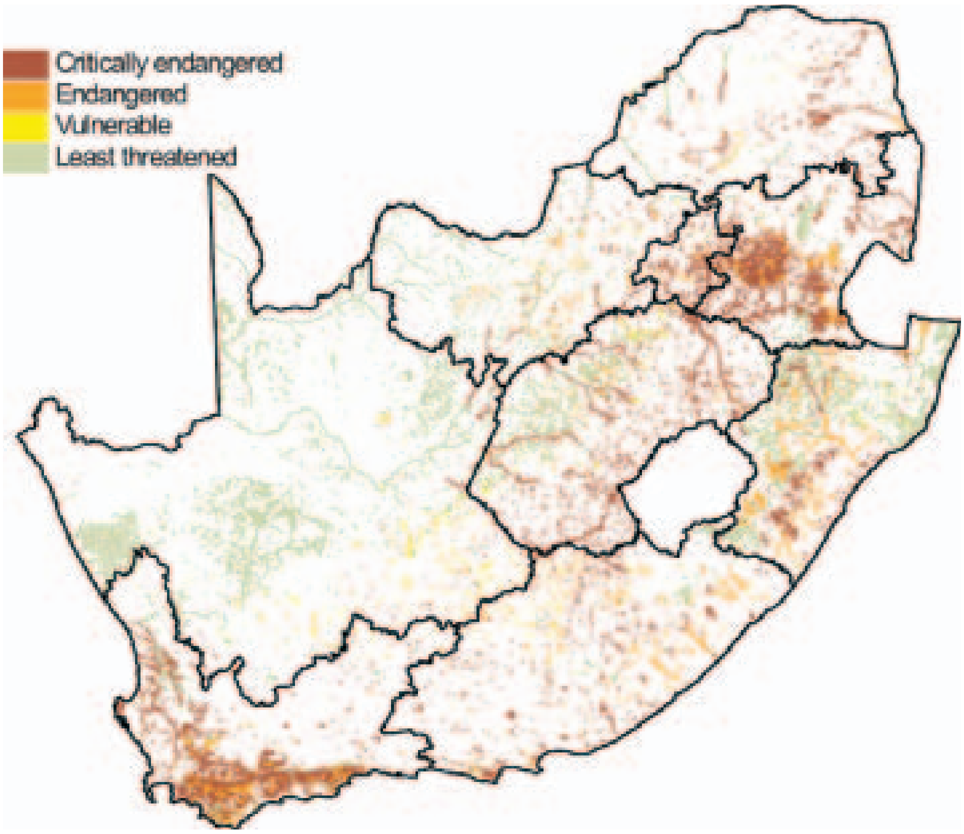
It is not possible to map the historical occurrence of wetlands in South Africa, and in substantial parts of the country outright loss of wetlands is estimated to be more than 50% of the original wetland area. Approximately 300 000 wetlands remain, making up only 2.4% of South Africa's surface area.

The NBA 2011 provides the first ever national assessment of wetland ecosystems. A disturbing 65% of wetland ecosystem types are threatened (48% critically endangered, 12% endangered and 5% vulnerable), making wetlands the most threatened of all ecosystems. Floodplain wetlands have the highest proportion of critically endangered ecosystem types, followed by valley-head seeps and valley-bottom wetlands. These wetland classes, especially floodplain wetlands, are often associated with highly productive land and are often the ones that are dammed, drained or bulldozed for agricultural purposes.

Fortunately, wetlands are more resilient than many other ecosystems. As long as they have not been irreversibly lost to cultivation or concrete, many wetlands that are in poor condition can be rehabilitated to at least a basic level of ecological and hydrological functioning, thus restoring ecosystem services such as water purification and regulation of water supply.

Only 11% of wetland ecosystem types are well protected, with 71% not protected at all, reflecting the fact that wetland ecosystems have not been taken systematically into account in establishing and expanding land-based protected areas. There is clearly scope for the protected area network to play a bigger role in protecting South Africa's wetlands.

As with rivers, protected areas alone are unlikely ever to do the full job of protect-



Ecosystem threat status for wetland ecosystem types. Consistent with the picture for rivers, high numbers of critically endangered and endangered wetland ecosystem types are associated with production landscapes and urban centres. Outlines of wetlands have been accentuated for visual clarity.

ing wetlands, which are vulnerable to impacts in their catchments beyond the boundaries of protected areas. This highlights the importance of integrated water resource management in securing the quality, quantity and timing of freshwater flows on which the functioning of wetlands depends. For all wetlands, keeping a buffer of natural vegetation intact around the wetland can go a long way towards reducing the impacts of damaging land-use practices in the catchment.

Wetlands are exceptionally high-value ecosystems that make up only a small fraction of the country. Given their strategic importance as ecological infrastructure for ensuring water quality and regulating water supplies, investments in conserving, managing and restoring wetlands are likely to generate disproportionately large returns.

7. Estuarine ecosystems

Estuaries are formed where fresh water from rivers runs out to sea, although the mouths of some estuaries periodically close off from the sea. They are often focal points for coastal development and recreation, including water sports, fishing and holiday-making. Estuaries provide nursery areas for many commercially important fish species, and deliver sediments that form and maintain beaches and provide nutrients for marine food webs. Estuaries face multiple pressures from human activities, often resulting from development too close to the estuary as well as the cumulative impacts of land uses throughout the catchment that feeds the estuary. Reductions in the quantity and quality of fresh water that reaches an estuary, for example as a result of dams higher up in the catchment, can impact severely on its ecological condition and ability to provide ecosystem services.

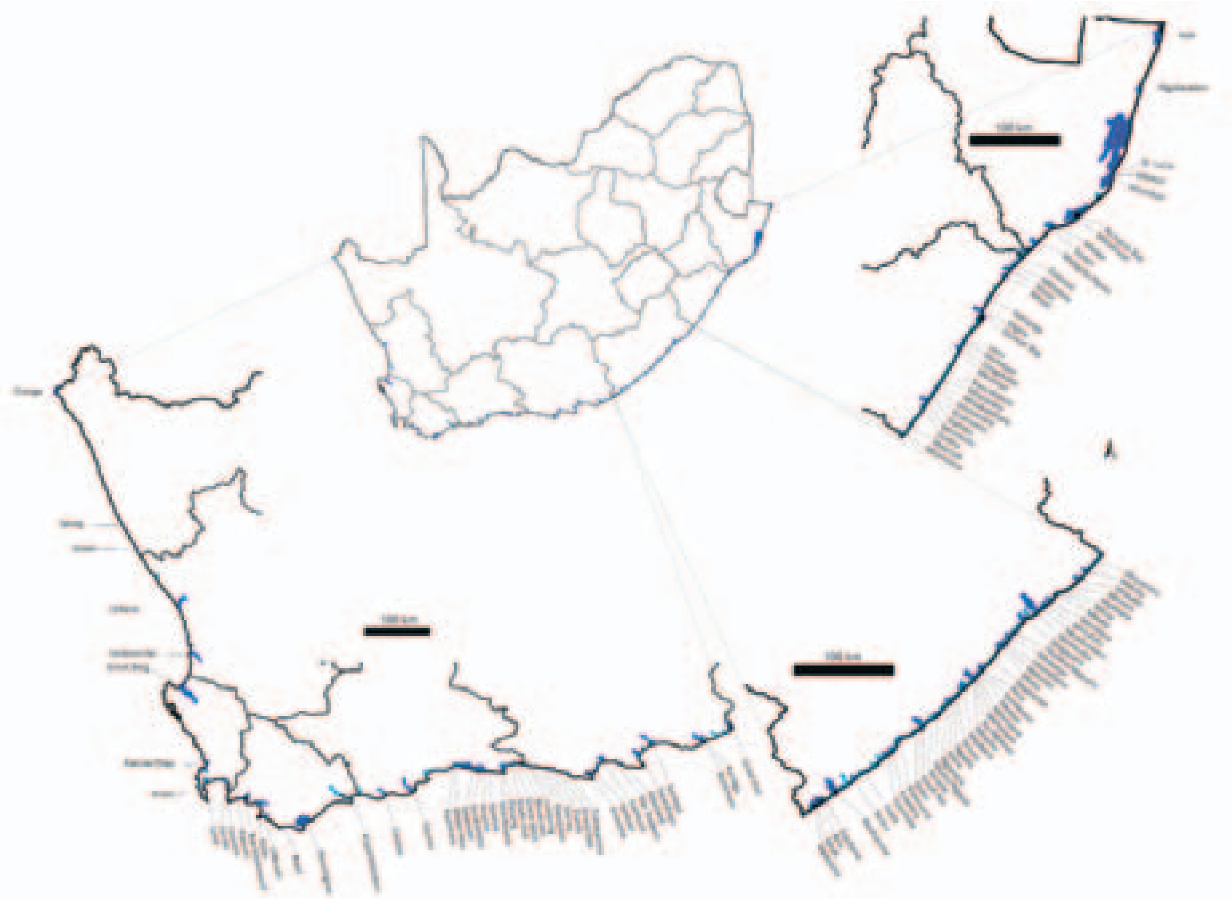
The NBA 2011 mapped the estuarine functional zone for each of South Africa's 291 estuaries for the first time, including the open water area of each estuary as well as the associated floodplain, totalling about 170 000 ha for all estuaries. Nested within this, the total area of estuarine habitat, including the open water area and adjacent habitats such as salt marshes and mangroves, is about 90 000 ha. The St Lucia Lake system in northern KwaZulu-Natal accounts for more than half of South Africa's estuarine area.

Forty-three percent of estuary ecosystem types are threatened (39% critically endangered, 2% endangered and 2% vulnerable). The proportion of threatened types is highest in the cool temperate region (the west coast, which has relatively few estuaries) and lowest in the warm temperate region (south and southeast coast, including the many small estuaries along the Wild Coast, most of which are in good ecological condition).

Only 33% of estuary ecosystem types are well protected and 59% have no protection at all. To be fully protected, an estuary should be protected from the land side with a land-based protected area, from the aquatic side with a no-take marine or estuarine protected area, and have its freshwater flow requirements met using legal mechanisms in the National Water Act. For many estuaries, partial protection is adequate and can take various forms (such as zonation, closed seasons, bag limits) that still allow for some direct use of the estuary.

South Africa's flagship estuary, St Lucia, is currently in poor ecological condition in spite of the fact that it forms part of a World Heritage Site, the iSimangaliso Wetland Park. The artificial separation of the uMfolozi River Mouth from Lake St Lucia several decades ago, combined with other factors such as drought, have led to reductions in freshwater flow to St Lucia. This has resulted in the estuary being closed to the sea for much of the last decade, unable to fulfil its role as the most important nursery area for marine fish along the southeast African coastline, among other impacts. The iSimangaliso Wetland Park Authority has prioritised the restoration of St Lucia and has initiated measures to facilitate the relinking of St Lucia and uMfolozi and to monitor the responses of the system. Restoring the ecological health of St Lucia is challenging but feasible and should be seen as a national priority.

In addition to the ecosystem threat status and protection level assessments, a national set of 120 priority estuaries was identified by the NBA 2011 through the first ever National Estuary Biodiversity Plan. These estuaries are priorities for the development of Estuary Management Plans in terms of the Integrated Coastal Management Act, and should ultimately be either fully or partially protected.



Priority estuaries from the National Estuary Biodiversity Plan, shown in dark blue. The estuarine functional zone is shown for all estuaries, but only the priority estuaries are labelled.

8. Marine and coastal ecosystems

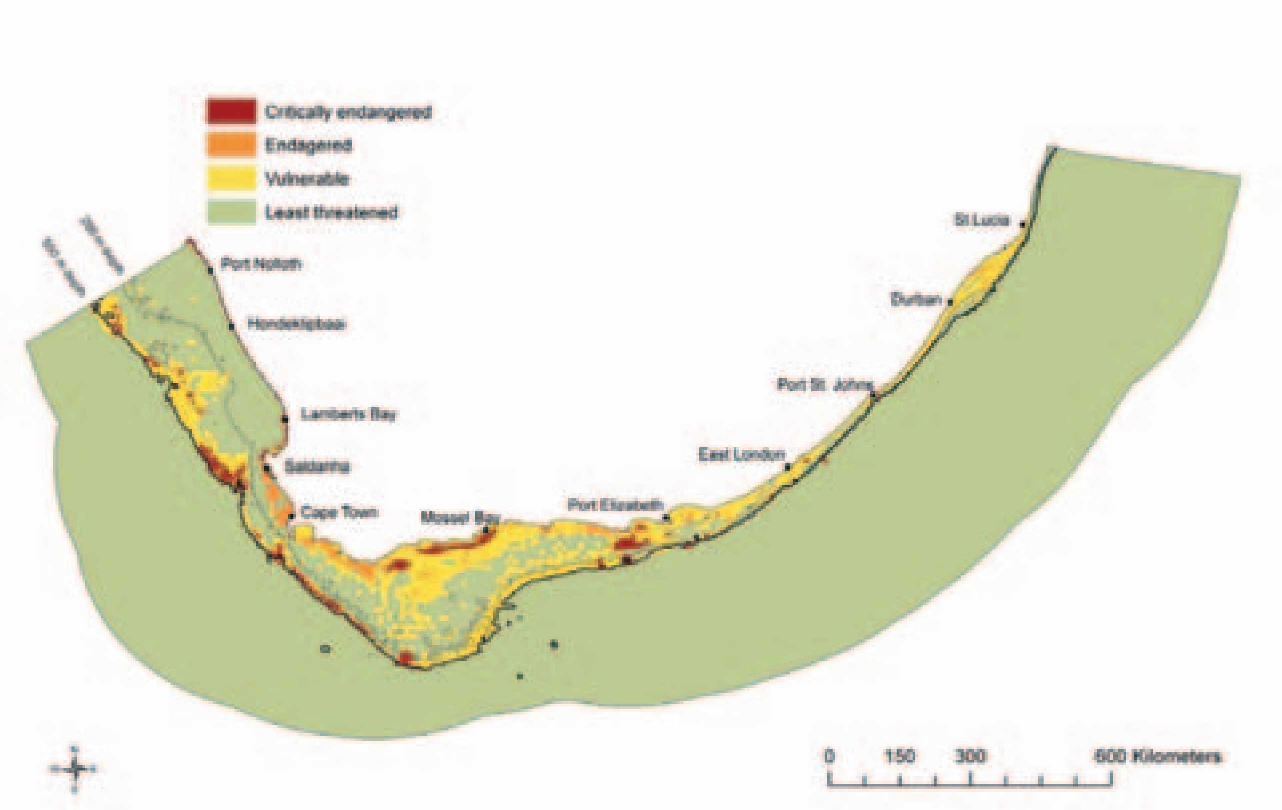
Marine and coastal ecosystems form the basis for South Africa's fishing industry, support key mining activities and provide an array of opportunities for recreation, tourism and settlements, with the coast in particular being a focus for human activity and development. They are also exceptionally diverse, straddling three oceans, with habitats ranging from cool-water kelp forests to subtropical coral communities and a vast array of species. Pressures on marine and coastal ecosystems are multiple, and tend to be more intense along the coast and inshore, which are more accessible to people than the open ocean. Coastal development is the biggest pressure on coastal ecosystems, and fishing is the biggest pressure in most inshore and offshore ecosystems. Fishing not only impacts on the targeted species and those caught as by-catch—and thus on food webs and ecosystem dynamics—but also causes direct damage to marine habitats in some cases. For example, trawling of the seabed can be likened to ploughing in the terrestrial environment, with severe impacts that may be irreversible in some habitats.

The NBA 2011 mapped and classified marine and coastal habitat types for the first time in South Africa, providing the basis for the first national assessment of marine and coastal ecosystems at a meaningful scale. The assessment covered South Africa's mainland Exclusive Economic Zone, which extends 200 nautical miles offshore.

For coastal and inshore ecosystem types, 58% are threatened (24% critically endangered, 10% endangered and 24% vulnerable), compared with 41% of offshore ecosystems types (11% critically endangered, 8% endangered and 22% vulnerable), reflecting the fact that coastal and inshore ecosystems are more heavily impacted by human activities. Nearly a quarter of South Africa's population lives within 30 km of the coast, and already nearly a fifth of the coast has some form of development within 100 m of the shoreline. Such development not only puts people and property directly at risk, but also compromises the ability of coastal ecosystems to buffer the impacts of sea-level rise and storm surges, all the more important in the face of climate change. In the offshore environment, habitat types along the shelf edge (the steep area where the ocean floor drops off into the continental slope and abyss) are particularly threatened because of the concentration of pressures such as trawling and long-lining on this narrow, highly productive area.

Currently the marine protected area network is focused almost entirely on the coast and inshore, providing almost no protection to offshore ecosystems. Only 9% of coastal and inshore ecosystem types are well protected, but the majority have at least some form of protection, with only 16% not protected at all. In the offshore environment, only 4% of ecosystem types are well protected and 69% are not protected at all.

Marine protected areas (MPAs) are often divided into zones, including no-take zones where no extractive use (such as fishing) is allowed, and extractive use zones where various forms of harvesting are permitted. Because fishing is the biggest pressure on marine ecosystems, the degree of protection provided by no-take zones is higher. Coastal MPAs that allow extractive use can actually become nodes of increased exploitation by fishers, rather than providing protection. Increasing the number and size of strategically placed no-take zones in existing MPAs would result in a substantial increase in the proportion of well protected coastal and inshore ecosystem types. A national coastal biodiversity plan is an urgent priority to identify coastal ecosystem priority areas, including priorities for consolidating, zoning and expanding coastal MPAs. In the offshore environment, the recently completed Offshore Marine Protected Area project identifies focus areas for offshore marine protection.



Ecosystem threat status for coastal, inshore and offshore benthic (seabed) habitat types. Along the coast and inshore, many habitats in Namaqualand and the southwestern Cape are threatened. In the offshore environment, habitat types along the shelf edge are particularly threatened because of the concentration of pressures such as trawling on this narrow, highly productive area.

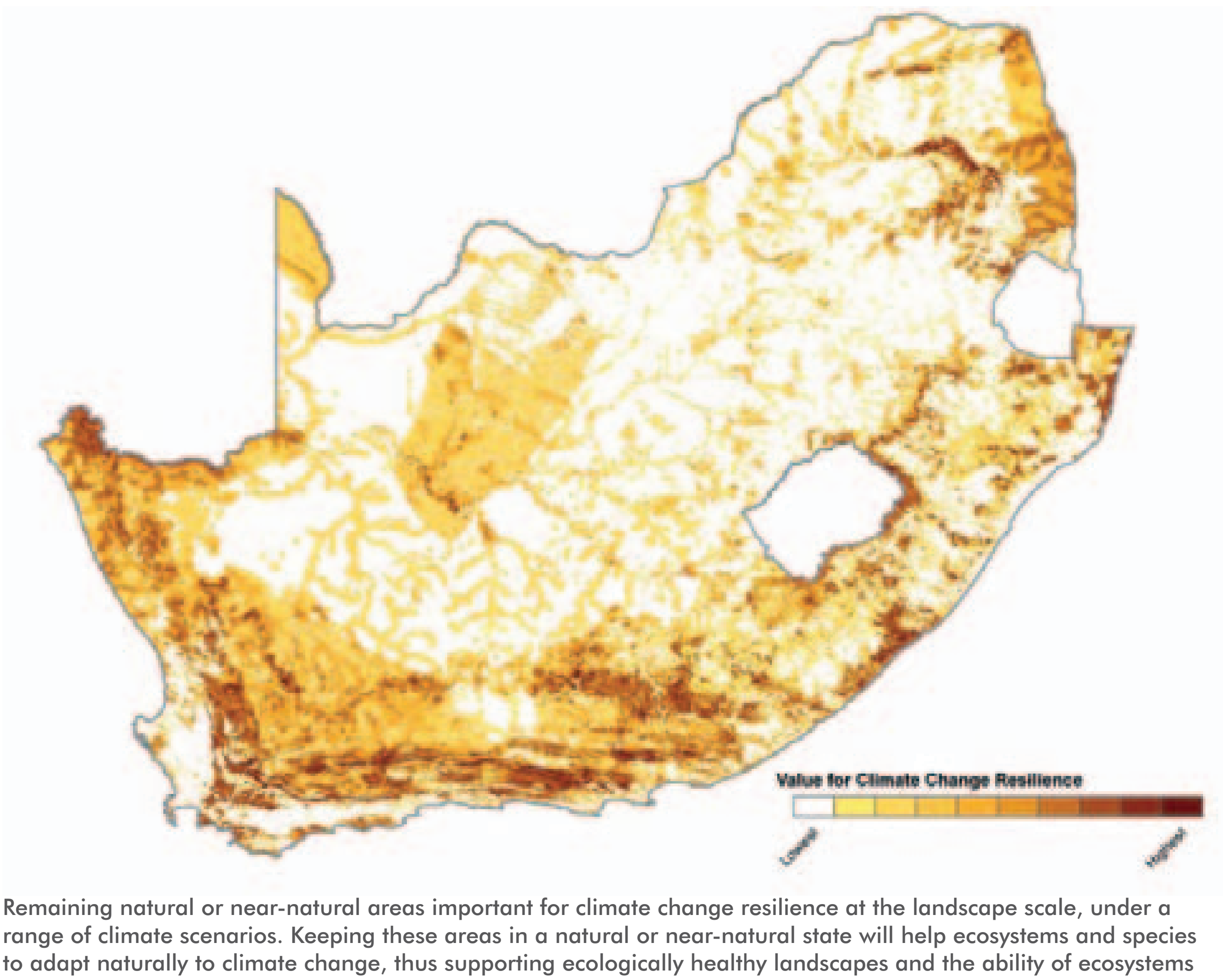
The role of marine protected areas and other spatial management measures in supporting sustainable fisheries is emphasised in the ecosystem approach to fisheries management. Implementing this approach is a priority in South Africa, as discussed further in Section 10 below.

9. Resilience of biodiversity to climate change

It is well known that climate change will impact on biodiversity, and with this the ability of biodiversity and ecosystems to provide ecosystem services that support human society. With these impacts in mind, it is important to understand the potential resilience of biomes and ecosystems to climate change, as well as the role of ecosystems in helping humans cope with climate change. By resilience we mean the ability of a biome, landscape or ecosystem to absorb change and re-organise itself in order to retain its character and ecological functioning.

Spatial analysis undertaken for the NBA 2011 identified **areas where biomes are most likely to be at risk** as a result of climate change, as well as **areas of biome stability** where biomes are most likely to maintain a stable ecological composition and structure in the face of climate change, based on a range of possible future climate scenarios. Areas of biome stability present good opportunities for new or expanded protected areas aimed at improving representation of the biome concerned in the protected area network.

Within areas of biome stability as well as areas where biomes are most likely to be at risk, some features in the landscape are more likely to support resilience of biodiversity to climate change than others. Such features include: riparian corridors and buffers; coastal corridors; areas with temperature, rainfall and altitudinal gradients; areas of high diversity; areas of high plant endemism; refuge sites including south-facing slopes and kloofs; and priority large unfragmented landscapes. All of these features were mapped, and then combined to provide a single map of **areas important for resilience of biodiversity to climate change** at the landscape scale. Keeping these areas in a natural or near-natural state will help ecosystems and species to adapt naturally to climate change, thus supporting healthy landscapes



Remaining natural or near-natural areas important for climate change resilience at the landscape scale, under a range of climate scenarios. Keeping these areas in a natural or near-natural state will help ecosystems and species to adapt naturally to climate change, thus supporting ecologically healthy landscapes and the ability of ecosystems to continue to provide a range of ecosystem services.

and the ability of ecosystems to continue to provide ecosystem services. They should be considered vital elements of South Africa's ecological infrastructure in the face of climate change.

Areas important for climate change resilience need to be managed and conserved through a range of mechanisms including land-use planning, environmental impact assessments, protected area expansion, and working with industry sectors to minimise their spatial footprint and other impacts.

In addition to supporting well-functioning landscapes in the long term, some of the areas important for climate change resilience may also provide more specific, immediate benefits that assist directly with human adaptation to the impacts of climate change, known as ecosystem-based adaptation. For example, buffers of natural vegetation along river corridors and around wetlands mitigate floods, reduce erosion and improve water quality. Intact coastal ecosystems such as dunes, mangroves, kelp beds and saltwater marshes help to protect human settlements and infrastructure against sea storms. Ecosystem-based adaptation has the potential to be both more effective and less costly than engineered solutions. Further work is needed to determine which ecosystems are most important for ecosystem-based adaptation in South Africa, and to examine the extent to which they overlap with areas important for climate change resilience at the landscape scale.

Because a relatively large proportion of South Africa's ecosystems are still in a natural or near-natural state, there are far better opportunities here than in many developed parts of the world to capitalise on options for supporting climate change resilience at the landscape scale. With quick action, it is still possible to conserve the required areas, whereas in many more developed countries that opportunity no longer exists.

The recently published National Climate Change Response White Paper recognises the integral role of healthy ecosystems in responding effectively to climate change. The work presented here will support the ability to put this into practice.

10. Species of special concern

Species of special concern

- South Africa has over 95 000 known species, with many more still to be discovered and described.
- SA Red Lists show that 1 in 5 inland mammal species, 1 in 5 freshwater fish species, 1 in 7 frog species, 1 in 7 bird species, 1 in 8 plant species, 1 in 12 reptile species, and 1 in 12 butterfly species are threatened. Key threats to indigenous species include loss of natural habitat and invasive alien species.
- SA has over 2 000 medicinal plant species, 656 of which are traded. Of these, 56 are threatened.
- More than 630 marine species are caught by fisheries in SA. The stock status of 41 of these was reported in 2010. Of the 41 species, 25 were considered overexploited, collapsed or threatened

Species are the building blocks of ecosystems, playing a fundamental role in maintaining well-functioning ecosystems and thus in supporting the provision of ecosystem services. South Africa has over 95 000 known species, far more than our fair share based on the percentage of Earth's surface the country occupies, with a further 50 000, conservatively estimated, yet to be discovered and described. Species

of special concern are those that have particular ecological, economic or cultural significance, some of which are the focus of this NBA. In future NBAs we will endeavour to deal with a wider range of species of special concern.

Medicinal plants

South Africa has over 2 000 plant species that are recorded as used for medicinal purposes, out of a total of over 20 000 plant species, with the highest numbers of medicinal plant species occurring in the Grassland, Forest and Savanna biomes. About a third of medicinal plant species (656 species) are traded in medicinal markets. Trade in traditional medicines was estimated at R2.9 billion per year in 2007, with at least 133 000 people employed in the trade, many of whom are rural women.

Harvesting of plants for medicinal use is often destructive to the plant, so one might expect to find that a large proportion of medical plant species are threatened with extinction. However, the Red List of South African Plants shows that of the 656 medicinal plant species that are traded, 9% (56 species) are threatened. Urgent action is required for these 56 threatened medicinal plant species if future generations are to continue to benefit from them, and research and monitoring of the remaining traded species is needed to ensure that harvesting patterns are sustainable. Possible actions include developing Biodiversity Management Plans in terms of the Biodiversity Act and exploring options for cultivation of medicinal plant species.

Harvested marine species

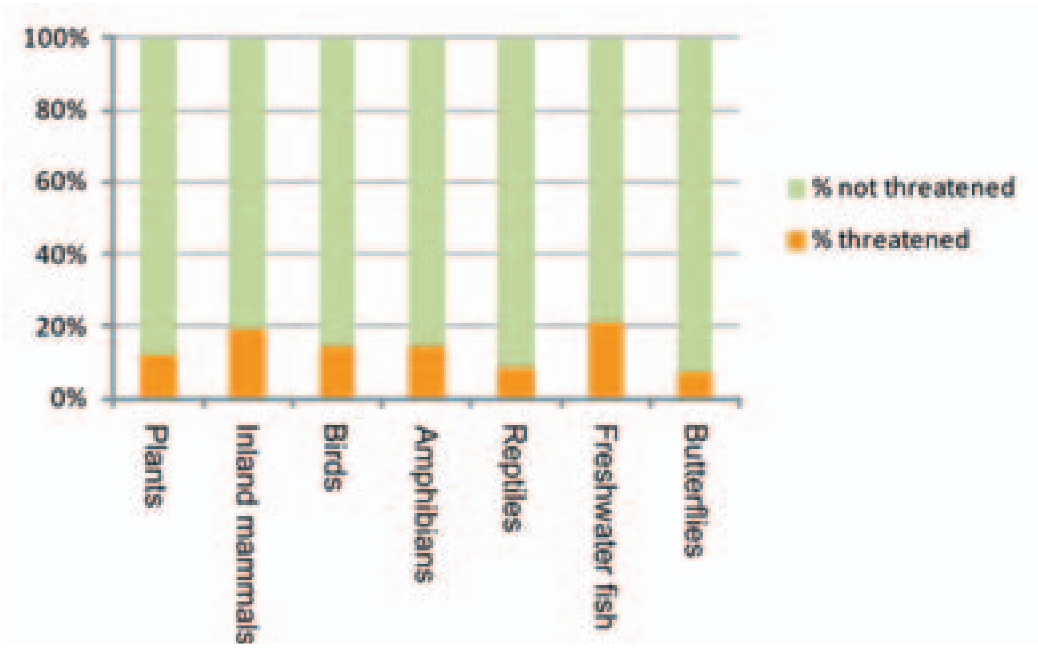
Fisheries make a significant contribution to the South African economy, but the resources on which fisheries depend—the species that are harvested—are in many cases in decline. This does not bode well for long-term food and job security. More than 630 marine species, most of them fish species, are caught by commercial, subsistence and recreational fisheries in South Africa. The country has a long history of fisheries management grounded in science, focused mainly on managing total catch and fishing effort for individual species. However, only a small proportion of these 630 species are managed in this way, and the stock status of only 41 of them was reported in 2010. Of those 41 species, 25 were considered overexploited, collapsed or threatened.

The good news is that fish stocks can recover with management interventions, with deep water hake and south coast rock lobster providing recent South African examples. More and better assessments of stock status or trends for harvested marine resources are essential in order to know how to intervene. However, it will never be feasible to manage all harvested species using a traditional fisheries management approach that regulates catch or fishing effort for each individual species. Hence the importance of implementing the ecosystem approach to fisheries management to ensure the long-term integrity of marine resources and ecosystems, including using marine protected areas and other spatial management measures to protect important habitats such as spawning and nursery areas, foraging areas and other habitats that play a role in the recovery of fish stocks.

Threatened species

Conservation assessments, or Red Lists, use an internationally agreed set of criteria to assess how threatened different species are, based on the likelihood of extinction. South Africa is a world leader in Red Listing, having assessed a wider range of taxonomic groups than most countries, and being the only mega-diverse country to have assessed its entire flora, in the Red List of South African Plants. Red List assessments in South Africa to date show that: one in five inland mammal species is threatened; one in five freshwater fish species is threatened; one in seven frog species is threatened; one in seven bird species is threatened; one in eight plant species is threatened; one in twelve reptile species is threatened; and one in twelve butterfly species is threatened. Analysis based on Red Lists shows clearly that the primary threat to species comes from loss of natural habitat, particularly as a result of cultivation in the terrestrial environment. Invasive alien species are another severe threat in the terrestrial and freshwater environments.

Keeping track of the status of species and gathering the required data for assessing their status is a daunting task. Hundreds of volunteers, or citizen scientists, have played a crucial role in the process and continue to do so through a range of atlassing projects and virtual museums that make use of modern technology to enable amateurs to contribute data from around the country.



Proportion of threatened species for those taxonomic groups that have been comprehensively assessed, based on the most recent available Red Lists. The proportion of threatened species is highest for freshwater fish and inland mammals. By far the highest numbers of threatened species (over 2 500) are found among the plant group.

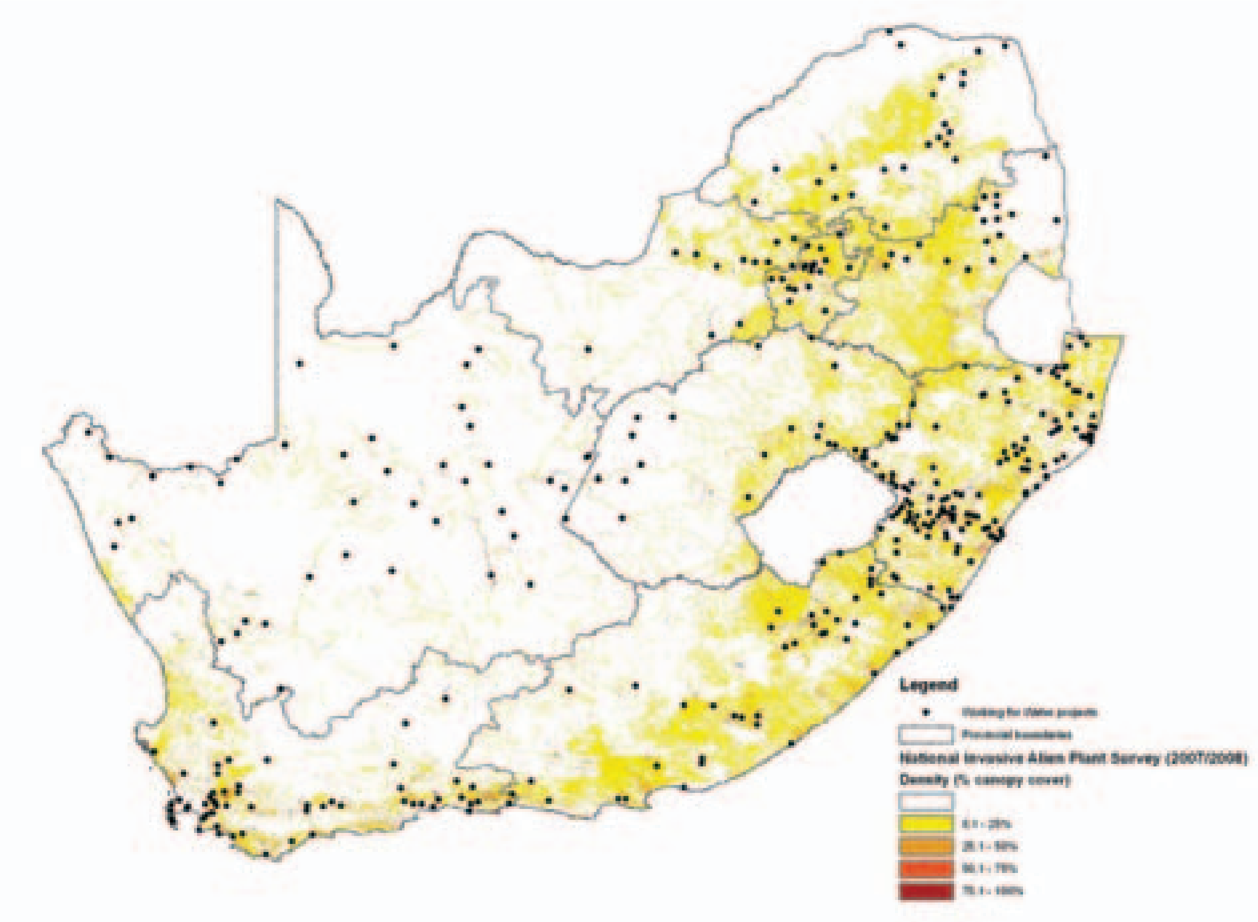
There are still many knowledge gaps with respect to the conservation status of species in South Africa. Priorities include assessments of marine species, especially linefish, and increasing the numbers of invertebrates assessed. Further challenges include developing a strategy for keeping assessments current, making a consolidated national Red List available online, and developing a national Red List Index to track trends in conservation status of species over time. See http://redlist.sanbi.org for more information.

11. Invasive alien species

Invasive alien species

- Known invasive species in South Africa include 660 plants species and about 150 animal species. These are under-estimates as thorough surveys have not taken place in most environments.
- Extent of invasion by established invasive woody plants doubled between the mid-1990s and 2007.
- At least R6.5 billion worth of ecosystem services lost every year to invasive plants–this would be as much as R42 billion in the absence of intervention.
- Estimated cost to clear established invasive plants is R1.4 billion per year over the next 25 years.
- Return on investment is highest from early detection of potentially invasive species and rapid action to eradicate before they become established.

Invasive alien species are species that have become established in an area beyond their natural distribution range following introduction by humans, and whose spread threatens ecosystems, habitats or species with environmental or economic harm. They present a large and growing challenge in South Africa and globally. Not only do invasive species threaten indigenous biodiversity, they also have serious socio-economic impacts including threats to water security, reduced productivity of rangelands, increased fire risk, and impacts on crop agriculture. In South Africa, a conservatively estimated R6.5 billion worth of ecosystem services is lost each year as a result of invasive alien plants, a value that would be more than six times higher had no management of these plants been carried out.



Density of 27 established invasive plant species or groups of species in South Africa, as surveyed by the National Invasive Alien Plant Survey 2010. The total area of land infested increased from an estimated 10 million hectares in the mid-1990s to approximately 20 million hectares in 2007 when the survey was conducted.

Known invasive alien species in South Africa include 660 plant species, six mammal species, ten bird species, at least six reptile species, at least 22 freshwater fish species, at least 26 mollusc species, at least seven crustacean species, and more than 70 invertebrate species. These figures are almost certainly underestimates, as thorough surveys have yet to take place in most environments.

The pathways or routes by which alien species are introduced are varied. Common ones include transport of agricultural products and other freight; movement of travellers by air, sea and land; release of ballast water from ships; fouling (colonisation by species) of ships' hulls and other infrastructure in the sea; aquaculture and mariculture; inter-basin transfers of water; plants introduced for forestry or biofuels; horticultural trade; and trade in pets. Efforts to prevent the introduction of potentially invasive species need to address all of these diverse pathways.

Invasive species are not evenly distributed across the South African landscape and seascape. More is known about the distribution of invasive woody plant species than other groups of invasive species. In the mid-1990s an estimated ten million hectares of South Africa's land area had been invaded by invasive woody plants. In 2010 the first National Invasive Alien Plant Survey showed that this had doubled to 20 million hectares (16% of South Africa's land area). Widespread species or groups include wattle (*Acacia* spp.), gum (*Eucalyptus* spp.), prickly pear (*Opuntia* spp.), pine (*Pinus* spp.), poplar (*Populus* spp.), weeping willow (*Salix babylonica*) and mesquite (*Prosopis* spp.).

Addressing the challenge of invasive alien species can create opportunities linked to restoring ecosystem functioning, securing the provision of ecosystem services and creating employment. One of the best known examples of this, in South Africa and globally, is the Working for Water programme, which uses labour-intensive methods to clear invasive woody plants, supporting job creation and relieving poverty as well as protecting scarce water resources and restoring productive land and biodiversity. From its inception in the mid-1990s to 2010/11, the programme created a total of over 130 000 person-years of employment.

In 2010/11 Working for Water had a budget of just more than R700 million. The projected cost of controlling the species included in the National Invasive Alien Plant survey over the next 25 years is R36 billion (an average of R1.4 billion a year). These costs may seem high until one considers the value of the ecosystem services currently being lost as a result of invasive alien plants. There is enormous scope to scale up the operations of Working for Water and other natural resource management programmes, with potential for further job creation combined with the benefits of restoring ecosystem functioning and securing ecosystem services.

The bulk of Working for Water's activities focus on physical removal of invasive plants through mechanical or chemical means. However, South Africa is also a leader in biological control of invasive plants, which involves using a completely host-specific natural enemy of a species, such as a plant-feeding insect or a fungus, to reduce population or seed production. Biological control can be highly cost effective, especially for invasive plant species that are so widespread that other methods of containment and management are difficult.

Recognising that prevention is better and cheaper than cure when it comes to invasive alien species, Working for Water established an Early Detection and Rapid Response programme in 2008, which aims to identify potentially invasive plants already present in the country and act quickly to eradicate them before they become widely established. Provincial coordinators work with taxonomists and networks of 'informers' including professionals and members of the public.

Although South Africa has responded significantly to the challenge of invasive alien species, most effort has tended to be invested in managing invasive species that have already become a problem. Increasingly, countries around the world are recognising the value of a hierarchical approach to dealing with invasive species, with a strong focus on preventing the entry of new high risk alien species and eradicating those that are at an early stage of establishment. The return on investment of public funds is much higher for prevention and early eradication than for containment and management of established invasive species. For invasive species that are so widespread they cannot be contained, it is important to take an asset-based approach to management, restoring and protecting specific highly valued ecological assets. Working for Water does exactly this, with sophisticated planning tools for prioritising quaternary catchments for clearing of invasive plants based on a range of factors.

In the freshwater environment, in addition to the destructive impacts of invasive woody plants on water flows, several invasive aquatic plants clog up waterways and can damage infrastructure. Invasive alien fish, such as bass, carp and trout, interfere with ecological functioning and are the primary reason for the high numbers of threatened indigenous freshwater fish species. In the marine and estuarine environment, invasive species are a growing concern, with the rate of discovery of alien species increasing as more research is done in this emerging field.

The Biodiversity Act provides the legal framework for prevention, management and control of invasive species, and regulations for alien and invasive species and accompanying lists of species were in the process of being finalised at the time of writing. In addition to the regulations, South Africa would benefit from a national strategy for invasive alien species to support the effective implementation of legislation. Such a strategy was in the process of being initiated at the time of writing. Cooperative governance and involvement of a wide range of stakeholders are critical foundations for success.

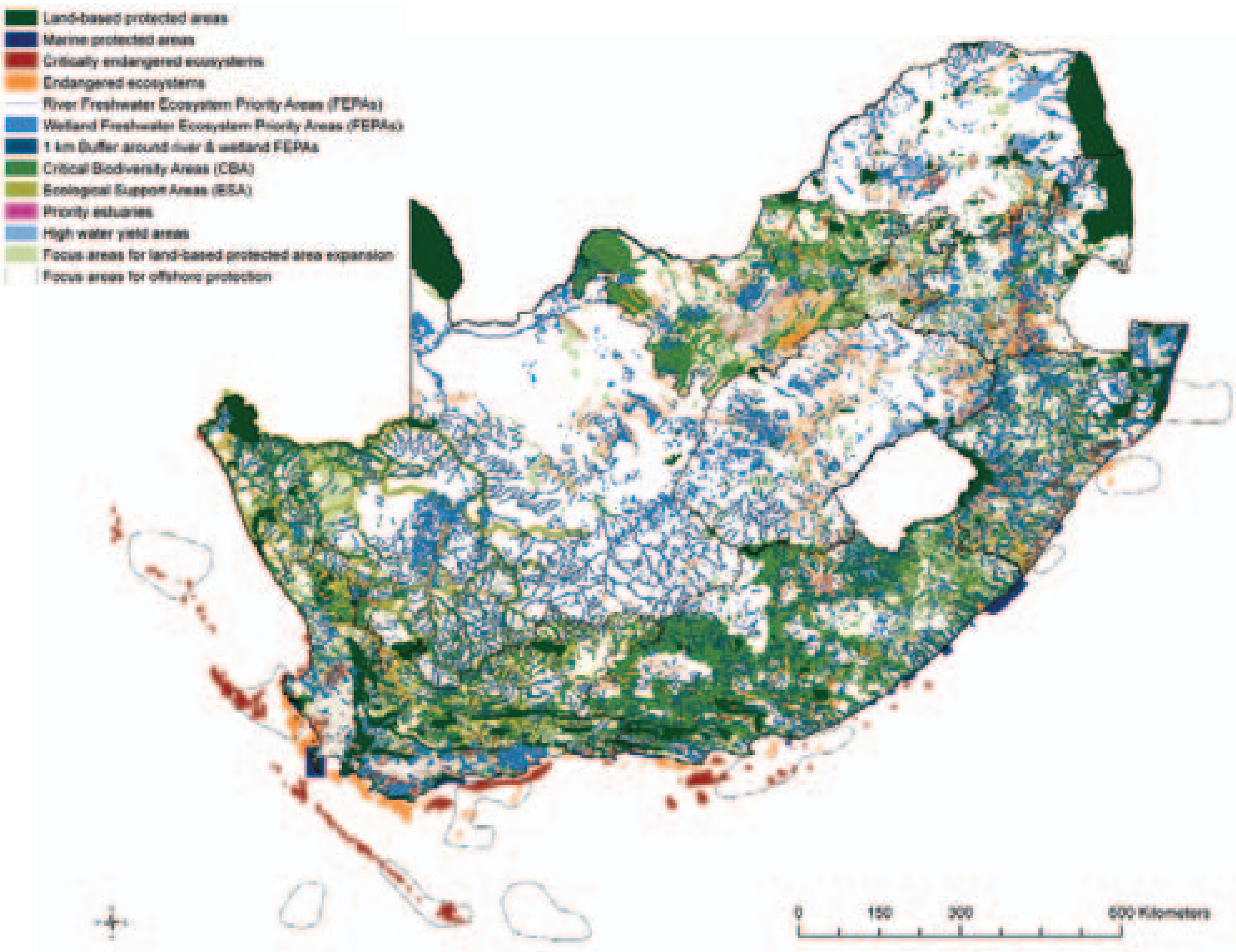
12. Spatial biodiversity priority areas and priority actions

Priority areas

South Africa has well-established capacity for producing spatial biodiversity plans that are based on best available science **and** relate directly to policy and legislative tools. These maps and accompanying data are a valuable information resource to assist with planning and decision-making in the biodiversity sector and beyond. They help to focus the limited resources available for conserving and managing biodiversity on geographic areas that will make the most difference, and can inform planning and decision-making in a range of sectors, especially those that impact directly on biodiversity.

Spatial biodiversity plans identify biodiversity priority areas that are important for conserving a representative sample of ecosystems and species, for maintaining ecological processes, or for the provision of ecosystem services. Biodiversity priority areas include the following categories, shown in the map below:

- **Protected areas**: areas of land or sea that are formally protected by law and managed mainly for biodiversity conservation.
- **Critically endangered ecosystems**: ecosystem types that have very little of their original extent left in natural or near-natural condition.
- **Endangered ecosystems**: ecosystem types that are close to becoming critically endangered.
- **Critical Biodiversity Areas**: areas required to meet biodiversity targets for ecosystems, species or ecological processes, as identified in a systematic biodiversity plan. They may be terrestrial or aquatic.



Biodiversity priority areas in South Africa. The different categories are not mutually exclusive and in many cases overlap, often because a particular area or site is important for more than one reason. The categories are complementary, with overlaps reinforcing the significance of an area from a biodiversity point of view.

- **Ecological Support Areas**: areas that are not essential for meeting biodiversity targets but play an important role in supporting the ecological functioning of Critical Biodiversity Areas or in delivering ecosystem services. They may be terrestrial or aquatic.
- **Freshwater Ecosystem Priority Areas**: rivers and wetlands required to meet biodiversity targets for freshwater ecosystems.
- **High water yield areas**: sub-quaternary catchments where mean annual runoff is at least three times more than the average for the related primary catchment.
- **Flagship free-flowing rivers**: the 19 free-flowing rivers that have been identified as representative of the last remaining 63 free-flowing rivers in South Africa. A free-flowing river is a long stretch of river that has not been dammed, flowing undisturbed from its source to the confluence with another large river or to the sea.
- **Priority estuaries**: estuaries that are required to meet targets for representing estuarine ecosystems, habitats and estuarine-dependent species.
- **Focus areas for land-based protected area expansion**: large, intact and unfragmented areas of high biodiversity importance, suitable for the creation and expansion of large protected areas.
- **Focus areas for offshore protection**: areas identified as priorities for representing offshore marine biodiversity, protecting vulnerable marine ecosystems, contributing to fisheries sustainability, and supporting the management of by-catch.

These categories are not mutually exclusive, and in some cases they overlap, often because a particular area or site is important for more than one reason. The different sets of biodiversity priority areas should be seen as complementary, with overlaps reinforcing the significance of an area from a biodiversity or ecological infrastructure point of view.

Coastal ecosystem priority areas and marine ecosystem priority areas have yet to be identified across the country, and are the missing elements in this set of biodiversity priority areas. Development of a national coastal biodiversity plan is an urgent priority.

Maps, spatial data and reports on most of these biodiversity priority areas are freely available on SANBI's Biodiversity GIS website (http://bgis.sanbi.org.za), and represent an excellent biodiversity information resource to assist with development planning and decision-making.

Priority actions

Strategic objectives and priority actions for managing and conserving South Africa's biodiversity are set out in the National Biodiversity Strategy and Action Plan (NBSAP) and the National Biodiversity Framework (NBF), both of which are due to be reviewed shortly. Priority actions suggested by the results of the NBA 2011, which should feed into the review process, can be grouped into three major categories that apply across terrestrial and aquatic environments:

- **Reduce loss and degradation of natural habitat in priority areas**. These actions focus on preventing loss and degradation of natural habitat in those biodiversity priority areas that are still in good ecological condition.
- **Protect critical ecosystems**. These actions focus on consolidating and expanding the protected area network as well as strengthening the effectiveness of existing protected areas. It deals with formal protection by law, recognised in terms of the Protected Areas Act, including contract protected areas on private or communal land.
- **Restore and enhance ecological infrastructure**. These actions focus on active interventions required to restore those biodiversity priority areas that are currently not in good ecological condition, in order to enhance ecological infrastructure and support delivery of ecosystem services.

Key actions suggested by the NBA 2011 in each of these categories are highlighted in the report. All of them are underpinned by the maps of biodiversity priority areas referred to above.

In order to implement the priorities identified in the NBA and unlock the opportunities presented by South Africa's wealth of biodiversity resources, a concerted investment in human capital is essential. Lack of sufficient skilled and experienced people has been identified as a key constraint in the biodiversity sector, along with many other sectors in South Africa. In response, the biodiversity sector has initiated a Human Capital Development Strategy, with great potential to contribute to national job creation and development objectives. For more information see www.greenmatter.co.za.

13. Knowledge gaps and research priorities

Through this assessment, a number of knowledge gaps and research priorities have been identified, with a view to strengthening future NBAs. They range from gaps in taxonomy through to the need for a more thorough understanding of ecosystem services.

A national assessment of biodiversity depends on a good foundation of knowledge of species and ecosystems, including which ones are found in South Africa and where they occur. Taxonomy is the science of describing, naming and classifying species and has good foundations in South Africa, providing the basis on which our understanding of biodiversity is built. However, the distribution of taxonomists across different groups of organisms is highly uneven. For example, there is one taxonomist for every 28 mammal species in South Africa but only one taxonomist for every 1 319 known insect species, with many more still to be discovered. Globally the number of taxonomists is declining with relatively few young scientists being recruited into the discipline. A national strategy for taxonomy is required, to ensure a strategic approach to taxonomic research and the development of new taxonomic capacity.

Perhaps less well recognised than the importance of describing and classifying species is the importance of mapping and classifying ecosystems as an essential foundation for monitoring, assessing and managing biodiversity. South Africa has some of the best ecosystem mapping and classification in the world, with a long history of vegetation mapping and more recent progress in the aquatic environments, as reflected in this NBA. This work amounts to an emerging national ecosystem classification system, which should be formalised and strengthened. Linked to this work is the development of biodiversity targets for ecosystem types based on their ecological characteristics, as has been achieved for vegetation types in the terrestrial environment.

Following closely in importance to strengthening the emerging national ecosystem classification system is the need for regularly updated, countrywide data on the condition of ecosystems. Without good data on ecological condition, it is not possible to assess ecosystem threat status. The Department of Water Affairs' system of Present Ecological State categories provides the basis for ecological condition assessment for rivers, wetlands and estuaries. The possibility of applying this type of approach in the terrestrial and marine environments should be explored. Programmes for long-term in situ monitoring of ecosystems based on quantitative indices, such as the River Health Programme, need to be strengthened or established in all environments, and opportunities to involve civil society in such programmes should be explored.

Other priorities for assessing ecological condition include regularly updated maps of land cover for the country, a consistent national map of degradation in the terrestrial environment, and quantification of the modification in freshwater flow to the coast on a watershed scale.

Mapping and valuing ecosystem services is another research priority, to demonstrate the value of biodiversity and ecosystems, and to enable the recognition of ecosystem services in market transactions, national accounting and the allocation of public sector resources.

These priorities for research and data gathering should inform the National Biodiversity Research Strategy, currently being developed. They will also guide the further development and implementation of the national biodiversity monitoring framework, which includes the headline indicators reported on in the NBA and is coordinated by SANBI in collaboration with a range of partners.

1. Introduction

Chapter summary

The National Biodiversity Assessment (NBA) 2011 assesses the state of South Africa's biodiversity and ecosystems, across terrestrial, freshwater, estuarine and marine environments, with an emphasis on giving spatial (mapped) information where possible, especially about ecosystems. It provides a mechanism for synthesising key aspects of South Africa's excellent biodiversity science and making it available to policymakers, decision-makers and practitioners in a range of sectors.

The NBA is central to fulfilling SANBI's mandate to monitor and report regularly on the state of biodiversity, and includes two headline indicators that are assessed across all environments: ecosystem threat status and ecosystem protection level. The NBA 2011 also deals with species of special concern and invasive alien species, presents new work on geographic areas that contribute to climate change resilience, and provides a summary of spatial biodiversity priority areas that have been identified through systematic biodiversity plans at national, provincial and local scales.

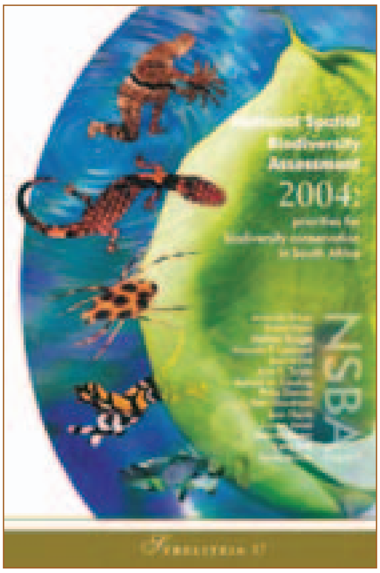
The NBA 2011 will inform the revision and updating of key national biodiversity policies and strategies, including the National Biodiversity Strategy and Action Plan, the National Biodiversity Framework and the National Protected Area Expansion Strategy. In addition, information from the NBA can be used to streamline environmental decision-making, strengthen land-use planning, strengthen strategic planning about optimal development futures for South Africa, and identify priorities for management and restoration of ecosystems with related opportunities for ecosystem-based job creation.

This report presents the results of South Africa's National Biodiversity Assessment (NBA) 2011, which was led by the South African National Biodiversity Institute (SANBI) in partnership with a range of organisations. The NBA 2011 assesses the state of the country's biodiversity (see Box 1), across terrestrial (land), freshwater, estuarine and marine environments, emphasising spatial (mapped) information for both ecosystems and species. It highlights the role of biodiversity in underpinning economic development, and presents new work on geographic areas that contribute to climate change resilience.

In 2004, SANBI led the National **Spatial** Biodiversity Assessment (NSBA)[1], which dealt only with spatial aspects of biodiversity. In 2011, we have added non-spatial thematic elements, such as a summary of the state of species of special concern and invasive alien species, to present a more comprehensive picture. In future revisions of the NBA, which will take place every five to seven years, the non-spatial elements of the assessment will be further strengthened.

Key advances in the NBA 2011 include a more thorough focus on aquatic ecosystems (marine, estuarine and freshwater) than was possible in 2004, underpinned by exceptional work in the intervening years on mapping and classifying aquatic ecosystems and assessing their condition.

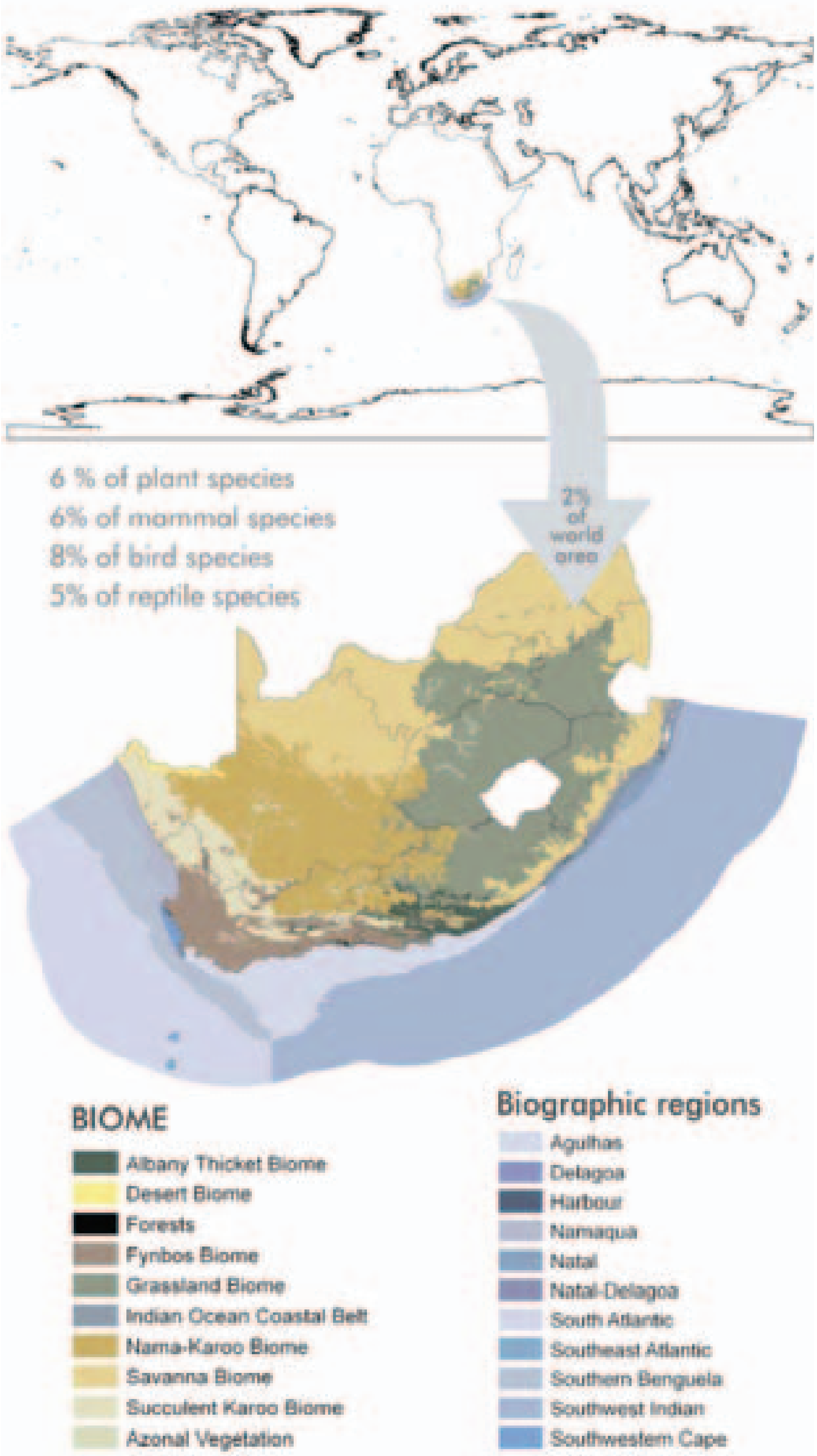
The NBA 2011 was undertaken over a period of three years and involved wide participation from stakeholders, scientists and biodiversity management experts throughout the country, including as part of a technical reference group that was convened twice, multiple workshops and reference group meetings held for each component of the NBA, and discussions at South Africa's annual Biodiversity Planning Forum which brings together more than 100 scientists, practitioners and managers.



The NBA 2011 builds on the NSBA 2004, expanding the scope of the assessment to include thematic as well as spatial elements.

[1] Driver, A., Maze, K., Rouget, M., Lombard, A.T., Nel, J., Turpie, J.K., Cowling, R.M., Desmet, P., Goodman, P., Harris, J., Jonas, Z., Reyers, B., Sink, K. & Strauss, T. 2005. National Spatial Biodiversity Assessment 2004: priorities for biodiversity conservation in South Africa. *Strelitzia* 17. South African National Biodiversity Institute, Pretoria.

Box 1: South Africa's biodiversity in a nutshell



South Africa is diverse not only in terms of people and culture but also in terms of biological resources and ecology. With only 2% of the planet's land area, the country is home to 6% of the world's plant and mammal species, 8% of bird species and 5% of reptile species, many of which are found only in South Africa. With nine biomes ranging from Desert to Grassland to Forest, South Africa has a huge range of habitats, ecosystems and landscapes. The country has three of 34 globally recognised biodiversity hotspots: the Cape Floristic Region, which falls entirely within South Africa; the Succulent Karoo, shared with Namibia; and the Maputaland-Pondoland-Albany hotspot, shared with Mozambique and Swaziland.[2] South Africa's seas straddle three oceans, the Atlantic, the Indian and the Southern Ocean, and include an exceptional range of habitats, from cool-water kelp forests to subtropical coral communities. The southern African coast is home to almost 15% of known coastal marine species, including 270 marine fish families out of a world total of 325.

These facts and figures are quoted so often that it is easy to forget how remarkable they are in global terms. South Africa is recognised as one of only 17 megadiverse countries. This vast wealth of biodiversity assets provides a foundation for economic growth, social development and human wellbeing, a theme which we will explore throughout this report.

1.1 The role of the NBA

The NBA provides a mechanism for synthesising key aspects of South Africa's biodiversity science, building on decades of research and innovation by South African scientists, and making it available in a useful form to policymakers, decision-makers and practitioners in a range of sectors. The NBA has an especially important role to play in supporting the development and implementation of biodiversity policy and legislation in South Africa (see Box 2). It will inform the upcoming revision of the National Biodiversity Strategy and Action Plan (NBSAP), updates of the National Biodiversity Framework (NBF) and the National Protected Area Expansion Strategy (NPAES), and the listing

[2]For more on these and other global biodiversity hotspots see www.conservation.org.

of threatened ecosystems in terms of the National Environmental Management: Biodiversity Act (Act 10 of 2004). The relationship between the NBA, the NBSAP and the NBF is shown in Figure 1. The NBA also contributes to tracking progress in achieving the objectives of the Delivery Agreement for Outcome 10, which the Minister of Environmental Affairs has signed with the President.

The NBA is central to fulfilling SANBI's mandate to monitor and report regularly on the state of biodiversity, and will feed directly into the Department of Environmental Affairs' South African Environment Outlook 2012 report, as well as South Africa's Fifth Country Report to the Convention on Biological Diversity (CBD) due in 2014. See Box 3 for more on the purpose and uses of the NBA, and Box 4 for discussion on what is meant by an 'assessment'.

Box 2: Key national biodiversity policy, legislation and strategy documents

South Africa has excellent biodiversity policy and legislation. Here we provide a brief overview of some of the key national documents.

White Paper on Biodiversity: The White Paper on the Conservation and Sustainable Use of South Africa's Biological Diversity was developed through a consultative process and published in 1997. It took a far-sighted and progressive approach, including highlighting the important role of biodiversity and ecosystems in providing ecosystem services and the relevance of biodiversity to the country's development agenda. The White Paper also drew attention to the need for new tools for managing and conserving landscapes and ecosystems outside the protected area network, and laid the basis for the development of the Biodiversity Act.

Biodiversity Act: The National Environmental Management: Biodiversity Act (Act 10 of 2004) (hereafter referred to as the Biodiversity Act) provides for the coordinated management, conservation and sustainable use of biodiversity across the whole country. It promotes an ecosystem-oriented approach to the management of biodiversity, recognising that biodiversity conservation involves working beyond the boundaries of formal protected areas, across production landscapes. The Biodiversity Act introduces new tools for this purpose such as listing of threatened ecosystems, publication of bioregional plans, and development of Biodiversity Management Plans for ecosystems or species.

Protected Areas Act: The National Environmental Management: Protected Areas Act (Act 57 of 2003) (hereafter referred to as the Protected Areas Act) provides for the formal protection of a network of ecologically viable areas that are representative of South Africa's biodiversity and natural land- and seascapes. It establishes a consistent set of legal requirements for the management of national, provincial and local protected areas, and aims to balance the relationships between biodiversity conservation, human settlement and economic development. The Protected Areas Act allows for the declaration of a protected area on private or communal land and for the landowner to be recognised as the management authority of the protected area.

National Biodiversity Strategy and Action Plan (NBSAP): In response to requirements of the CBD as well as national needs South Africa developed an NBSAP, finalised in 2005 after a two-year consultative process. It sets out a comprehensive framework and long-term plan of action for the conservation and sustainable use of South Africa's biodiversity, including a long-term goal and five strategic objectives. The NSBA 2004 informed the development of the NBSAP 2005. A revision of the NBSAP will be initiated during 2012.

National Biodiversity Framework (NBF): The Biodiversity Act requires the Minister of Environmental Affairs to develop and publish an NBF and to review it at least every five years. The first NBF was published in 2008, informed by both the NBSAP 2005 and the NSBA 2004. The purpose of the NBF is to coordinate and align the efforts of the many organisations and individuals involved in conserving and managing South Africa's biodiversity. While the NBSAP is comprehensive and long-term, the NBF focuses attention on the most urgent strategies and actions that can make the greatest difference. The NBF 2008 identifies 33 priority actions for the period 2008 to 2013, organised according to the five strategic objectives of the NBSAP 2005.

National Protected Area Expansion Strategy (NPAES): South Africa's first NPAES was developed in 2008, with the goal of achieving cost-effective expansion of the protected area network that enhances ecological sustainability and resilience to climate change. It was in part a response to the NSBA 2004 which highlighted that many ecosystems were under-protected. The NPAES sets ecosystem-specific targets for protected area expansion, identifies geographic focus areas for land-based protected area expansion, and makes recommendations about mechanisms for protected area expansion.

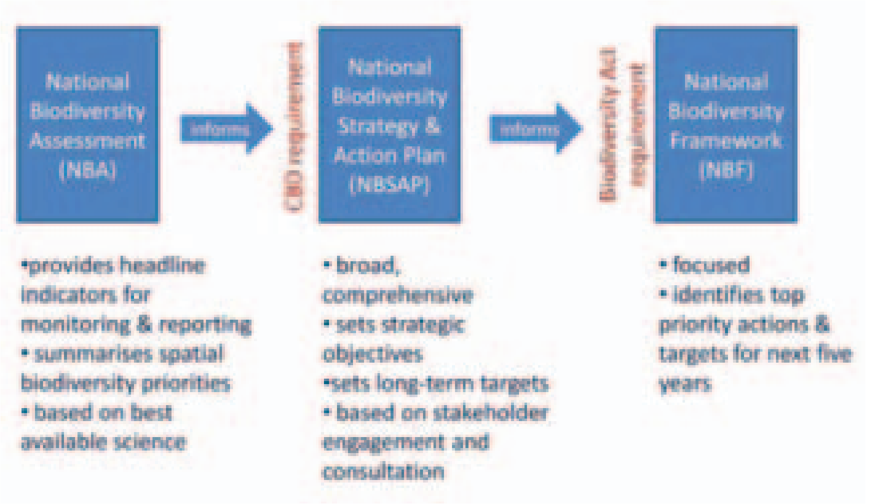


Figure 1.—Relationship between the NBA, NBSAP and NBF. The NBA 2011 will inform the upcoming revision of the NBSAP 2005, which in turn will provide the basis for the revision of the NBF 2008.

Box 3: How can the NBA be used?

The primary purpose of the NBA is to assess the state of South Africa's biodiversity and ecosystems based on best available science, with a strong focus on spatial analysis and a view to understanding trends over time.

This understanding of status and trends provides the foundation for reporting on the state of biodiversity, as well as identifying priorities for action that maximise the return on investment from limited human and financial resources. Over time, the NBA will help in assessing the effectiveness of investments and interventions to enhance South Africa's ecological infrastructure.

Information from the NBA can be used to:

- **Streamline environmental decision-making**, including environmental impact assessments (EIAs), by providing upfront information about threatened ecosystems and biodiversity priority areas that can be integrated early on in the process to improve the quality and efficiency of decision-making at the site scale.
- **Strengthen land-use planning**, including through provincial and municipal Spatial Development Frameworks which set out desired future patterns of land use, taking into account the priorities and requirements of a range of sectors.
- **Strengthen national development planning and other strategic planning processes** through provision of clear spatial inputs to enable optimal development decisions for South Africa's future. This should happen at the national and landscape scale through scenario planning, enabling strategic trade-offs where necessary, for example between minerals development, energy security and water security.
- **Identify priorities for management and restoration of ecosystems**, which provides opportunities for ecosystem-based job creation and supports the provision of ecosystem services.
- **Inform the revision of the NBSAP, NBF and NPAES** (see Box 2).
- **Provide initial identification of threatened ecosystems** for listing in terms of the Biodiversity Act.
- **Highlight areas where more detailed assessment and planning is required**, for example the need for a national coastal biodiversity plan to identify coastal ecosystem priority areas.

South Africa takes a landscape approach to biodiversity conservation, which means working both within and beyond the boundaries of protected areas, to manage a mosaic of land and resource uses including protection, restoration, production and subsistence use, in order to deliver ecological, economic and social benefits. The NBA, through its focus on ecosystems, supports the implementation of this landscape approach. For more on the landscape approach and its associated suite of practical tools, see *Biodiversity for Development: South Africa's landscape approach to conserving biodiversity and promoting ecosystem resilience.*[3]

The NBA also provides standard national spatial data layers that can be used in other national, provincial and local planning projects, and an agreed set of national biodiversity targets. In the NBA 2011 these include the first national map of coastal and marine habitat types, and the first national spatial demarcation of the estuarine functional zone. All data layers are available on SANBI's Biodiversity GIS website at http://bgis.sanbi.org.

[3]Cadman, M., Petersen, C., Driver, A., Sekhran, N., Maze, K. & Munzhedzi, S. 2010. *Biodiversity for Development: South Africa's landscape approach to conserving biodiversity and promoting ecosystem resilience.* South African National Biodiversity Institute, Pretoria. Available at www.undp.org/biodiversity/docs/primer.pdf.

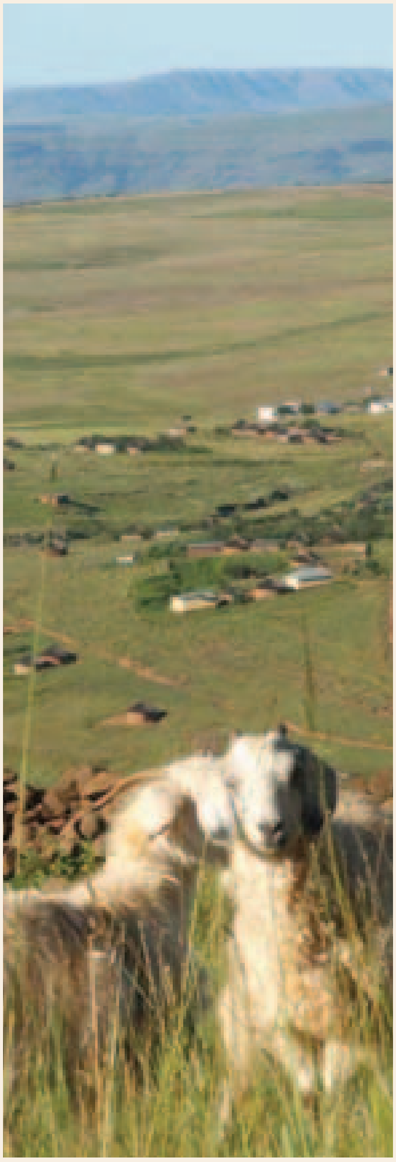
Box 4: What is an assessment?

Assessments are increasingly used as a tool to make the findings of science available to decision-makers. An assessment:

- Is a critical evaluation of information for the purpose of guiding decisions on a complex, public issue.
- Is policy relevant, but not prescriptive.
- Is conducted by a credible group of experts with a broad range of disciplinary and geographical experience.
- Reduces complexity by summarising and synthesising.
- Relates to the situation at a particular time and in a geographical domain.
- Is *not* a research paper, a review paper or an advocacy piece.

(Source: Adapted from www.agassessment.org/docs/assessmentdef.doc)

Panel 1: Defining biodiversity, ecosystems and ecological infrastructure



Biodiversity provides the foundation for ecological infrastructure, which in turn provides a range of ecosystem services.

Biodiversity is the variety of life on Earth, including genes, species and ecosystems, as shown in Figure 2. Biodiversity is important not simply for its own sake but also because it constitutes **ecological infrastructure** or **natural capital**, on which human wellbeing depends.

Traditionally one thinks of infrastructure as built or engineered—roads, railways, ports, electricity pylons, data cables and so on. However, healthy, well-functioning ecosystems also provide a substructure or foundation upon which the growth and continued functioning of society depends.

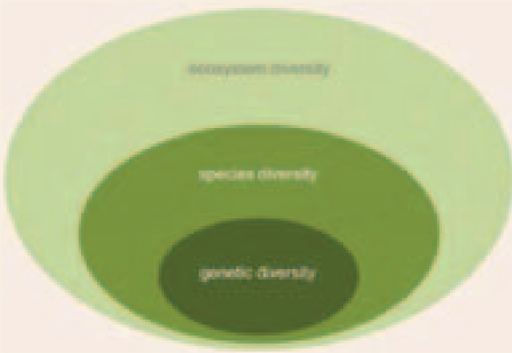


Figure 2.—Biodiversity is the variety of life on Earth, including genes, species and ecosystems.

Ecological infrastructure can be thought of as networks of intact natural habitat, in some cases large tracts of natural land or ocean, in other cases small remaining patches or corridors embedded in production landscapes. It is just as important as built infrastructure for providing vital services that underpin social and economic activity. Figure 3 shows how ecosystem composition (including the species associated with an ecosystem), structure and processes contribute to well-functioning ecosystems, which are, in turn, able to provide ecosystem services. For more on the range of ecosystem services that flow from healthy ecological infrastructure, see Panel 2.

It is possible to plan and manage ecological infrastructure networks strategically rather than leaving their configuration and persistence to chance. South Africa's excellent maps of biodiversity priority areas (see Chapter 12) provide the tools for doing exactly this. Planning for ecological infrastructure networks should be a key component of integrated development planning at all levels, from local to national.

South Africa is fortunate to have a vast wealth of biodiversity assets and ecological infrastructure, much of it still intact, representing a valuable resource for the nation's development path.

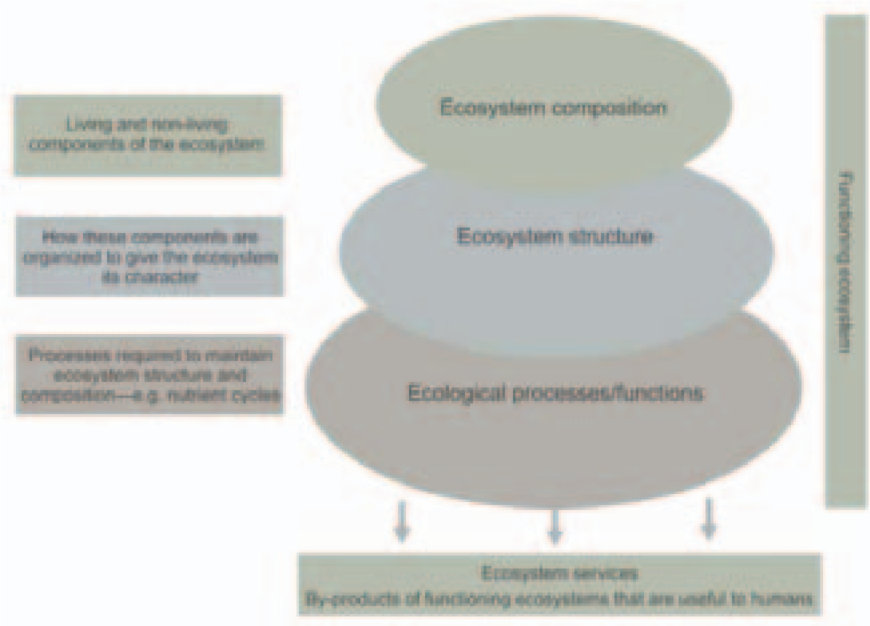


Figure 3.—Ecosystem composition, structure and processes contribute to well-functioning ecosystems, which are in turn able to provide ecosystem services that contribute to human wellbeing.

(Source: Adapted from Cadman *et al*. 2010)[3]

Panel 2: Defining ecosystem services

Ecosystem services are nature's goods and services that are fundamental for human life. They are the flows of value to human society that result from a healthy stock of natural capital or ecological infrastructure (see Panel 1). If ecological infrastructure is degraded or lost, the flow of ecosystem services will diminish. While ecosystems can recover from a certain amount of degradation, once an ecosystem is damaged beyond repair, its social and economic benefits are also likely to be lost.

Loss of ecosystem services tends to harm the rural poor more directly—poor people have limited assets and are often more dependent on common property resources for their livelihoods.

The Millennium Ecosystem Assessment,[4] the most thorough examination to date of the health of the planet's ecosystems, defined four categories of ecosystem services that contribute to human wellbeing, each underpinned by biodiversity. They are shown in Figure 4:

- Provisioning services—material products from ecosystems, such as food, fresh water, materials for construction and fuel, medicinal plants.
- Regulating services—such as purification of polluted water by wetlands, prevention of erosion, climate regulation through carbon storage, pollination, regulation of water flow that prevents flooding.
- Cultural services—non-material benefits from ecosystems, such as recreation, spiritual experience, sense of place, inspiration for culture, art and design, tourism, education.
- Supporting services—these underpin almost all other services, for example soil formation, photosynthesis, nutrient cycling.

It is often difficult to put a price on ecosystem services, many of which are public goods. This means that their value is not factored fully into market transactions and they are often undervalued or even ignored in development planning and decision-making. The recent far-reaching global study on The Economics of Ecosystems and Biodiversity (TEEB) recommends addressing this problem of market failure using a tiered approach: recognising the value of biodiversity and ecosystems, demonstrating this value, and capturing it in planning and decision-making.[5] A national study on valuing ecosystems and biodiversity was being initiated at the time of writing, to apply this approach in the South African context.

For more on the value of biodiversity and ecosystem services in terrestrial, freshwater, estuarine and marine environments, see Box 6, Box 9, Box 11, Box 13 and Box 15 in Chapters 4 to 8.

[4]Millennium Ecosystem Assessment. 2005. *Millennium Ecosystem Assessment: General Synthesis Report*. Island Press, Washington D.C.

[5]TEEB. 2010. *The Economics of Ecosystems and Biodiversity: Mainstreaming the economics of nature: a synthesis of the approach, conclusions and recommendations of TEEB*. Available at www.teebweb.org.

Figure 4.—Ecosystem services include provisioning services, regulating services, cultural services and supporting services. Ecosystem services are fundamental to human wellbeing, but their value is often not factored fully into market transactions, so they are often undervalued or even ignored in development planning and decision-making.

1.2 Headline indicators in the NBA

The NSBA 2004 introduced two new headline indicators for assessing the state of ecosystems in South Africa: ecosystem threat status and ecosystem protection level. These indicators have been carried through to the NBA 2011 (Chapters 3 to 8), and will feature in future NBAs. They enable two powerful types of analysis: time series analysis of the state of ecosystems; and meaningful comparison between marine, river, wetland, estuarine and terrestrial ecosystems. This application of the same headline ecosystem indicators across environments is unusual and has not been done in most other countries.

Working in an integrated and aligned way across aquatic and terrestrial environments is a key feature of the NBA. It is challenging, as disciplines in these environments have historically developed separately, with separate sets of terminology, methods and approaches. Insisting on compatible approaches can be seen as a constraint on conventional approaches. However, the benefits have proved numerous, including enabling comparisons between environments and stimulating shared learning among scientists who would otherwise not usually have the opportunity to work together.

Both of the headline indicators, ecosystem threat status and ecosystem protection level, can be calculated only if ecosystems have been surveyed, mapped and classified—the ecosystem equivalent of identifying and classifying species. South Africa has some of the best ecosystem mapping and classification in the world, with huge advances in the last five years in aquatic environments as highlighted in Chapters 5 to 8. This emerging national ecosystem classification system is an essential underpinning of the NBA 2011 and future NBAs. The focus on ecosystem types allows us to advance beyond species as the only measure of biodiversity, and to examine the management and conservation of habitats and ecosystems systematically.

1.3 The systematic approach to biodiversity planning and assessment

South Africa's approach to biodiversity assessment and planning is based on the so-called systematic approach, which represents the best practice in this field. The systematic approach emphasises the need to conserve a representative sample of ecosystems and species (the principle of representation) as well as the ecological processes that allow them to persist over time (the principle of persistence), and to set quantitative biodiversity targets that tell us how much of each biodiversity feature should be maintained in a natural or near-natural state. These principles of systematic biodiversity planning are reflected in the NBA headline indicators, ecosystem threat status and ecosystem protection level, through the use of biodiversity targets and thresholds (see Chapter 3). They also underpin spatial biodiversity planning at the national and sub-national level in South Africa.

The NBA summarises spatial biodiversity priority areas that have been identified through systematic biodiversity planning in South Africa at the national and sub-national scale (see Chapter 12). The NBA complements rather than replaces South Africa's suite of spatial biodiversity plans, which together should inform land-use planning, environmental impact assessment, water resource management, and protected area expansion.

1.4 How to find your way around this report

This report is structured as follows:

- Chapter 2 summarises some of the key highlights of the NBA 2011.
- Chapter 3 introduces the headline indicators, explaining how they are measured.
- Chapters 4 to 8 summarise the state of terrestrial, river, wetland, estuarine, and marine and coastal ecosystems.
- Chapter 9 presents significant new work on where terrestrial biodiversity is likely to be most stable in the face of climate change and a new national map of areas important for climate change resilience at the landscape scale.
- Chapter 10 focuses on species of special concern, including medicinal plant species, harvested marine species and threatened species.
- Chapter 11 summarises the state of invasive alien species and discusses opportunities that emerge from addressing this challenge.
- Chapter 12 provides an overview of spatial biodiversity priority areas that have been identified at the national and sub-national level in South Africa based on systematic biodiversity planning principles, and points to priority actions that emerge from the results of this assessment.
- Chapter 13 highlights knowledge gaps and suggests research priorities to strengthen future revisions of the NBA.

For more on the detailed science that is synthesised in this report, see the individual technical reports for each NBA 2011 component (terrestrial, freshwater, estuarine, marine and coastal), which are available on SANBI's Biodiversity Advisor website (http://biodiversityadvisor.sanbi.org).

2. Key highlights

Chapter summary

In this chapter, we highlight 12 of the most important findings from the NBA 2011 and discuss them briefly. For more detailed discussions, see Chapters 4 to 11.

1. Wetlands are the most threatened of all South Africa's ecosystems, with 48% of wetland ecosystem types critically endangered. Wetlands make up only 2.4% of the country's area. This small area represents high-value ecological infrastructure that provides critical ecosystem services such as water purification and flood regulation.

2. High water yield areas are South Africa's water factories and are of strategic importance for water security. They make up less than 4% of the country's area but only 18% have any form of formal protection.

3. River tributaries are generally in better condition and less threatened than main rivers, which tend to be harder working. Keeping tributaries healthy will help to improve and maintain the quality and quantity of water supplies.

4. Coastal and inshore marine ecosystems are more threatened than offshore ecosystems. Nearly a fifth of South Africa's coast has some form of development within 100 m of the shoreline, placing people and property at risk and compromising the ability of coastal ecosystems to buffer the impacts of climate change.

5. St Lucia, South Africa's flagship estuary, is in a poor state and thus unable to fulfil its role as the most important nursery for marine fish on the southeast African coast. Restoring the health of St Lucia is challenging but feasible, and has been prioritised by the iSimangaliso Wetland Park Authority.

6. Offshore marine ecosystems are the most poorly protected ecosystems of all South Africa's ecosystems, with only 4% of offshore ecosystem types well protected. Offshore ecosystems play a vital role in sustaining fisheries, and spatial management measures including marine protected areas are a key tool in the ecosystem approach to fisheries management.

7. Biodiversity stewardship programmes have been successfully established in the last seven years and are making a significant contribution to meeting national protected area targets, at much lower cost to the state than land acquisition. With modest increases in resources, biodiversity stewardship programmes could make an even larger contribution.

8. Rates of loss of natural habitat are high in some part of the country. For example, in Gauteng, KwaZulu-Natal and North West Province, if current rates of loss were to continue, there would be almost no natural habitat left outside protected areas by 2050. In regions with high rates of conversion of natural vegetation to other land uses, it is especially important to use maps of biodiversity priority areas to guide decisions about where best to locate development.

9. The NBA 2011 provides a new national map of areas that are important for climate change resilience, supporting functional, stable landscapes in the long term. It is important to keep natural habitat intact in these areas.

10. South Africa has over 2 000 medicinal plant species, of which 656 species are traded in medicinal markets. Of these traded species, 56 are threatened. Action is required for threatened medicinal plant species, as well as research and monitoring to ensure that the use of traded species that are currently not threatened is sustainable.

11. The total area infested by invasive alien plants in South Africa doubled between the mid-1990s and 2007, and at least R6.5 billion of ecosystem services are lost every year as a result. There is huge scope to scale up natural resource management programmes such as Working for Water, with coupled job creation and ecosystem service benefits.

12. Since 2004 there has been significant progress in the science of mapping and classifying ecosystems, laying the foundation for more meaningful assessment, planning and monitoring of ecosystems. For example, marine and coastal habitat types and wetland ecosystem types have been identified and mapped for the first time, and the estuarine functional zone has been mapped for the first time for all estuaries.

The scope of the NBA 2011 is broad, and the findings discussed in the chapters that follow are wide-ranging. Chapters 4 to 11 set out the findings of the NBA for ecosystems, species of special concern and invasive alien species, and represent the heart of the assessment. In this chapter, we draw together some of the most important findings that have emerged from the NBA 2011 and discuss them briefly.

As explained in Chapter 1 and discussed further in Chapter 3, the NBA includes two headline indicators: ecosystem threat status and ecosystem protection level. The results of the assessment of these indicators across all environments are shown in Figure 5 and Figure 6 and referred to in some of the highlights below.

This chapter and those that follow highlight challenges that need urgent attention (for example that wetlands are South Africa's most threatened ecosystems), as well as positive findings and successes (for example that many ecosystems are still intact, and the protected area network has been expanded to provide protection for more ecosystems). All of these findings should be viewed in the context of South Africa's exceptional endowments of biodiversity assets and ecological infrastructure. On balance, there is immense opportunity to unlock the value of biodiversity and ecosystems in support of the country's development agenda, especially as the knowledge base on the value of ecosystems and how to manage them effectively expands.

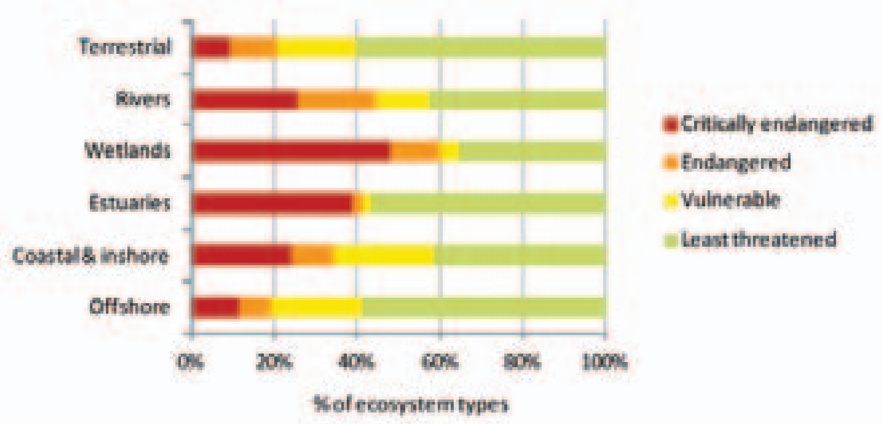


Figure 5.—Comparison of threat status for terrestrial, river, wetland, estuarine, coastal and inshore, and offshore ecosystems. Wetlands are the most threatened of all South Africa's ecosystems, with 48% of wetland ecosystem types critically endangered (see highlight #1).

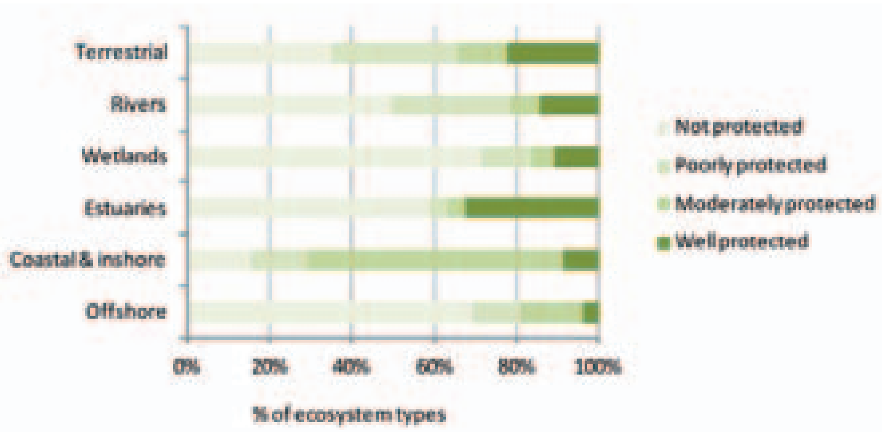


Figure 6.—Comparison of protection levels for terrestrial, river, wetland, estuarine, coastal and inshore, and offshore ecosystems. Offshore ecosystems are the least protected of all South Africa's ecosystems, with only 4% of offshore habitat types well protected (see highlight #6).

1. Wetlands are the most threatened of all South Africa's ecosystems, with 48% of wetland ecosystem types critically endangered. Wetlands make up only 2.4% of the country's area.

The analysis of ecosystem threat status in the NBA 2011 shows for the first time that wetlands are the most threatened of all South Africa's ecosystems, as summarised in Figure 5. Previously it has not been possible to assess the threat status of wetland ecosystems because of inadequate data. Many of South Africa's wetlands have already been irreversibly lost, and the approximately 300 000 remaining wetlands make up only 2.4% of the country. This small area represents high-value ecological infrastructure that provides critical ecosystem services such as water purification and flood regulation. Investing in keeping wetland ecosystems healthy is likely to generate disproportionately large returns in terms of water quantity and quality and climate change adaptation. See Chapter 6 for more.

2. High water yield areas are South Africa's water factories and are of strategic importance for water security. They make up less than 4% of the country's area but only 18% have any form of formal protection.

High water yield areas are subcatchments in which mean annual runoff is more than three times greater than in the related primary catchment. In a water scarce country like South Africa, where water availability is a constraint on socio-economic development, high water yield areas are of national strategic significance. Currently only 18% of high water yield areas have any form of formal protection, in spite of their strategic importance for water security. Options for extending and strengthening protection of high water yield areas, such as declaring parts of them as Protected Environments in terms of the Protected Areas Act, should be explored. See Chapter 12 for more.

3. River tributaries are generally in better condition and less threatened than main rivers, which tend to be harder working. Keeping tributaries healthy will help to improve and maintain the quality and quantity of water supplies.

In 2004 we were able to assess ecosystem threat status for main rivers only, because of lack of data on the condition of tributaries. The assessment in 2011 has revealed that tributaries are generally better off than larger rivers, with 46% of main river ecosystems critically endangered compared with 25% of main rivers and tributaries combined. Healthy tributaries play a critical role in keeping main rivers at least in a functional state, for example by flushing pollutants and restoring natural flow pulses when they meet up with a main river, thereby contributing to the quantity and quality of water supplies. See Chapter 5 for more.

4. Coastal and inshore marine ecosystems are more threatened than offshore ecosystems. Nearly a fifth of South Africa's coast has some form of development within 100 m of the shoreline, placing people and property at risk and compromising the ability of coastal ecosystems to buffer the impacts of climate change.

In 2004 we were able to assess ecosystem threat status in the marine environment only at a very broad scale, for 34 marine biozones. In 2011 we have a map of 136 marine and coastal habitat types and much better data on pressures in the marine and coastal environment, making the assessment much more meaningful. Twelve percent of offshore ecosystems are critically endangered compared with 24% of coastal and inshore ecosystems, as shown in Figure 5, reflecting the fact that the coast is more accessible to human activities and indeed a focus for development. Nearly a quarter of South Africa's population lives within 30 km of the coast, and already nearly a fifth of the coast has some form of inappropriate development within 100 m of the shoreline. Such development not only puts people and property directly at risk but also compromises the ability of coastal ecosystems to buffer the impacts of sea-level rise and sea storms, all the more important in the face of climate change. A national coastal biodiversity plan to identify coastal ecosystem priority areas is an urgent priority. See Chapters 8 and 12 for more.


Healthy tributaries support hard-working main rivers, helping to maintain water quality and quantity.

5. St Lucia, South Africa's flagship estuary, is in a poor state and thus unable to fulfil its role as the most important nursery for marine fish on the southeast African coast.

Restoring the health of St Lucia is challenging but feasible, and has been prioritised by the iSimangaliso Wetland Park Authority.

The St Lucia Lake system makes up more than half of South Africa's estuarine area, and forms part of the iSimangaliso Wetland Park, which is a World Heritage Site and an important ecotourism attraction. However, reductions in freshwater flow to the estuary, as a result of the artificial diversion of the uMfolozi River in the 1950s combined with an extended drought in the region, have resulted in St Lucia being closed to the sea for much of the last decade. This means that the estuary is unable to fulfil its role as the most important nursery for marine fish on the southeast African coastline, among other impacts. The iSimangaliso Wetland Park Authority has prioritised the restoration of St Lucia and is implementing a strategy to join the uMfolozi and St Lucia mouths in order to restore the ecological functioning of the system. Restor-

Restoring the health of St Lucia, South Africa's largest estuary, is a national priority.

ing the health of St Lucia is not straightforward, but is feasible and should be seen as a national priority. See Chapter 7 for more.

6. Offshore marine ecosystems are the most poorly protected ecosystems of all South Africa's ecosystems, with only 4% of offshore ecosystem types well protected.

The analysis of ecosystem protection levels in the NBA 2011 shows that offshore marine ecosystems are the most poorly protected of all South Africa's ecosystems, as shown in Figure 6. Offshore ecosystems play a vital role in sustaining fisheries, and marine protected areas are a key tool in the ecosystem approach to fisheries management. Establishing offshore marine protected areas to ensure the continued productivity and integrity of offshore ecosystems is a priority, and will contribute to food and job security in the long term. The recently completed Offshore Marine Protected Area project identified focus areas for offshore marine protection, which could include marine protected areas as well as other spatial management measures. See Chapters 8 and 12 for more.

7. Biodiversity stewardship programmes have been successfully established in the last seven years and are making a significant contribution to meeting national protected area targets, at much lower cost to the state than land acquisition.

In 2004 the term biodiversity stewardship was still new and unfamiliar, with a modest donor-funded pilot project underway to test the feasibility of the biodiversity stewardship concept, and not a single biodiversity stewardship contract yet signed. Just seven years later, biodiversity stewardship programmes are operational in six provinces, 24 provincial contract protected areas have been declared (more than 75 000 ha), another 35 contracts have been signed and are awaiting proclamation, and over 70 more are in negotiation. If all of these are successfully proclaimed, around 430 000 ha will have been added to the protected area network through biodiversity stewardship programmes, achieving over 15% of the 2013 national protected area expansion target of 2.7 million hectares, at a fraction of the cost of the traditional approach of acquiring land. With modest additional resources, biodiversity stewardship programmes have the potential to play an even greater role, and to expand their scope to river, wetland and estuarine ecosystems. See Chapter 4 for more.

8. Rates of loss of natural habitat are high in some parts of the country. For example, in Gauteng, KwaZulu-Natal and North West Province, if current rates of loss were to continue, there would be almost no natural habitat left outside protected areas by 2050. In regions with high rates of conversion of natural vegetation to other land uses, it is especially important to use maps of biodiversity priority areas to guide decisions about where best to locate development.

In the terrestrial environment, conversion of natural vegetation to other land uses, such as cultivation, mining and plantations, is the biggest pressure on biodiversity. Such loss of natural habitat is irreversible. From a national perspective, around 20% of natural habitat in South Africa has been irreversibly lost, most of it in the last century. In some provinces far more than 20% of natural habitat has been lost, and rates of ongoing loss are high. For example, if current rates of habitat loss continue in Gauteng, KwaZulu-Natal and North West, these provinces will have little natural habitat left outside protected areas by about 2050. While further development in these provinces is clearly desirable, it is also important to ensure that natural open spaces and ecological infrastructure are kept intact, so that terrestrial ecosystems can continue to provide ecosystem services and support climate change resilience, and future generations can continue to enjoy the natural spaces and landscapes that are part of our heritage. South Africa is fortunate to have excellent maps of biodiversity priority areas, based on best available science, which can guide decisions about where best to locate development and where it is most critical to keep natural habitat intact. See Chapters 4 and 12 for more.

9. The NBA 2011 provides a new national map of areas that are important for climate change resilience, supporting functional, stable landscapes in the long term. It is important to keep natural habitat intact in these areas.

Analysis undertaken for the NBA has identified areas and features in the landscape that are likely to support resilience of biodiversity to climate change, and combined them to produce a single national map. Keeping these areas in a natural or near-natural state will help ecosystems and species to adapt naturally to climate change, thus supporting healthy landscapes and the ability of ecosystems to continue to provide ecosystem services. Some of these areas also provide more specific, immediate benefits that assist humans directly in coping with the impacts of climate change, known as ecosystem-based adaptation. Further work is needed to determine which ecosystems are most important for ecosystem-based adaptation in South Africa, and to examine the extent to which they overlap with areas important for climate change resilience at the landscape scale. Because a relatively large proportion of South Africa's ecosystems are still in a natural or near-natural state, there are far better opportunities here than in many developed parts of the world to capitalise on options for supporting climate change resilience at the landscape scale. With quick action, it is still possible to conserve the required areas, whereas in many more developed countries that opportunity no longer exists. See Chapter 9 for more.

10. South Africa has over 2 000 medicinal plant species, of which 656 species are traded in medicinal markets. Of these traded species, 56 are threatened. Action is required for threatened medicinal plant species, as well as research and monitoring to ensure that the use of traded species that are currently not threatened is sustainable.

The recently published Red List of South African Plants[6] enables a systematic assessment of the conservation status of all medicinal plant species for the first time. Of more than 2 000 medicinal plant species, 656 are traded in medicinal markets. Of these 656 traded species, 56 (one in 12) are threatened. These threatened medicinal plant species require urgent action if future generations are to continue to benefit from them, for example in the form of Biodiversity Management Plans, exploring options for cultivation, and research on sustainable harvesting practices. Monitoring and research of traded medicinal plant species that are not threatened is needed to ensure that patterns of harvesting are sustainable. See Chapter 10 for more.

11. The total area infested by invasive alien plants in South Africa doubled between the mid-1990s and 2007, and at least R6.5 billion of ecosystem services are lost every year as a result. There is huge scope to scale up natural resource management programmes such as Working for Water, with coupled job creation and ecosystem service benefits.

Cultivation results in irreversible loss of natural vegetation and is one of the main contributors to loss of habitat in South Africa. Others are urban sprawl, mining and plantations.

Invasive alien species are a significant and growing challenge in South Africa and around the world. Addressing this challenge can create opportunities linked to restoring ecological infrastructure, securing the provision of ecosystem services, and creating employment. The Working for Water programme is one of the best-known examples globally of such a response, and without it the loss in ecosystem services would be several times higher. In addition to scaling up the management of established invasive alien plants it is important to invest resources in preventing the introduction of new invasive species to South Africa and eradicating those that are not yet fully established, both of which provide significantly higher returns on investment. See Chapter 11 for more.

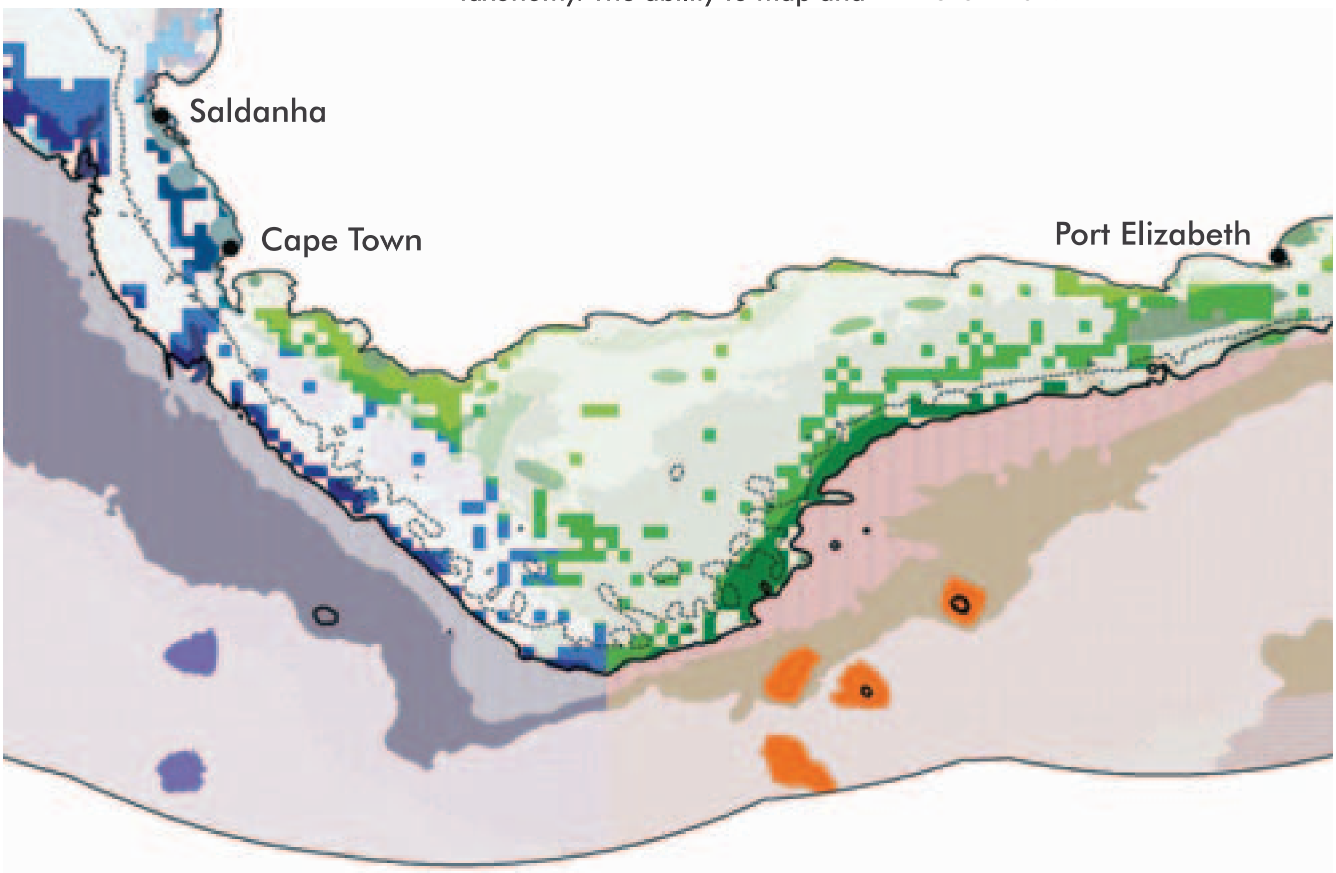
[6] Raimondo, D., Von Staden, L., Foden, W., Victor, J.E., Helme, N.A., Turner, R.C., Kamundi, D.A. & Manyama, P.A. (eds). Red List of South African plants. *Strelitzia* 25. South African National Biodiversity Institute, Pretoria.

About a third of South Africa's 2 000 medicinal plant species are traded in medicinal markets. The traditional medicine trade was estimated to be worth nearly R3 billion a year in 2007 and to employ over 130 000 people

12. Since 2004 there has been significant progress in the science of mapping and classifying ecosystems, laying the foundation for ecosystem-level assessment, planning, monitoring and management. For example, marine and coastal habitat types and wetland ecosystem types have been identified and mapped for the first time, and the estuarine functional zone has been mapped for the first time for all estuaries.

South Africa's national ecosystem classification system has taken strides forward in the NBA 2011, enabling us to assess wetland ecosystems for the first time and to make our assessment of marine, coastal, river and estuarine ecosystems much more meaningful. Mapping and classifying ecosystems is the ecosystem equivalent of identifying, describing and classifying species, known as taxonomy. The ability to map and classify ecosystem types allows us to advance beyond species as the only measure of biodiversity, and assists greatly in taking an ecosystem approach to the management and conservation of biodiversity. The national ecosystem classification system is an essential scientific foundation for ecosystem-level assessment, planning, monitoring and management, and needs to be strengthened and formalised.

These findings, together with other information presented in the NBA 2011, put South Africa in a strong position to invest strategically in biodiversity assets and ecological infrastructure, optimising their contribution to the country's development. Excellent biodiversity information tools, including maps of biodiversity priority areas, are available to assist with development planning and decision-making, as discussed further in Chapter 12. Chapter 12 also looks at priority actions suggested by the findings of the NBA 2011, helping to set the scene for the upcoming revision of the National Biodiversity Strategy and Action Plan.



Marine and coastal habitats were mapped and classified for the first time for the NBA 2011, making an important contribution to South Africa's national ecosystem classification system

3. Ecosystem threat status and protection level

Chapter summary

The two headline indicators assessed in the NBA are ecosystem threat status and ecosystem protection level. Each of them is assessed in a consistent way across all environments, enabling comparison between terrestrial, river, wetland, estuarine, coastal and marine ecosystems.

Ecosystem threat status tells us about the degree to which ecosystems are still intact or alternatively losing vital aspects of their structure, function and composition, on which their ability to provide ecosystem services ultimately depends. Ecosystem types are categorised as critically endangered (CR), endangered (EN), vulnerable (VU) or least threatened (LT), based on the proportion of each ecosystem type that remains in good ecological condition relative to a series of thresholds.

Ecosystem protection level tells us whether ecosystems are adequately protected or under-protected. Ecosystem types are categorised as not protected, poorly protected, moderately protected or well protected, based on the proportion of each ecosystem type that occurs within a protected area recognised in the Protected Areas Act.

The ability to map and classify ecosystems into different ecosystem types is essential in order to assess threat status and protection levels and track trends over time. South Africa has an emerging national ecosystem classification system, including vegetation types, river ecosystem types, wetland ecosystem types, estuary ecosystem types, and marine and coastal habitat types, which provides an essential basis for ecosystem-level monitoring, assessment and planning.

Refinements in methods for assessing the headline indicators and in classification of ecosystem types between 2004 and 2011 mean that we are not able to provide a time series analysis of ecosystem threat status and protection levels for this period. However, we are well placed to assess trends going forward.

This chapter explains how ecosystem threat status and ecosystem protection level, the two headline indicators in the NBA, are assessed. It is the most technical of the chapters in this report. Readers are encouraged to persevere especially with Sections 3.2 and 3.3 as the concepts introduced here lay the basis for the discussion in Chapters 5 to 8. An alternative is to read just Section 3.1.

These headline indicators also feature in the national biodiversity monitoring framework, developed by SANBI in collaboration with partners to guide and coordinate monitoring efforts nationally.

3.1 Introducing the headline indicators

Ecosystem threat status tells us about the degree to which ecosystems are still intact, or alternatively losing vital aspects of their structure, function or composition, on which their ability to provide ecosystem services ultimately depends (see Figure 3 in Chapter 1). Threat status has traditionally been assessed for species, in the form of national or global Red Lists that draw attention to species threatened with extinction (see Chapter 10). It is less usual for threat status to be assessed at the ecosystem level, with South Africa at the forefront of such assessments internationally.[7] Assessing threat status and protection level at the ecosystem scale supports a landscape or seascape approach to managing and conserving biodiversity.

Ecosystem protection level tells us whether ecosystems are adequately protected or under-protected. By protected, we mean included in a protected area recognised by the Protected Areas Act, such as a National Park, Nature Reserve or Marine Protected Area (see Panel 4 in Section 3.3 below). Protected areas are vital nodes in South Africa's ecological infrastructure network, helping to ensure functional landscapes

[7]At the time of writing, South African scientists were contributing to an IUCN-led process to develop globally agreed criteria for identifying a Red List of threatened ecosystems. See Rodriguez, J.P., Rodriguez-Clark, K.M., Bailie, J.E.M., Ash, N., Benson, J., Boucher, T., Brown, C., Burgess, N.D., Collen, B., Jennings, M., Keith, D.A., Nicholson, E., Revenga, C., Reyers, B., Rouget, M., Smith, T., Spalding, M., Taber, A., Walpole, M., Zager, I. & Zamin, T. 2010. Establishing IUCN Red List criteria for threatened ecosystems. *Conservation Biology* 25(1): 21–29.

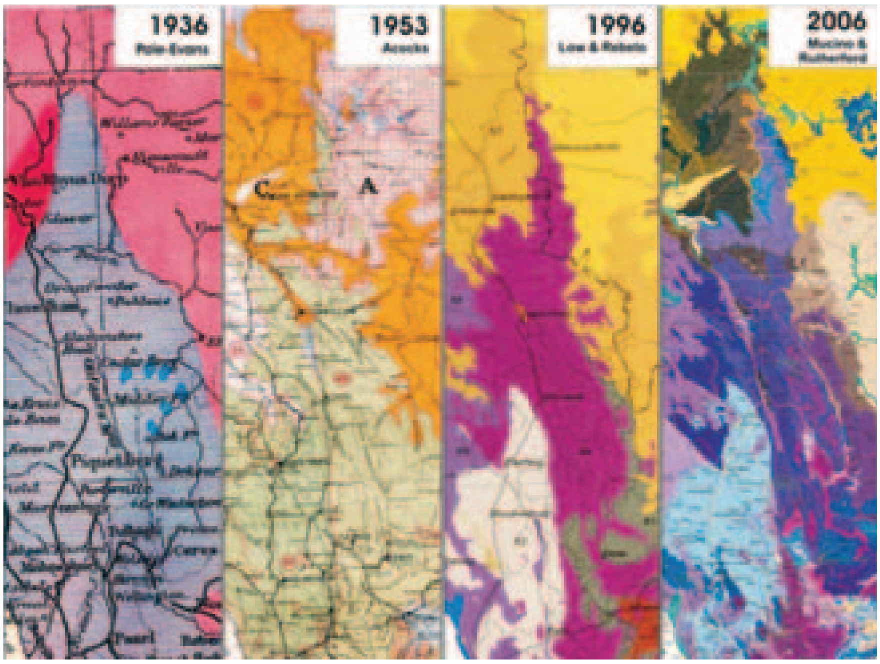
Table 1.—Proportion of land-based, coastal and offshore environments protected, 2004 and 2011

	2004	2011
Land-based*	Nearly 6%	6.5%
Coastline	21.5%** (9.14% no-take)	23.2% (9.26% no-take)
Offshore (mainland EEZ)	0.4% (0.16% no-take)	0.4% (0.16% no-take)
Offshore (Prince Edward Islands EEZ)	0%	0%

EEZ—Exclusive Economic Zone

* Land-based protected areas may protect river, wetland or estuarine ecosystems as well as terrestrial ecosystems, although currently in most cases they are designed primarily to protect terrestrial ecosystems.

** The NSBA 2004 reported that 23% of the coastline was protected. However, this figure included three closed areas that, at that stage, had not been declared as marine protected areas. These closed areas have now been included in the Amathole Marine Protected Area that was proclaimed in late 2011, and make up part of the 23.2% of the coastline reported as protected in 2011.



South Africa has a long history of vegetation mapping in the terrestrial environment. More recently, enormous progress has been made in mapping and classifying aquatic ecosystems, providing an essential foundation for the NBA.

that provide stable environments for human wellbeing as well as a range of other benefits (see Box 5 in Section 3.3 below).

Internationally, the extent of protection is usually reported on simply by giving the overall proportion of land or sea protected. In South Africa, 6.5% of land area, 21.5% of the coastline and less than 1% of the offshore marine environment is protected (see Table 1 and Table 5). However, these figures do not provide any information about which ecosystems are well protected and which are poorly protected. The location of protected areas has historically been driven by a range of factors, mostly unrelated to biodiversity importance, resulting in a protected area network that does not represent all ecosystem types and excludes key ecological processes. This means the protected area network is not as effective at protecting biodiversity and providing ecosystem services as it could be.

Mapping and classifying ecosystems

Assessments of ecosystem threat status and ecosystem protection level both depend on being able to map and classify ecosystem types—the ecosystem equivalent of identifying and classifying species. Mapping and classifying ecosystems is not simple. Ecosystems can be defined in many ways, at different spatial scales (from a garden pond to the Amazon rain forest), and their boundaries are often inherently fuzzy rather than exact.

In spite of these challenges, South African scientists have made great strides in developing hierarchical classification systems for ecosystems in terrestrial and aquatic environments. Progress between 2004 and 2011 has been especially dramatic in the marine environment. The delineation of ecosystems used in the NBA 2011 is presented in more detail in Chapters 4 to 8, and provides an emerging **national ecosystem classification system**[8]—an essential basis for ecosystem-level monitoring, assessment and planning.

[8]Note that this differs from land cover classification. Ecosystems are mapped and classified based on their 'pre-development' extent, independent of current land cover, land use or ecological condition.

Figure 7.—Critically endangered, endangered and vulnerable ecosystem types are collectively referred to as threatened ecosystems, the ecosystem equivalent of threatened species.

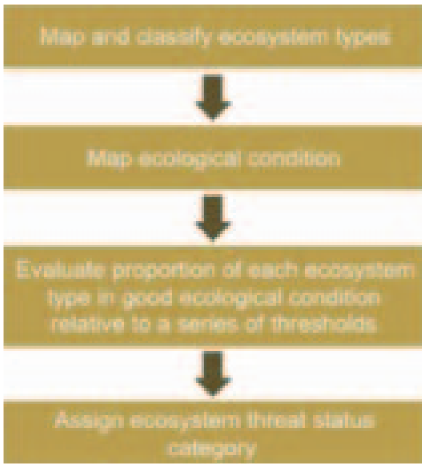


Figure 8.—Main steps in assessing ecosystem threat status, in aquatic and terrestrial environments.

In the absence of detailed data on the interaction between species and their abiotic environments, different ecosystem types have been distinguished in most cases through the use of various bio-physical data layers, which have been combined as proxies or surrogates to represent distinguishing features of different ecosystem types at a national scale. Ecosystems of the same type are likely to share broadly similar ecological characteristics and functioning. See Chapter 13 for more on how the national ecosystem classification system should be further developed.

Biodiversity targets

Assessments of ecosystem threat status and ecosystem protection level also require biodiversity targets to be set for ecosystem types. The biodiversity target is the minimum proportion of each ecosystem type that needs to be kept in a natural or near-natural state in the long term in order to maintain viable representative samples of all ecosystem types and the majority of species associated with those ecosystems.

Biodiversity targets should preferably be based on the ecological characteristics of the ecosystem concerned. For terrestrial ecosystems, the biodiversity target is calculated based on species richness, using the scientifically formulated species-area relationship, and varies between 16% and 36% of the original extent of each ecosystem type. For freshwater, estuarine and marine ecosystems, a standard biodiversity target of 20% of the extent of each ecosystem type is used, until such time as better scientific knowledge and data allows for ecologically differentiated biodiversity targets to be determined. Biodiversity targets may be refined over time as scientific knowledge and data improves.

Ecosystem threat status and ecosystem protection level are assessed independently of each other

The assessment of ecosystem threat status is independent of the assessment of ecosystem protection level. In other words, threat status cannot be inferred from protection level, or the other way around. While threat status and protection level co-vary for some ecosystems, this is not always the case, especially for aquatic ecosystems. For example, an ecosystem type may be least threatened and have no protection, or may be critically endangered and well protected, although this second example is less likely in practice.

3.2 More about ecosystem threat status

As explained above, ecosystem threat status tells us how threatened ecosystems are, in other words the degree to which ecosystems are still intact or alternatively losing vital aspects of their structure, function or composition. Ecosystem types are categorised as critically endangered (CR), endangered (EN), vulnerable (VU) or least threatened (LT), based on the proportion of each ecosystem type that remains in good ecological condition relative to a series of thresholds. CR, EN and VU ecosystem types collectively referred to as threatened, as shown in Figure 7. For definitions of the ecosystem threat status categories, see Panel 3.

How is ecosystem threat status measured?

The main steps involved in assessing ecosystem threat status are broadly equivalent in aquatic and terrestrial environments and are summarised in Figure 8.

Once ecosystem types have been mapped and classified, the next step is to measure and map the condition or ecological integrity of ecosystems, including where ecosystems have been lost or degraded. Changes in the condition of ecosystems are caused by multiple interacting drivers of change, such as land cover change, alteration of freshwater flows, over-harvesting of resources, invasive alien species and climate change. The major drivers of change or pressures on ecosystems differ in terrestrial and aquatic environments, and their relative importance varies considerably amongst ecosystem types. In Chapters 4 to 8 we highlight some of the key pressures in different environments which contribute to deteriorating ecosystem condition. This helps to identify human activities that should be avoided in biodiversity priority areas, as discussed further in Chapter 12.

Measuring and mapping ecological condition is complex, and requires different approaches in terrestrial and aquatic environments. The ability to map ecological condition across the country, not just in a few places, is fundamental to assessing ecosystem threat status and remains a challenge.

For terrestrial ecosystems, spatial data on land cover is used as a proxy or surrogate for ecological condition. For rivers, wetlands and estuaries, the Department of Water Affairs has developed a set of ecological condition categories which are used consistently across the country and take into account a range of factors including flow, inundation, water quality, stream bed condition, introduced instream biota, and riparian or stream bank condition. Known as Present Ecological State categories, they range from A (natural or unmodified) through to F (critically or extremely modified), with clear descriptions linked to each category, as shown in Table 2. This system forms the basis for the ecological condition categories used for river, wetland and estuarine ecosystems in the NBA, with rivers, wetlands and estuaries in an A or B category regarded as being in good ecological condition. For marine ecosystems, ecological condition has not been measured directly in most cases, and is inferred from spatial data on a range of pressures in the marine environment, taking into account how the same pressure may impact differently on different ecosystems.

Methods for assessing the condition of ecosystems in each environment are discussed in more detail in Chapters 4 to 8, and priorities for improving our knowledge in this regard are highlighted in Chapter 13.

Ecological condition can range from natural or near-natural through to extremely modified, and for purposes of the NBA is generally summarised into three categories: good, fair or poor.

In all environments, the proportion of each ecosystem type that remains in good ecological condition is evaluated against a series of thresholds, as shown in Figure 9, to determine ecosystem threat status:

- The first of these thresholds (set at the biodiversity target, often 20%) defines the cut-off for critically endangered ecosystems. Ecosystem types that have less than this proportion of their original extent in good ecological condition are likely to have lost much of their natural structure and functioning, and

Panel 3: Defining ecosystem threat status categories (CR, EN, VU, LT)

The definitions provided here are descriptive rather than legal or technical. They provide a plain English complement to the legal definitions in the Biodiversity Act and the technical thresholds shown in Figure 9.

Critically endangered ecosystems are ecosystem types* that have very little of their original extent (measured as area, length or volume) left in natural or near-natural condition. Most of the ecosystem type has been severely or moderately modified from its natural state. These ecosystem types are likely to have lost much of their natural structure and functioning, and species associated with the ecosystem may have been lost. Few natural or near-natural examples of these ecosystems remain. Any further loss of natural habitat or deterioration in condition of the remaining healthy examples of these ecosystem types must be avoided, and the remaining healthy examples should be the focus of urgent conservation action.

Endangered ecosystems are ecosystem types that are close to becoming critically endangered. Any further loss of natural habitat or deterioration of condition in these ecosystem types should be avoided, and the remaining healthy examples should be the focus of conservation action.

Vulnerable ecosystems are ecosystem types that still have the majority of their original extent (measured as area, length or volume) left in natural or near-natural condition, but have experienced some loss of habitat or deterioration in condition. These ecosystem types are likely to have lost some of their structure and functioning, and will be further compromised if they continue to lose natural habitat or deteriorate in condition. Maps of biodiversity priority areas should guide planning, resource management and decision-making in these ecosystem types.

Least threatened ecosystems are ecosystem types that have experienced little or no loss of natural habitat or deterioration in condition. Maps of biodiversity priority areas should guide planning, resource management and decision-making in these ecosystem types.

* Ecosystem types can be defined as, for example, vegetation types, marine habitats, wetland types, river types, estuary types. See Panel 5, Panel 6, Panel 7, Panel 8 and Panel 9 in Chapters 4 to 8 for more on how ecosystem types are defined.

Table 2.—Present Ecological State categories used by the Department of Water Affairs to describe the condition of South African rivers, wetlands and estuaries. For the NBA, rivers, wetlands and estuaries in an A or B category are regarded as being in good ecological condition

Ecological category	Description
A	Unmodified, natural
B	**Largely natural** with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C	**Moderately modified**. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.
D	**Largely modified**. A large loss of natural habitat, biota and basic ecosystem functions have occurred.
E	**Seriously modified**. The loss of natural habitat, biota and basic ecosystem functions are extensive.
F	**Critically/Extremely modified**. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances, the basic ecosystem functions have been destroyed and the changes are irreversible.

species associated with the ecosystem may have been lost.

- The second threshold (set at the biodiversity target plus 15%, e.g. 35% if the biodiversity target is 20%) defines the cut-off for endangered ecosystems, and indicates ecosystems that are close to becoming critically endangered. It acts as a warning bell.
- The third threshold (usually set at 60%) defines the cut-off point for vulnerable ecosystems. Ecosystem types that have reached this point are likely to have lost some of their structure and functioning, and will be further compromised if they continue to lose natural habitat or deteriorate in condition.

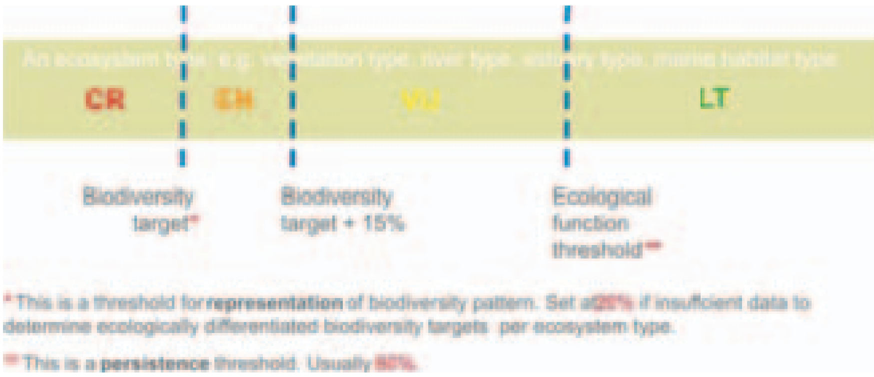


Figure 9.—Thresholds used in assessing ecosystem threat status.

FAQ: Can we report on trends in ecosystem threat status between 2004 and 2011?

Significant advances in mapping and classifying ecosystems, as well as refinement of the thresholds used in the assessment of ecosystem threat status, mean that is it not possible to report on trends in ecosystem threat status between 2004 and 2011. However, having achieved greater stability in ecosystem classification and in assessment methods, we are well positioned to assess trends going forward.

The NSBA 2004 represented the first attempt at assessing ecosystem threat status in South Africa.[9] At that stage we were able to assess marine ecosystems only at an extremely broad scale, and for freshwater ecosystems assessment was possible for main rivers but not for tributaries or wetlands. Advances in mapping and classifying ecosystems and better data on ecological condition mean that we are now able to assess ecosystem threat status for terrestrial ecosystems, main rivers and tributaries, wetlands, estuaries, coastal habitats and marine habitats. At the same time, we have refined the thresholds used in the ecosystem status assessment. These advances mean that ecosystem threat status results in 2004 and 2011 are not comparable, and reporting on trends in ecosystem threat status between 2004 and 2011 is not possible.

Links between ecosystem threat status and listing threatened ecosystems in terms of the Biodiversity Act

The assessment of ecosystem threat status links directly to the Biodiversity Act. Chapter 4 of the Act allows the Minister of Environmental Affairs or a provincial MEC for Environmental Affairs to publish a list of threatened or protected ecosystems, providing

[9]Ecosystem threat status was referred to as 'ecosystem status' in the NSBA 2004.

FAQ: What is the relationship between threatened ecosystems as reported in the NBA and threatened ecosystems listed in terms of the Biodiversity Act?

In cases where a draft or final list of threatened ecosystems has been published by the Minister in the Gazette, the NBA will always reflect the ecosystem threat status as gazetted. The terrestrial ecosystem threat status presented in the NBA 2011 is thus exactly the same as that in the national list of ecosystems that are threatened and in need of protection, published by the Minister in December 2011[10]. This is to prevent the confusion that would arise if there were effectively two lists, a gazetted list and an NBA list, with slight differences. In cases where no list has yet been published by the Minister, such as for all aquatic ecosystems, the ecosystem threat status assessment in the NBA can be used as an interim list in planning and decision-making.

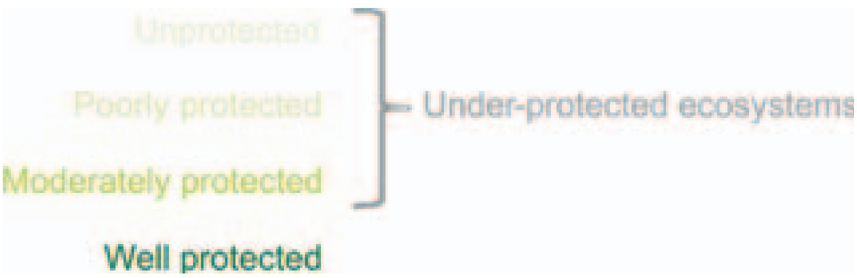


Figure 10.—Unprotected, poorly protected and moderately protected ecosystem types are collectively referred to under-protected ecosystems.

a powerful mechanism to address biodiversity conservation effectively at an ecosystem scale. The ecosystem threat status categories used in the NBA (CR, EN and VU) have deliberately been aligned with the terms and definitions used in the Biodiversity Act. The first list of threatened terrestrial ecosystems was published in the Government Gazette by the Minister in December 2011.[10] Aquatic ecosystems have yet to be listed in terms of the Biodiversity Act.

3.3 More about ecosystem protection level

As explained above, ecosystem protection level tells us the extent to which ecosystems are adequately protected or under-protected. Ecosystem types are categorised as well protected, moderately protected, poorly protected, or not protected. Moderately protected, poorly protected and unprotected ecosystem types are collectively referred to as under-protected ecosystems, as shown in Figure 10.

How is ecosystem protection level measured?

The main steps involved in assessing ecosystem protection level are broadly equivalent in aquatic and terrestrial environments and are summarised in Figure 11.

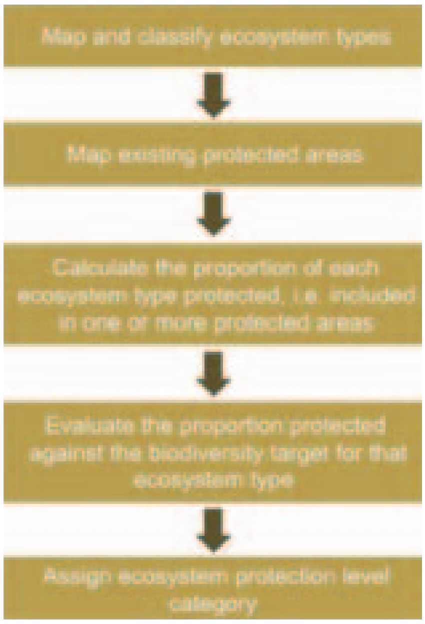


Figure 11.—Main steps in assessing ecosystem protection level, in aquatic and terrestrial environments.

Once ecosystem types have been mapped and classified, the next step is to map existing protected areas (see Panel 4 for a definition of protected areas). Mapping protected areas and keeping the map up to date is less straightforward than it sounds. Protected areas have been proclaimed under a wide range of national and provincial legislation as well as municipal by-laws, dating back many decades, and have often been inaccurately mapped. Boundaries of individual protected areas may change as new land is included or excluded.

A national map of all protected areas in South Africa was compiled for the first time for the NSBA 2004, and updated for the development of the National Protected Area Expansion Strategy 2008. For the NBA 2011, we used the protected area spatial layer developed for the NPAES 2008, which provided the most complete and reliable spatial data available on the protected area network. Ensuring that all protected areas are legally secure, accurately mapped, and included in an up-to-date and complete spatial layer, is a priority. Figure 12 shows land-based and marine protected areas in South Africa.

The proportion of each ecosystem type that falls within a protected area is calculated and compared with the biodiversity target for

[10]Department of Environmental Affairs. 2011. National Environmental Management: Biodiversity Act, 2004: National list of ecosystems that are threatened and in need of protection. *Government Gazette* Number 34809, Notice 1002, 9 December 2011.

Panel 4: Defining protected areas

Protected areas are areas of land or sea that are formally protected by law and managed mainly for biodiversity conservation. Protected areas recognised in the Protected Areas Act are considered formal protected areas in the NBA. The same definition is used in South Africa's National Protected Area Expansion Strategy (NPAES) 2008.

The Protected Areas Act sets out several categories of protected areas: Special Nature Reserves, National Parks, Nature Reserves and Protected Environments. It also recognises World Heritage Sites, Marine Protected Areas, Specially Protected Forest Areas and Mountain Catchment Areas, all of which are declared in terms of other legislation. In the NBA and the NPAES we distinguish between **land-based protected areas**, which may protect both terrestrial and freshwater biodiversity features, and **marine protected areas**.

Protected areas declared in terms of the Protected Areas Act need not be owned and managed by the state. A protected area can be declared on private or communal land, with the landowner recognised as the management authority. This provision has enabled the development of biodiversity stewardship programmes, in which conservation authorities enter into contract agreements with private and communal landowners. The landowner agrees to restrictions on use of the land in return for formal protected area status, an exclusion from property rates, and possible income tax benefits. The conservation authority provides technical advice and management assistance; however, the primary responsibility for management remains with the landowner. Contract protected areas are playing an increasingly important role in protected area expansion—see Chapter 4 for more on this.

It is important to differentiate protected areas from conservation areas. Conservation areas are areas of land not formally protected by law but informally protected by the current owners and users and managed at least partly for biodiversity conservation. Because there is no long-term security associated with conservation areas, they are not considered a strong form of protection. Conservation areas are not considered in the analysis of ecosystem protection levels in the NBA.

The IUCN defines a protected area as a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values. This is a broader definition than the one used in the NBA and the NPAES, as it includes areas that are not legally protected and that we would define in South Africa as conservation areas rather than protected areas.

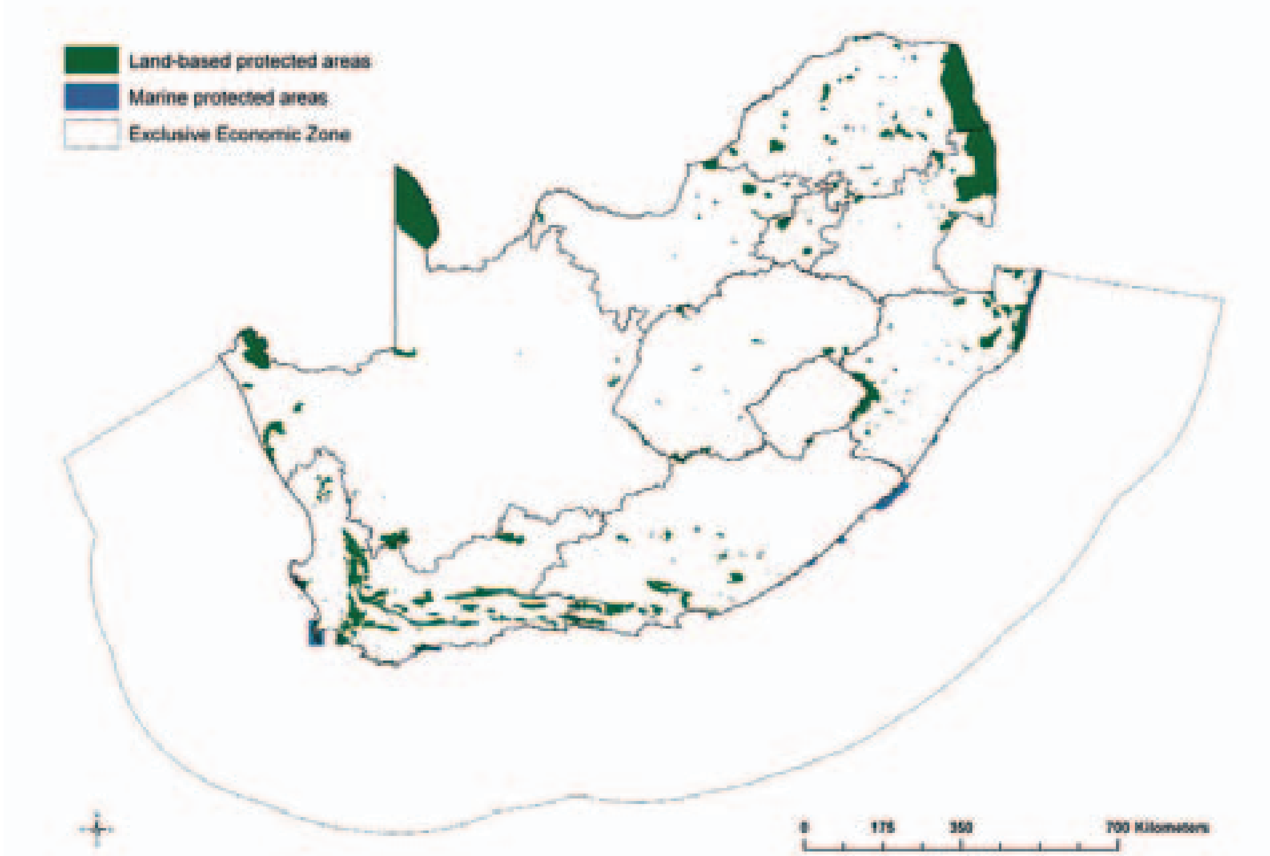


Figure 12.—Land-based and marine protected areas in South Africa.

that ecosystem type, to determine ecosystem protection level, as shown in Table 3. If the full biodiversity target has been met in a protected area, the ecosystem type is considered well protected. If the ecosystem type does not occur in any protected area at all or if less than 5% of the biodiversity target has been met in a protected area, the ecosystem is considered not protected.[11]

In aquatic environments, deciding what is protected and what is not is more complex than for terrestrial ecosystems. For example, rivers and estuaries are subject to influences from the entire catchment, well beyond the boundaries of protected areas, and marine protected areas along the coast can become nodes of activity and exploitation rather than sanctuaries. As a result, an additional step is undertaken in the assessment of ecosystem protection level in

Box 5: Protected areas are national assets

Some of the first protected areas in the world were established in South Africa in the late 1800s, and many protected areas are national icons and a source of pride. Apart from these intangible benefits, protected areas are vital for ecological sustainability and adaptation to climate change, serving as nodes in the country's ecological infrastructure network. They contribute not only to biodiversity conservation and ecological sustainability, but also to climate change adaptation, land reform and rural livelihoods, sustaining fisheries, and socio-economic development more generally.

Table Mountain National Park is an iconic national asset that contributes to the economy of the City of Cape Town.

Through the protection and management that they provide for priority ecosystems and catchments, protected areas help to secure the provision of important ecosystem services, such as production of clean water, flood moderation, prevention of erosion, carbon storage, and the aesthetic value of the landscape. Marine protected areas (MPAs) can play a particularly important role in keeping fisheries sustainable, for example by protecting nursery grounds for commercially important fish species.

Protected areas can support land reform, especially in agriculturally marginal areas, for example through contract agreements in which the land remains in the hands of its owners rather than being transferred to a protected area agency.

Protected areas can support rural livelihoods and contribute to local and regional economies. Especially in marginal agricultural areas, evidence to date suggests that conservation-related industries have higher economic potential than regular agricultural activities such as stock farming. For example, a

[11]For a typical biodiversity target of 20%, a value of more than zero but less than 5% of the biodiversity target means that at most 1% of the original extent of the ecosystem type is protected. Such cases usually occur where a tiny corner or patch of an ecosystem falls just within the boundary of a protected area, or as a result of scale-related inaccuracies in GIS data. Either way, these ecosystem types are effectively not protected.

aquatic environments. For rivers, wetlands and estuaries, if an ecosystem is not in good ecological condition it is not considered to contribute towards the protection level of that ecosystem type even if it falls within the boundary of a protected area. In the marine environment, an ecosystem is considered well protected if its biodiversity target is met in a marine protected area **and** at least 15% of the ecosystem is in a no-take zone within the protected area.

The biodiversity target for an ecosystem should not be confused with the ecosystem's protected area target, which sets a goal for how much of the ecosystem should be included in the protected area network **by a certain date**. The National Protected Area Expansion Strategy 2008 sets five-year and twenty-year protected area targets for each terrestrial ecosystem type, based on a portion of its biodiversity target. The assessment of ecosystem protection level is made in relation to the biodiversity target, not the protected area target which necessarily changes when the NPAES is revised every five years.

Management effectiveness of protected areas

Protected areas need to be well managed in order to conserve ecosystems effectively and deliver the range of benefits highlighted in Box 5. South Africa has adapted the global Management Effectiveness Tracking Tool (METT)

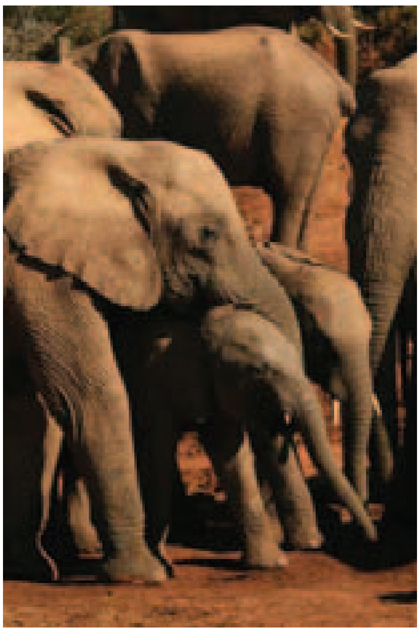
study in the in the Eastern Cape showed that a change from livestock farming to ecotourism resulted in four times the income per hectare and double the number of jobs per 100 ha.* In Namaqualand, anecdotal evidence suggests that the Namaqua National Park creates twice as many jobs as commercial farming on an equivalent area of land. The most valuable rural land in the country outside peri-urban development nodes, based on 2005–2007 land prices, is found on the boundaries of the Kruger National Park, suggesting that game farming and ecotourism provide the most lucrative land-use option in at least some parts of the country.**

The relationship between protected areas and land reform has tended to be a controversial issue, with the focus usually on land claims in existing protected areas. Less attention has been paid to the opportunities for protected area expansion to actively support the land reform agenda and the diversification of rural livelihood options, especially in agriculturally marginal areas. Scope exists for protected area expansion to work in partnership with land reform for mutual benefit, for example through contract agreements which establish nature reserves or other forms of biodiversity stewardship agreement on land that remains in the hands of its owners, rather than being transferred to a protected area agency. The opportunity exists for local communities, as potentially major landholders through the land reform process, to have full access to the economic opportunities associated with ecotourism.

Marine protected areas have a particularly important role to play in helping to sustain fish stocks for commercial, subsistence and recreational fishing. For example, marine protected areas can protect spawning (breeding) grounds and spawning stocks of fish species, allowing for recovery of over-exploited fish species and resulting in improved fishing yields outside marine protected areas through a spill-over effect. Marine protected areas have to be 'no-take' to play this role.

* Sims-Castley, R. 2002. *A preliminary review of gross financial incomes generated by industries dependent on thicket vegetation*. Report No. 37, September 2002. Terrestrial Ecology Research Unit, Nelson Mandela Metropolitan University.

** Philip Desmet, pers. comm.



Protected areas provide protection for species as well as ecosystems.

Marine protected areas such as those in the iSimangaliso Wetland Park are national assets that protect biodiversity, support fisheries management, and contribute to job creation through ecotourism and non-consumptive resource use such as scuba diving, whale watching and turtle tours.

for protected areas, and in 2010 conducted the first national assessment of management effectiveness of state-owned protected areas[12]. The intention is to repeat the assessment every five years. Only land-based protected areas were assessed in 2010, with a recommendation that marine protected areas should be included in the next assessment.

The METT-SA involves self-assessment by conservation authorities and is intended to track progress over time rather than to compare protected areas or conservation authorities. The 2010 assessment highlighted significant management challenges and pointed to the importance of adequate infrastructure, equipment and facilities as determinants of management effectiveness. Invasive alien plants and poaching emerged as the top two threats faced by land-based protected areas. In general, National Parks and World Heritage Sites appeared to be on a more sound management footing than state-owned provincial Nature Reserves.

The state of management of marine protected areas was assessed in 2009 in a study which provides a thorough overview of the legal and institutional framework for marine protected areas as well as some of the key management challenges and priorities[13]. Managing marine protected areas presents particular challenges, and sea-based activities can be difficult and costly to manage. Poaching, intensive recreational fishing, coastal development and pollution are the main current threats to South Africa's marine protected area network.

Management effectiveness of protected areas is not a direct focus of the NBA. However, monitoring of protected area management effectiveness is a complementary tool for the effective management of biodiversity. The fact that ecological condition factors into the assessment of ecosystem protection level means that some aspects of management effectiveness are indirectly considered.

Table 3.—Ecosystem protection level categories and thresholds

Ecosystem protection level	Proportion of biodiversity target met in a protected area
Not protected	Zero or less than 5% of biodiversity target
Poorly protected	5–49% of biodiversity target
Moderately protected	50–99% of biodiversity target
Well protected	>=100% of biodiversity target

FAQ: Can we report on trends in ecosystem protection levels between 2004 and 2011?

The analysis of ecosystem protection levels in the NBA 2011 refined the protection level categories and thresholds used in the NSBA 2004, consolidating from five to four categories. In addition, advances in the delineation of ecosystem types mean that time series comparisons between 2004 and 2011 are not possible in most cases. However, having achieved greater stability in ecosystem classification and in assessment methods, we are well positioned to assess trends going forward.

[12] Cowan, G.I., Mpongoma, N. & Britton, P. (eds) 2010. *Management effectiveness of South Africa's protected areas*. Department of Environmental Affairs, Pretoria.

[13] Tunley, K. 2009. *State of management of South Africa's marine protected areas*. WWF South Africa Report Series – 2009/Marine/001.

4. Terrestrial ecosystems

Chapter summary

Terrestrial ecosystems	• Ecosystem threat status: 40% of ecosystem types threatened • Ecosystem protection level: 22% of ecosystem types well protected, 35% not protected • Key ecosystem services: grazing, pollination, ecotourism and the wildlife industry, medicinal plants • Key pressures: cultivation, urban sprawl, overgrazing, invasive alien plants

Terrestrial ecosystems are critical for food security, protection from natural hazards, and development of economic sectors such as tourism and the wildlife industry, as well as providing a safety net for rural communities where the cash economy is meagre. Healthy terrestrial ecosystems are vital for healthy catchments, which supply South Africa's water. The main pressure faced by terrestrial ecosystems is outright loss of natural habitat as a result of land cover change through, for example, cultivation, mining, forest plantations and urban expansion.

Forty percent of terrestrial ecosystem types are threatened (9% critically endangered, 11% endangered and 19% vulnerable). The Indian Ocean Coastal Belt, Grassland, Fynbos and Forest biomes have the highest proportions of threatened ecosystem types. Threatened terrestrial ecosystems tend to be concentrated in areas that are hubs of economic production, with the remaining fragments of these ecosystems embedded in production landscapes. The remaining natural habitat in critically endangered and endangered ecosystems makes up less than 3% of the country's area.

The threatened terrestrial ecosystems reported in the NBA 2011 are the same as the national list of ecosystems that are threatened and in need of protection published in December 2011 by the Minister of Environmental Affairs in terms of the Biodiversity Act.

Twenty-two percent of terrestrial ecosystem types are well protected. However, 35% remain completely unprotected, highlighting that the protected area network does not yet include a representative sample of all ecosystems. The total extent of the land-based protected area network increased from just under 6% in 2004 to 6.5% in 2011, representing an increase of approximately 10% in the extent of the protected area network. Much of this expansion was focused on under-protected ecosystems, with the Succulent Karoo biome in particular benefiting from inclusion of previously unprotected vegetation types in new or expanded protected areas. The National Protected Area Expansion Strategy 2008 identifies spatial focus areas for further expansion of the land-based protected area network.

A major success story for the protection of terrestrial ecosystems over the last seven years has been the establishment of biodiversity stewardship programmes in several provinces, in which contract protected areas are declared on private or communal land. Conservation authorities enter into contract agreements with landowners who retain title to the land and are recognised as the management authority of the protected area. The cost to the state is a fraction of the cost of acquiring and managing land, making biodiversity stewardship a highly cost effective approach to expanding the protected area network. Twenty-four contract protected areas have been declared through biodiversity stewardship programmes to date, totalling over 75 000 ha, with approximately 360 000 ha more in the pipeline. The limiting factor in declaring further contract protected areas is not lack of willing landowners but rather lack of resources in conservation authorities to take advantage of these opportunities.

This chapter presents the results of the assessment of terrestrial ecosystems, including their threat status and protection levels. It explains how terrestrial ecosystems are defined, discusses their importance and value, and outlines some of the major pressures that impact on their condition. The methods used to assess ecosystem threat status and ecosystem protection level were explained in Chapter 3 and are not repeated in this chapter. More detail is available in the technical report for the terrestrial component of the NBA.

The main basis for defining terrestrial ecosystems in South Africa is the national vegetation map, a draft version of which was used in the NSBA 2004, as discussed in Panel 5.

4.1 Terrestrial ecosystem threat status

As explained in Chapter 3, ecosystem threat status tells us about the degree to which ecosystems are still intact, or alternatively losing vital aspects of their structure, function and composition, on which their ability to provide ecosystem services ultimately depends. Healthy terrestrial ecosystems are essential for human wellbeing (see Box 6), but are under pressure from a range of human activities, especially those that result in outright loss of natural habitat through change in land cover (see Box 7).

Box 6: Terrestrial biodiversity assets support human wellbeing

Economies and societies depend not only upon human and manufactured capital but also upon the store of natural capital found in biodiversity and ecosystems. This capital, which has been banked for millennia, yields a flow of ecosystem services supporting the wellbeing of all citizens. Terrestrial ecosystems provide healthy soils, pollinators and pest control critical for food security, they slow down floods and store water for times of drought, protecting people from natural hazards, and play a vital role in economic sectors such as tourism and the film industry. They also provide a crucial safety net in rural communities providing food, water, forage for livestock and useful plants. Clean water, an ever more critical issue in South Africa, depends not only on healthy rivers, wetlands and estuaries, but also on healthy terrestrial ecosystems surrounding these water bodies. Below are some specific examples of the value of terrestrial ecosystems in South Africa.

The value of natural grazing for livestock in the grassland biome has been calculated to be worth over R8 000/km^2 per year*, while the contribution of wild pollinators (not including managed honey bees) to the Western Cape deciduous fruit industry is worth between US$49 million and US$311 million annually.**

In an urban context, it is estimated that the ecosystem services of natural hazard regulation, tourism and recreation, and support to the film industry provide a benefit of between R1.5 billion and R4 billion per year to people in the City of Cape Town.***

Tourism in South Africa is strongly linked to South Africa's environmental features—protected areas, natural landscapes, wild animals and pristine beaches. The Annual Tourism Report 2005 states that the Total Foreign Direct Spend in South Africa was R56 billion, or R28 billion more than gold exports. This places tourism in a prime position as one of the key economic drivers in South Africa.

The game ranching industry, including hunting, is estimated to generate R7.7 billion a year and provide 100 000 jobs. It is substantially more labour intensive than livestock farming, and has grown at an average rate of 20% a year over the last 15 years.[#] A study in the Eastern Cape found that, for private game reserves, the switch from farming to ecotourism resulted in 4.5 times as many full-time employees and a five-fold increase in the average annual salary for full-time employees, as well as large increases in revenues.[##] This industry is driven by private sector wildlife reserves and depends directly on healthy natural ecosystems.This industry is driven by private sector wildlife reserves and depends directly on healthy natural ecosystems.

Grazing is a valuable service derived from healthy ecosystems, and in many cases is compatible with good biodiversity management

In impoverished rural areas, where the cash economy is a sporadic trickle, natural capital contributes significantly to people's direct daily consumption (such as food, clean water, fuel wood and building material), income generation (such as the sale of medicinal plants and reed mats) and a crucial safety net for households in times of shock or need. This contribution from the natural environment is seldom considered, yet it holds substantial value. Small reductions in ecosystem services can have large welfare impacts.

South Africa's rich variety of plants provides natural medicine (see Chapter 10 for more on medicinal plants). Trade in medicinal plants in South Africa is estimated to be worth nearly R3 billion a year and to employ over 130 000 people, many of whom are rural women. An estimated 27 million South Africans from a wide range of age categories, education levels, religions and occupations use traditional medicine.[###]

In South Africa, the number of people using forest resources (which can come from forest or savanna ecosystems) is in the millions, including rural and urban populations. The direct use of forest resources consumed is worth at least R8 billion per year, a value that is comparable to competing land uses. Between 9 and 12 million people use fuel wood, wild fruits and wooden utensils obtained from forests and savannas.####

* Blignaut, J., Marais, C., Rouget, M., Mander, M., Turpie, J., Klassen, T. & Preston, G. 2008. *Making markets work for people and the environment: employment creation from payment for ecosystem services, combating environmental degradation and poverty on a single budget while delivering real services to real people*. Second Economy Strategy: Addressing Inequality and Economic Marginalisation. An initiative of the Presidency, hosted by Trade and Industrial Policy Strategies (TIPS).

** Allsopp, M.H., De Lange, W.J. & Veldtman, R. 2008. Valuing insect pollination services with cost of replacement. *PLOS One* 3(9): e3128.

*** De Wit, M., Van Zyl, H., Crookes, D., Blignaut, J., Jayiya, T., Goiset, V. & Mahumani, B. 2010. *Investing in Natural Assets. A business case for the environment in the City of Cape Town*. Report for the City of Cape Town.

Steyn, L. 2012. Big bucks for game ranchers. *Mail & Guardian*, 6 January 2012.

Langholz, J.A. & Kerley, G.I.H. 2006. *Combining conservation and development on private lands: an assessment of ecotourism-based private game reserves in the Eastern Cape*. Report no 65 commissioned by the Wilderness Foundation. Centre for African Conservation Ecology, Nelson Mandela Metropolitan University.

Mander, M., Ntuli, L., Diederichs, N. & Mavundla, K. 2007. Economics of traditional medicine trade in South Africa. In S. Harrison, R. Bhana & A. Ntuli (eds), *South African Health Review 2007*. Health Systems Trust, Durban.

Shackleton, C. 2004. *Assessment of the Livelihoods Importance of Forestry, Forests and Forest Products in South Africa*. Unpublished report, Rhodes University.

The NSBA 2004 presented an initial assessment of the threat status of terrestrial ecosystems, which provided the starting point for the development of a list of threatened terrestrial ecosystems for publication by the Minister of Environmental Affairs in terms of the Biodiversity Act (see Section 3.3 in Chapter 3). In the process of developing the list of ecosystems for purposes of the Act, substantial further work was done on a comprehensive set of criteria for assessing ecosystem threat status, discussed further below.

A draft list of threatened ecosystems was gazetted in November 2009 for public comment, and the final list was gazetted in December 2011.[14] As explained in Chapter 3, in cases where a draft or final list of threatened ecosystems has been published by the Minister, the NBA will always reflect the ecosystem threat status as gazetted. The threatened terrestrial ecosystems reported in the NBA 2011 are thus the same as the national list of threatened ecosystems in need of protection published by the Minister in December 2011.

As change in land cover is a major pressure on terrestrial ecosystems, land cover data is used to quantify where natural habitat has been irreversibly lost, providing the basis for mapping ecological condition in the terrestrial environment. The best currently available land cover data nationally is the SANBI mosaic land cover 2009, shown in Figure 13, and available at http://bgis.sanbi.org. It is based on the National Land Cover 2000 (the most recent National Land Cover map available) supplemented with more recent data from provinces and other sources where available.[15] There has been outright loss of natural habitat over 18% of South Africa's land surface, mostly as a result of cultivation of crops (such as maize, wheat and sugar cane), but also mining, forestry plantations and urban development. Most of this loss has taken place in the last century.[16] In some regions the percentage is much higher and the rates of loss are alarming. For example, in North West, Gauteng and KwaZulu-Natal, if loss of natural habitat continues at current rates there will be little natural vegetation left outside protected areas in these provinces by about 2050. See Box 8 for further discussion on this.

The condition of terrestrial ecosystems is impacted not only by outright loss of habitat but also by various forms of vegetation and soil degradation, for example as a result of overgrazing, invasive alien plants or too-frequent fires.

[14]Department of Environmental Affairs. 2011. National Environmental Management: Biodiversity Act, 2004: National list of ecosystems that are threatened and in need of protection. *Government Gazette* Number 34809, Notice 1002, 9 December 2011.

[15]Including the Agricultural Research Council's cultivated fields data, Eskom's building count and informal settlements data, and provincial land cover data from all provinces except Free State, Limpopo and parts of the Northern Cape.

[16]Biggs, R. & Scholes, R.J. 2002. Land-cover changes in South Africa 1911–1913. *South African Journal of Science* 98: 420–424.

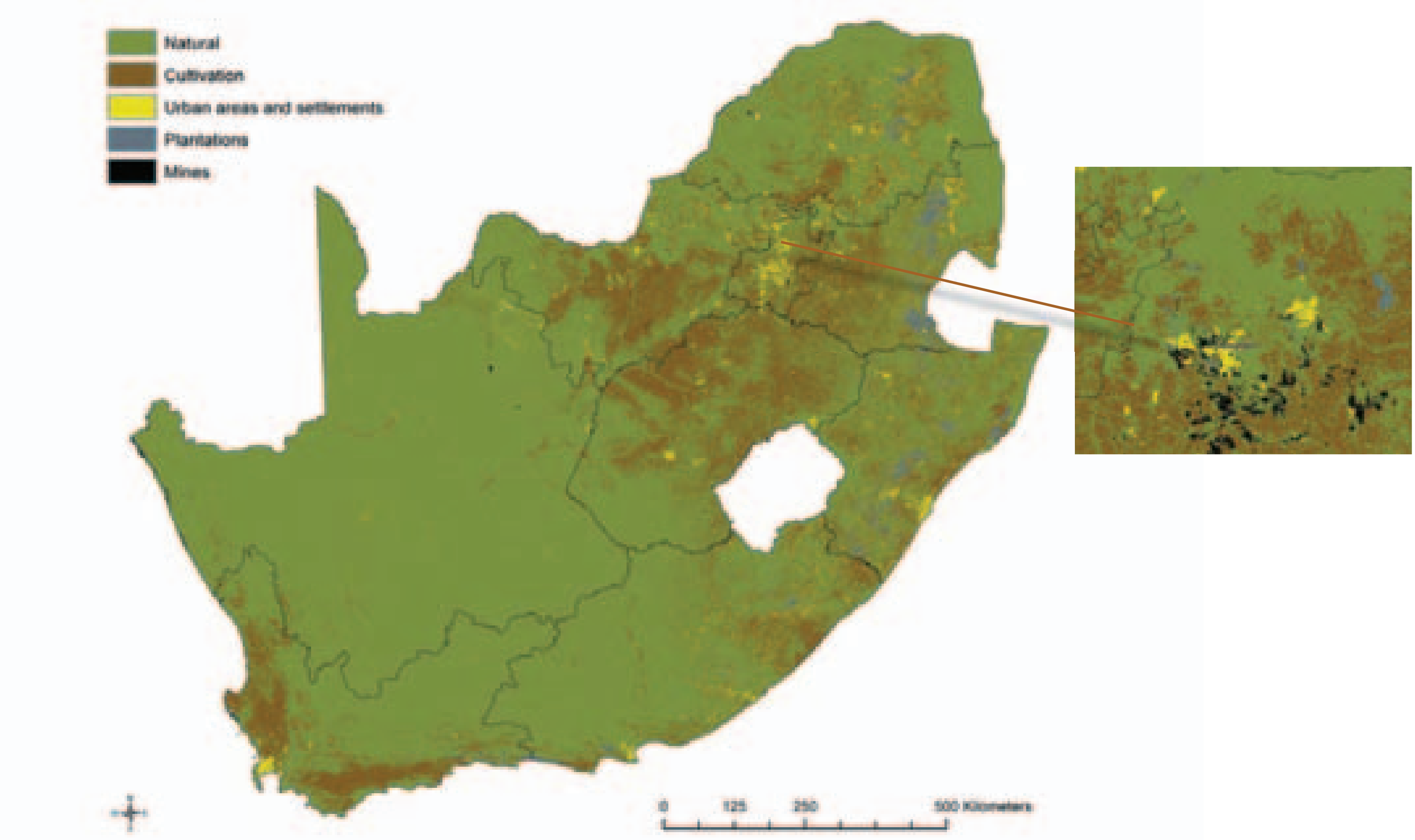


Figure 13.—SANBI mosaic land cover 2009, showing detail for part of Mpumalanga, based on the National Land Cover 2000 supplemented with provincial and other datasets where available. Cultivation, mining, plantations and urban development result in irreversible loss of natural habitat. Degraded areas are not mapped, as there is not yet a nationally consistent or complete map of land degradation at an equivalent scale to the map of land cover.

In some cases ecosystems can recover from moderate degradation if the cause of the degradation is removed, making degradation different from outright loss of natural habitat. There is not yet a nationally consistent or complete map of land degradation at an appropriate scale for this type of assessment, as it is difficult to determine consistent definitions of degradation and to identify degraded areas based on remote images. As a result, we were not able to take degradation into account in mapping the condition of terrestrial ecosystems, and areas that are actually degraded are reflected as being in good ecological condition. This means that the 82% of South Africa that appears as 'natural' in the land cover map in Figure 13 includes substantial areas of degraded habitat and represents an overestimate of ecosystems in good condition. Degradation is a significant problem in South Africa, especially in the more arid ecosystems of the western part of the country. For example, a study in the Little Karoo region of the Western Cape in 2005 found that, in addition to irreversible loss of natural vegetation in 10% of the area, 15% of the area was severely degraded and 37% moderately degraded, mostly as a result of overgrazing.[17]

As noted, loss of natural habitat is more widespread in some areas of the country than others, especially in areas that are hubs of economic production, thus impacting on some ecosystem types to a greater extent than others. This is why it is important not simply to assess the condition of terrestrial ecosystems as a whole, but to take the analysis further to assess the proportion of each ecosystem type that remains in good ecological condition, giving an assessment of ecosystem threat status. See Chapter 3 for more on how ecosystem threat status is calculated. For terrestrial ecosystems, the assessment of ecosystem threat status was based not only on the proportion of each ecosystem type in good ecological condition but also on several additional criteria, including high numbers of threatened plants associated with an ecosystem, very limited extent combined with imminent threat, and, for forest ecosystem types only, levels of severe degradation.[18] The criteria are summarised in Table 4. For a full explanation of the criteria and thresholds used, see the supporting documentation for the published list of threatened terrestrial ecosystems.[14]

[17]Thompson, M.W., Vlok, J., Cowling, R.M., Cundill, S.L. & Mudau, N. 2005. *A land transformation map for the Little Karoo*. Report for a project funded by the Critical Ecosystem Partnership Fund, August 2005.

[18]See the supporting documentation for the published list of threatened terrestrial ecosystems for a full explanation of the criteria and thresholds used.

Panel 5: Defining terrestrial ecosystem types

As noted in Chapter 3, ecosystems can be defined at a range of spatial scales. Their boundaries are often fuzzy rather than precise, making mapping of ecosystems a complex task. In the terrestrial environment, vegetation types provide an excellent way of delineating ecosystems at a relatively fine scale. Vegetation types are based on a range of factors, such as geology, soil types, rainfall, temperature and altitude, which determine the composition and structure of plant communities. They provide a good indication of terrestrial biodiversity other than plant species, because many animals, birds, insects and other organisms are associated with particular vegetation types or groups of vegetation types.

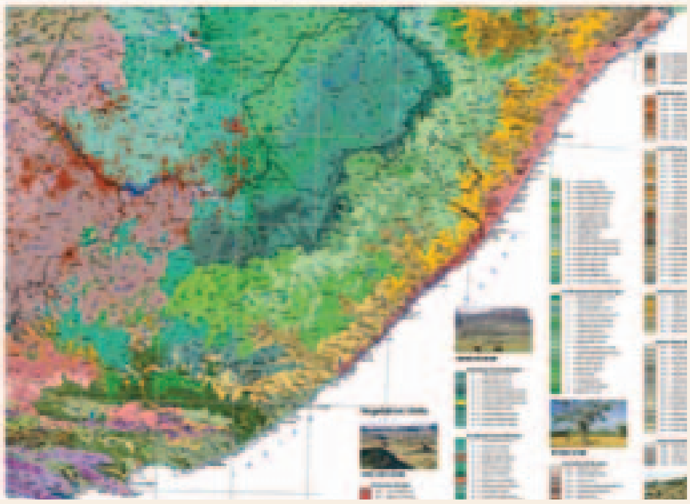


Figure 14.—An example of vegetation types from part of the Eastern Cape. The vegetation map of South Africa, Lesotho and Swaziland provided the main reference for defining terrestrial ecosystems.

South Africa is fortunate to have a long history of vegetation mapping, going back to Acocks' *Veld Types of South Africa* published in 1953.[19] The *Vegetation of South Africa, Lesotho and Swaziland*, published in 2006,[20] maps and describes an agreed set of 438 national vegetation types that provided the main basis for delineating terrestrial ecosystem types in the NBA 2011 (see Figure 14). A draft version of these vegetation types was used in the NSBA 2004. In aquatic environments, in contrast, work on classifying and mapping ecosystem types at the national scale has been more recent (see Panel 6, Panel 7, Panel 8 and Panel 9 in Chapters 5 to 8).

For assessing ecosystem threat status and ecosystem protection level the national vegetation types were supplemented by the 26 national forest types recognised by the Department of Agriculture, Forestry and Fisheries (DAFF).[21] For assessing ecosystem threat status the vegetation types and forest types were further supplemented by finer scale units, giving a total of 567 terrestrial ecosystems.[22]

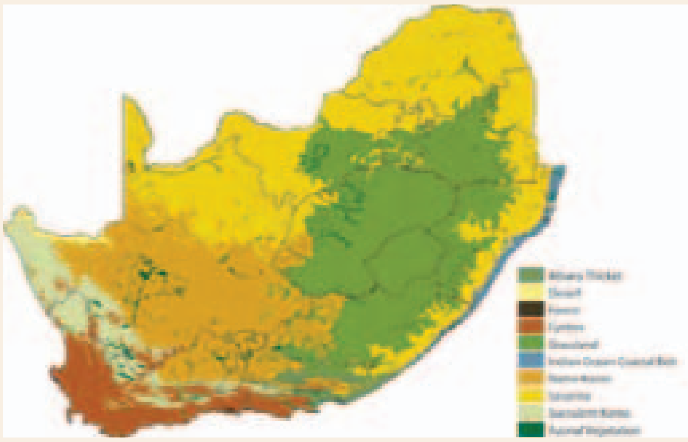


Figure 15.—Biomes in South Africa, Lesotho and Swaziland. Biomes are broad groupings of vegetation types that share similar ecological characteristics. Some biomes have a richer array of vegetation types than others, with the Fynbos biome having the highest number of vegetation types.

Vegetation types can be grouped into biomes, based on shared ecological and climatic characteristics. South Africa has nine biomes: Fynbos, Grassland, Savanna, Albany Thicket, Forest, Succulent Karoo, Nama-Karoo, Desert, and Indian Ocean Coastal Belt (see Figure 15). Some biomes have a richer array of vegetation types than others, with the Fynbos biome being the richest.

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[19]Acocks, J.P.H. 1953. Veld types of South Africa. *Memoirs of the Botanical Survey of South Africa*. No. 28: 1–192.

[20]Mucina, L. & Rutherford, M.C. (eds). 2006. The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia* 19. South African National Biodiversity Institute, Pretoria.

[21]Von Maltitz, G., Mucina, L., Geldenhuys, C., Lawes, M., Eeley, H., Adie, H., Vink, D., Flemming, G. & Bailey, C. 2003. Classification system for South African Indigenous Forests. An objective classification for the Department of Water Affairs and Forestry. *Environmentek Report* ENV-P-C 2003-017, CSIR, Pretoria.

[22]These included high irreplaceability clusters from provincial systematic biodiversity plans (Gauteng C-Plan V2 (2006), Mpumalanga Biodiversity Conservation Plan (2007) and KwaZulu-Natal Terrestrial Conservation Plan (C-Plan) V4 (2007)) and high irreplaceability forest patches or clusters identified by DAFF (Berliner, D. 2005. *Systematic conservation plan for the forest biome of South Africa: Approach, methods and results of the selection of priority forests for conservation action*. Department of Water Affairs and Forestry, Pretoria).

Table 4.—Criteria used to identify threatened terrestrial ecosystems, with thresholds for critically endangered (CR), endangered (EN) and vulnerable (VU) ecosystems

Criterion	CR	EN	VU
A1: Irreversible loss of natural habitat	Remaining natural habitat ≤ biodiversity target	Remaining natural habitat ≤ (biodiversity target + 15%)	Remaining natural habitat ≤ 60% of original area of ecosystem
A2: Ecosystem degradation and loss of integrity*	≥ 60% of ecosystem significantly degraded	≥ 40% of ecosystem significantly degraded	≥ 20% of ecosystem significantly degraded
B: Rate of loss of natural habitat**			
C: Limited extent and imminent threat*	--	Ecosystem extent ≤ 3 000 ha, and imminent threat	Ecosystem extent ≤ 6 000 ha, and imminent threat
D1: Threatened plant species associations	≥ 80 threatened Red Data List plant species	≥ 60 threatened Red Data List plant species	≥ 40 threatened Red Data List plant species
D2: Threatened animal species associations**			
E: Fragmentation**			
F: Priority areas for meeting explicit biodiversity targets as defined in a systematic biodiversity plan	Very high irreplaceability and high threat	Very high irreplaceability and medium threat	Very high irreplaceability and low threat

* Owing to data constraints, Criteria A2 and C were applied to forests but not to other vegetation types.

** Owing to data constraints, Criteria B and D2 are dormant at this stage and thresholds have not been set for these criteria. Further testing of Criterion E is needed to determine whether it is a workable criterion for terrestrial ecosystems.

Box 7: Key pressures on terrestrial ecosystems

Terrestrial ecosystems face pressures from a range of human activities, including loss and degradation of natural habitat, invasive alien species, pollution and waste, and climate change.

Loss of natural habitat, for example as a result of cultivation, is the biggest cause of loss of terrestrial biodiversity and is almost always irreversible.

Loss of natural habitat is the biggest single cause of loss of biodiversity and ecosystem functioning in the terrestrial environment. Outright loss of natural habitat takes place mainly as a result of conversion of natural vegetation for cultivation, mining, plantation forestry, infrastructure development and urban development, which means that patterns of land use have a great impact on the health and functioning of terrestrial ecosystems. Together with loss of natural habitat goes fragmentation of natural areas that remain, which impacts on their ecological functioning and viability, particularly in the context of climate change. See Box 8 below for more on rates of loss of natural habitat in parts of South Africa.

Degradation of natural habitat, for example as a result of overgrazing or inappropriate fire regimes, is also a significant pressure on terrestrial ecosystems, leading to loss of ecological integrity. Depending on how severe the degradation is and the characteristics of the ecosystem concerned, ecosystems may be able to recover from degradation in some cases if the cause is removed. Arid ecosystems generally take longer to recover from degradation.

A degraded ecosystem, for example as shown here on the left hand side of the fence, may be able to recover if the cause of the degradation is removed.

Invasive alien species, especially invasive alien plants, are a major problem in the terrestrial environment. They displace indigenous species, disturb habitats, and disrupt ecosystem functioning, transforming the ecology of the area they inhabit. The consequences are not only ecological but often also economic, for example, when invasive plants reduce the productivity of rangelands and increase the risk and severity of fire, or when invasive insects damage crops. See Chapter 11 for more on invasive alien species.

Waste generated by mining, agriculture, manufacturing and urban settlements generates **water pollution, soil pollution and air pollution**, impacting on ecosystems, species and ecological processes, often substantial distances away from the original pollution source. The average amount of waste generated per person per day in South Africa is closer to the average for developed countries than developing countries, and hazardous waste does not always receive proper treatment or disposal.

Climate change is likely to impact substantially on terrestrial ecosystems and species, and to exacerbate the impacts of other pressures such as habitat loss and fragmentation, overgrazing, incorrect fire regimes and invasive alien species. The cumulative impacts of loss and degradation of natural habitat, invasive species and climate change need to be looked at together when considering the future health and functioning of terrestrial ecosystems.

Loss and degradation of terrestrial ecosystems impacts in many cases on the ecological condition of rivers, wetlands and estuaries, especially if the loss takes place close to these aquatic ecosystems. Buffers of healthy natural vegetation along riverbanks and around wetlands and estuaries, even heavily used ones, can go a long way to reducing the effects of damaging land-use practices elsewhere in the catchment, thus helping to maintain the integrity of aquatic ecosystems and water resources.

Box 8: High rates of loss of natural habitat in parts of South Africa, including North West, KwaZulu-Natal and Gauteng

As discussed in the chapter and shown in Figure 13, there has been outright or irreversible loss of natural habitat in 18% of South Africa's area, mostly as a result of cultivation, but also mining, forestry plantations and urban development. In some regions the percentage of natural habitat lost is much higher and the rates of loss are alarming. Rates of land cover change have been especially high in three provinces, as discussed below.

A recent study by the North West Department of Economic Development, Environment, Conservation and Tourism used land cover data from 1994 and 2006 to assess the rate of loss of natural habitat in the province. In the 12 year period from 1994 to 2006, 26% of North West's remaining natural vegetation was lost (an average of nearly 100 000 ha per year), leaving only 50% remaining by 2006. Should this rate of conversion of natural vegetation to non-natural land uses continue, there would be **no natural vegetation left in North West province, outside protected areas, by about 2050**.[23]

[23]North West Department of Economic Development. 2011. *Environment, Conservation and Tourism. North West Province: Land Cover Change Detection Analysis: 1994 to 2006. Draft report, June 2011*. North West Department of Economic Development, Environment, Conservation and Tourism, Mmbatho.

Gauteng presents a similar picture. Between 1995 and 2009, 230 000 ha of natural habitat was lost, representing a 13% loss within a 15 year period. Less than 44% of the province remains in a natural or semi-natural state. Much of this remaining natural land is highly fragmented, occurring in disconnected patches, which compromises its ecological functioning and integrity. Given the rates of habitat loss, which appear to be increasing, it is likely that **virtually no natural habitat will remain within Gauteng by 2050**.[24]

Figures for KwaZulu-Natal show a similar trend, with the proportion of natural habitat in the province decreasing from 73% in 1994 to 54% in 2008—a loss of nearly 130 000 ha or more than 1 percent of the province's total area per year. Figure 16 shows this graphically. Should this rate of conversion of natural habitat to other land uses continue, there would be **little natural vegetation left in KwaZulu-Natal, outside protected areas, by about 2050**.[25]

As discussed in Box 7, loss of natural vegetation as a result of change in land cover is the biggest pressure on terrestrial ecosystems, compromising their ability to provide ecosystem services and also impacting on the ecological integrity of catchments, rivers and wetlands. Of course, loss of natural vegetation also has less tangible consequences such as the potential loss of wild iconic landscapes as well as the social and psychological consequences for future generations of having no accessible natural spaces to enjoy. While further development is clearly desirable, especially in a province such as Gauteng that accounts for nearly a third of South Africa's GDP, it is equally desirable to maintain natural open spaces and critical ecological infrastructure in the province to ensure functional settlements and landscapes. As discussed further in Chapter 12, South Africa is fortunate to have excellent maps of biodiversity priority areas, which can guide development decision-making to ensure that appropriate decisions are made about where development is best located and where it is most critical to keep natural habitat intact.

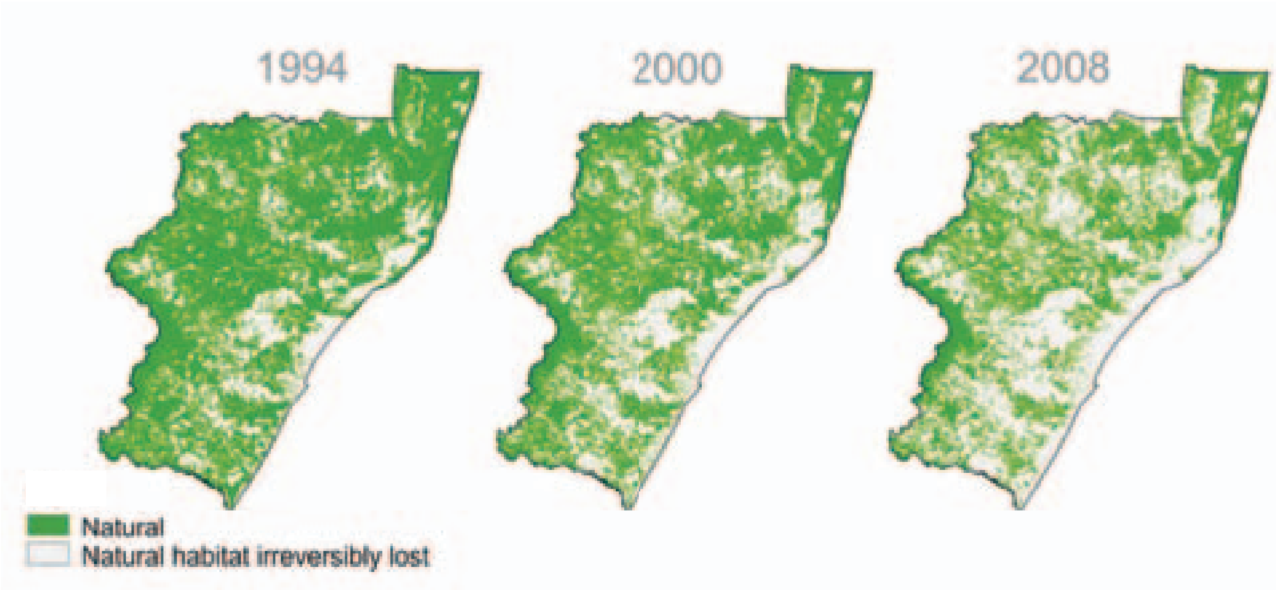


Figure 16.—Remaining natural habitat in KwaZulu-Natal, in 1994, 2000 and 2008. The average rate of conversion of natural vegetation to other land uses over this period was more than one percent of the total area of the province per year. Should this rate of loss continue, there would be little natural vegetation left in KwaZulu-Natal outside protected areas by about 2050. Similar trends are evident in Gauteng and North West Province.

[24]Gauteng Department of Agriculture and Rural Development. 2011. *Gauteng Protected Area Expansion Strategy, Final Report, February 2011*. Gauteng Department of Agriculture and Rural Development, Johannesburg.

[25]Jewitt, D. 2011. KZN Biodiversity Status Assessment Report 2010. Appendix 1: Natural landscapes - extent of transformation. In P.S. Goodman (ed.), *KwaZulu-Natal State of Biodiversity Report 2010*. Unpublished report, Ezemvelo KZN Wildlife, Pietermaritzburg.

Figure 17 shows the map of terrestrial ecosystem threat status. As might be expected, threatened ecosystems are concentrated in and around major cities, in production landscapes and in certain coastal regions. These are areas where outright loss of natural habitat, as a result of activities such as urban development, cultivation, forestry, mining and coastal development, tends to be most extensive. They are often lowlands rather than mountainous regions.

Of South Africa's terrestrial ecosystems, 40% are threatened, with 9% critically endangered,

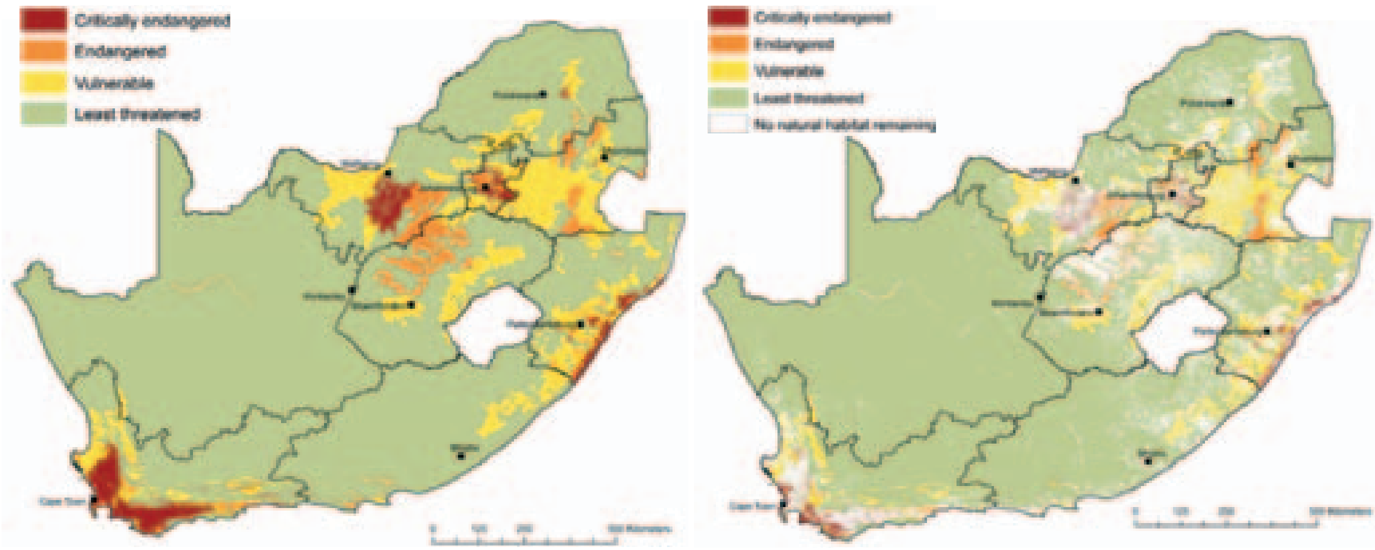


Figure 17.—Map of ecosystem threat status for terrestrial ecosystems, showing (a) original extent of ecosystems, and (b) remaining extent of ecosystems. The remaining natural habitat in critically endangered ecosystems makes up less than 1% of South Africa's area, and in endangered ecosystems just over 2%.

11% endangered and 19% vulnerable, as summarised in Figure 18. In many of these threatened ecosystems very little natural vegetation remains, as shown in Figure 17(b). The remaining natural fragments in critically endangered ecosystems makes up less than 1% of South Africa's surface area, and in endangered ecosystems just over 2% (see Table 5). Ensuring no further loss of the remaining natural vegetation in these highly threatened ecosystems is a priority.

The Indian Ocean Coastal Belt, Grassland, Fynbos and Forest biomes stand out as most threatened, as shown in Figure 19. The Fynbos and Grassland biomes have high numbers of ecosystem types as well as a high proportion of threatened ecosystems. In addition, the Grassland biome, Indian Ocean Coastal Belt and the Fynbos lowlands have high proportions of under-protected ecosystem types, discussed further below.

As discussed earlier, we do not have a comprehensive national picture of the extent of degradation in terrestrial ecosystems. This means that the proportion of ecosystems still in good ecological condition is over-estimated, and the results presented here thus underestimate the number of threatened ecosystems. Developing a national map of degrada-

The Fynbos biome has the highest number of threatened ecosystems in the terrestrial environment. In many of these ecosystems, such as Cape Flats Sand Fynbos (shown here) which occurs in the City of Cape Town, only small fragments of natural habitat remain.

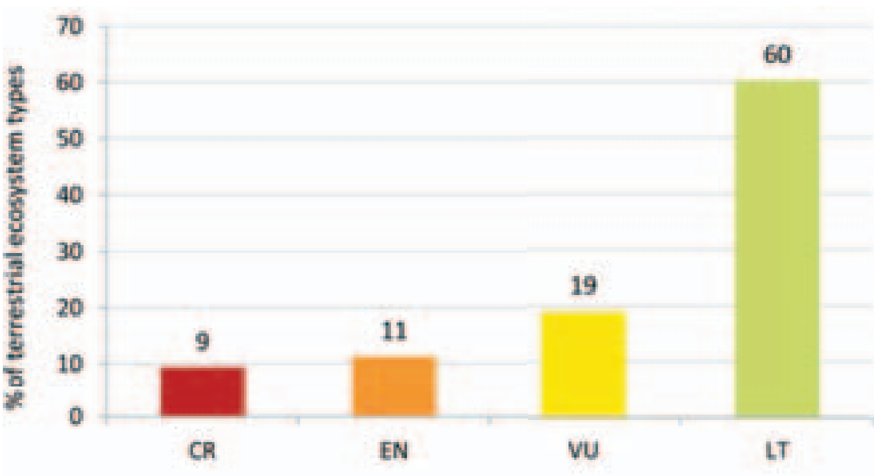


Figure 18.—Summary of ecosystem threat status for terrestrial ecosystem types. The lack of a comprehensive national picture of the extent of degradation in terrestrial ecosystems means that the number of threatened ecosystems is underestimated.

Table 5.—Remaining natural habitat in threatened terrestrial ecosystems, by province. Area figures refer to remaining natural area, not the original extent of the ecosystems concerned. They have been rounded to the nearest thousand hectares so totals may not add up exactly

	CR		EN		VU		TOTAL	
	000 ha	%	000 ha	%	000 ha	%	000 ha	%
Eastern Cape	4	<0.1	51	0.3	588	3.5	643	3.8
Free State	2	<0.1	383	3.0	1 049	8.1	1 433	11.0
Gauteng	99	6.0	95	5.8	189	11.4	384	23.2
KZN	224	2.4	464	5.0	1 164	12.5	1 852	19.9
Limpopo	9	0.1	123	1.0	536	4.3	668	5.3
Mpumalanga	6	0.1	634	8.3	2 226	29.1	2 866	37.5
Northern Cape	--	--	35	0.1	109	0.3	144	0.4
North West	186	1.8	452	4.3	1 309	12.3	1 947	18.3
Western Cape	374	2.9	154	1.2	1 083	8.4	1 611	12.5
South Africa	**903**	**0.7**	**2 392**	**2.0**	**8 252**	**6.8**	**11 547**	**9.5**

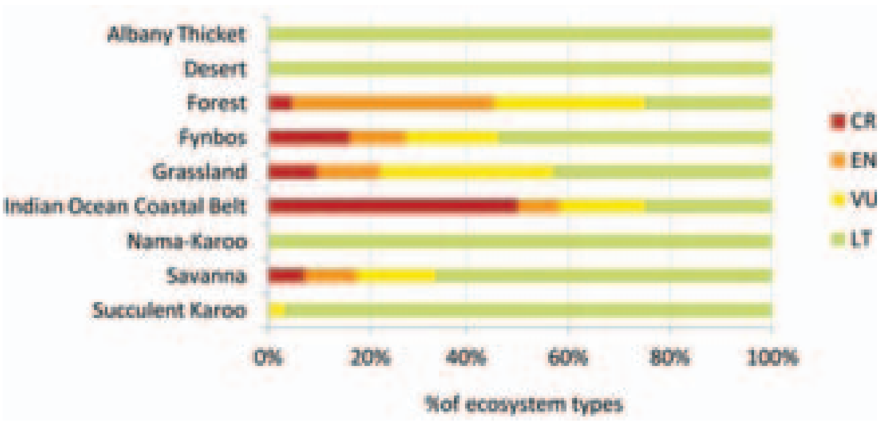


Figure 19.—Ecosystem threat status for terrestrial ecosystem types, by biome. The Fynbos and Grassland biomes have high numbers of ecosystem types as well as a high proportion of threatened ecosystems.

tion remains a priority, as noted in the NSBA 2004 and in Chapter 13.

Although 40% of terrestrial ecosystems are threatened, the majority are doing relatively well, and there are still large tracts of natural habitat that are intact, providing ecological infrastructure and supporting the supply of ecosystem services. Some parts of these least threatened ecosystems are priorities for formal protection; others form part of biodiversity priority areas that should be taken into account in land-use planning and environmental assessment. It is more cost effective to keep biodiversity priority areas healthy than to destroy or degrade them and deal with the consequences later. See Chapter 12 for more on maps of biodiversity priority areas that are available throughout the country and how they should be used.

4.2 Terrestrial ecosystem protection levels

As explained in Chapter 3, ecosystem protection level tells us whether ecosystems are adequately protected or under-protected. By protected, we mean included in a protected area recognised by the Protected Areas Act, such as a National Park or a Nature Reserve (see Panel 4 in Chapter 3).

Overall, the proportion of land area included in the protected area network has increased from just under 6% in 2004 to 6.5% in 2011 (see Table 1 in Chapter 3), representing an increase of approximately 10% in the extent of the protected area network. The levels of protection that this 6.5% of land area provides for terrestrial ecosystems are shown in Figure 20 and summarised in Figure 21. Nearly a quarter of terrestrial ecosystem types are well protected, while 35% have no protection. Figure 22 breaks these results down by biome, showing that the Grassland, Thicket and Nama-Karoo biomes have the highest proportion of under-protected ecosystems. Forest, Desert and Fynbos are the best protected biomes.

However, within the relatively well protected biomes there are sometimes significant differences between ecosystem types. For example, while Fynbos mountains tend to be well protected, lowland ecosystem types within the biome are very poorly protected. Similarly, lowveld Savannas are well protected by the Kruger National Park and arid Savannas by Kgalagadi Transfrontier Conservation Area, but the central bushveld Savannas (largely in central and western Limpopo) are poorly protected.

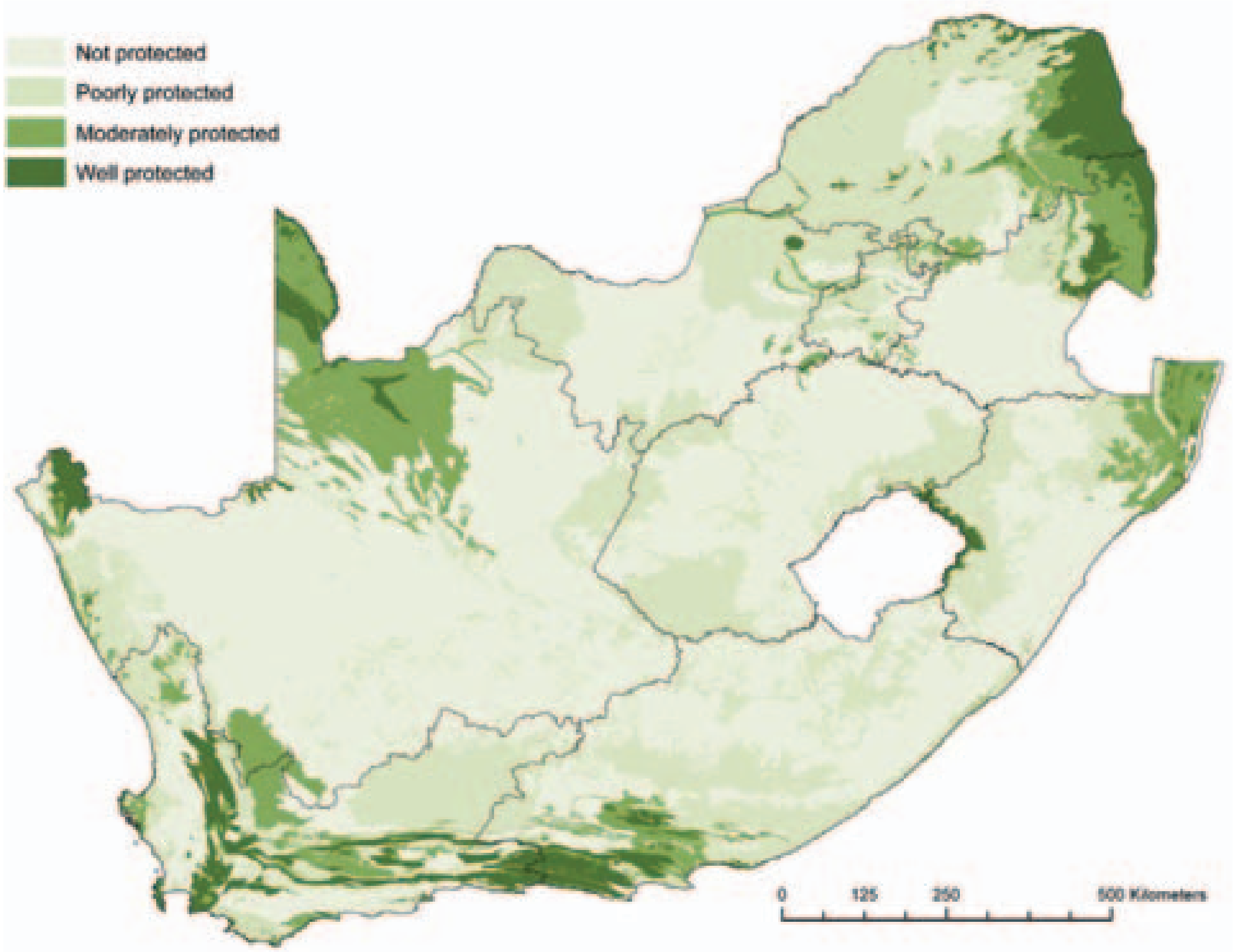


Figure 20.—Map of ecosystem protection levels for terrestrial ecosystems.

While it is not possible to compare ecosystem protection levels strictly between 2004 and 2011 due to differences in the underlying map of ecosystem types, 34 ecosystem types that were under-protected in 2004 are now well protected. An additional 60 ecosystem types have had some improvement in protection level although they are not yet well protected. This points to the fact that where protected area expansion has taken place it has often focused on the right ecosystems. The Succulent Karoo biome in particular has experienced gains in protection levels of several of its vegetation types.

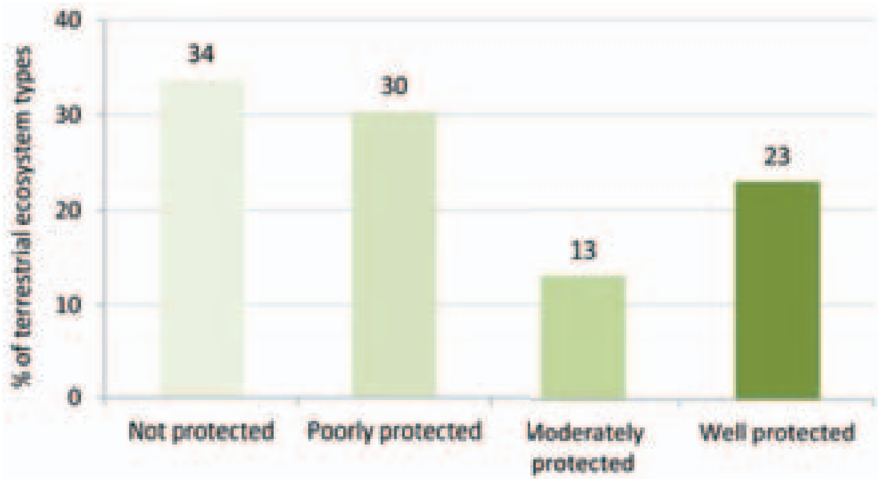


Figure 21.—Summary of ecosystem protection levels for terrestrial ecosystem types.

Some examples of protected area expansion since 2004 include:

- The Mokala National Park, a new state-owned protected area of 23 000 ha including otherwise poorly protected habitat in the Kimberley region of the arid Savanna, which is particularly important habitat for threatened mammal species.
- Expansion of existing state-owned protected areas such as Namaqua National Park in the Succulent Karoo, expanded by 100 000 ha to protect important biodiversity including quartz fields and to provide a climate gradient from the coast to the mountains; Tanqua Karoo National Park, expanded by 73 000 ha, much of which is in the Roggeveld Escarpment,

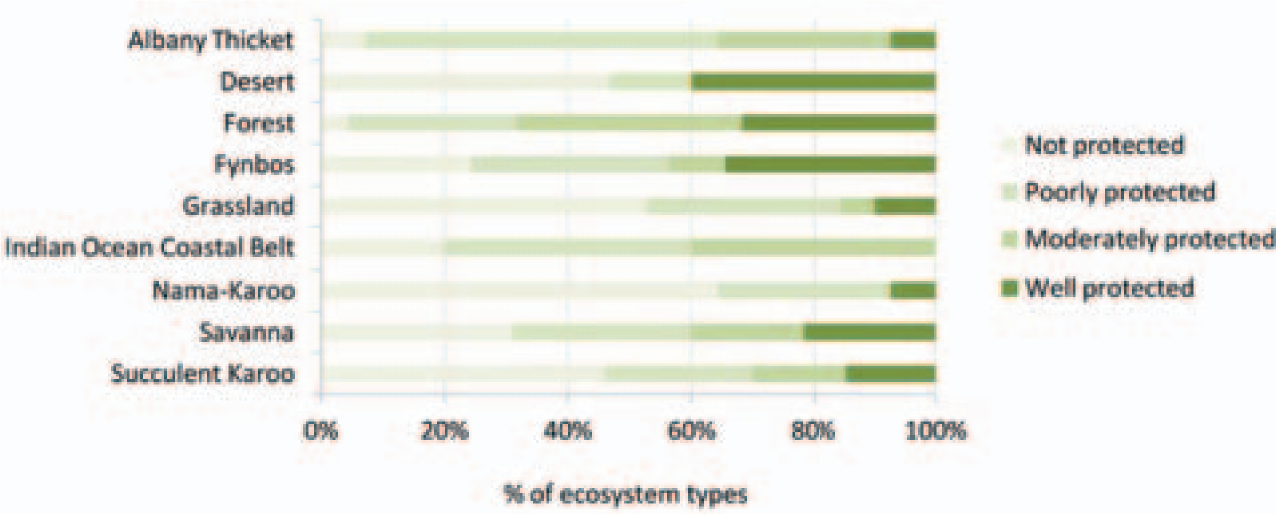


Figure 22.—Ecosystem protection levels for terrestrial ecosystem types, by biome. Within the relatively well protected biomes there are sometimes significant differences between ecosystem types. For example, Fynbos mountains tend to be well protected while Fynbos lowlands are very poorly protected. Similarly, lowveld and arid Savannas are well protected while central bushveld Savannas are poorly protected.

internationally recognised for its bulbous plants; and the Garden Route National Park, which has consolidated previously fragmented conservation efforts on 104 000 ha of Forest and Fynbos including expansion of 36 000 ha.

- Contract protected areas between South African National Parks and private landowners, including 33 000 ha of coastal Succulent Karoo which has been included in the Namaqua National Park, 17 000 ha contracted into the rapidly expanding Addo Elephant National Park, and the 44 000 ha Nuwejaars Wetland Special Management Area which includes important wetlands, renosterveld and lowland fynbos in the buffer of Agulhas National Park. Camdeboo National Park is a new

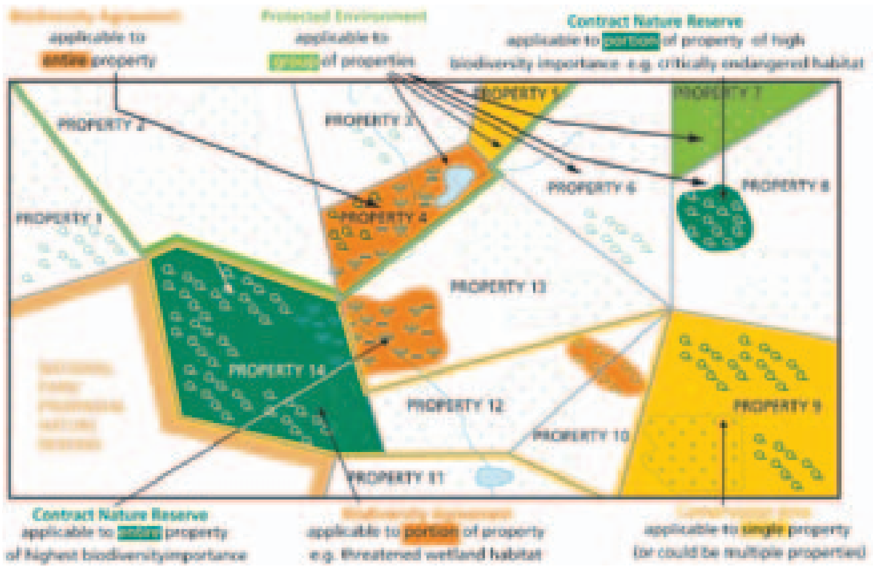
The Grassland biome is one of South Africa's most under-protected biomes. Over 50% of Grassland ecosystem types are not included in the protected area network at all, and only 10% are well protected.

contractual National Park of 15 000 ha in the Graaff-Reinet area.

- Twenty-four contract protected areas declared through provincial biodiversity stewardship programmes, totalling over 75 000 ha, discussed below.

As explained in Panel 4 in Chapter 3, protected areas need not be owned and managed by the state, but can be declared on private or communal land, with the landowner recognised as the management authority. This provision of the Protected Areas Act has enabled the development of biodiversity stewardship programmes, in which conservation authorities enter into contract agreements with private and communal landowners. The landowner agrees to restrictions on use of the land in return for formal protected area status, an exclusion from property rates, and possible income tax benefits. The conservation authority provides technical advice and management assistance; however, the primary responsibility for management remains with the landowner.

Biodiversity stewardship contracts between landowners and conservation authorities are a highly effective mechanism for expanding the protected area network at relatively low cost to the state, and with modestly increased resources could make an even bigger contribution.



A biodiversity stewardship contract can apply to a whole property, a group of properties or a portion of a property.

The establishment of biodiversity stewardship programmes is a major success story for land-based protected area expansion over the last seven years. In 2004 the term biodiversity stewardship was still new and unfamiliar: CapeNature was undertaking a modest donor-funded pilot project to test the feasibility of the biodiversity stewardship concept, and not a single biodiversity stewardship contract had yet been signed.[26] Just seven years later, biodiversity stewardship programmes are operational in six provinces,[27] a Biodiversity Stewardship Guideline is in place, and a national biodiversity stewardship policy is in the process of being approved. In addition to the 24 provincial contract protected areas already declared (totalling over 75 000 ha), another 35 are awaiting proclamation, and over 70 more are in negotiation. If all of these are successfully proclaimed, around 430 000 ha will have been added to the protected area network through biodiversity stewardship programmes, making a significant contribution to the National Protected Area Expan-

[26]South African National Parks has been entering into contract agreements with landowners since the 1980s. However, unlike in more recent provincial biodiversity stewardship contracts, SANParks, not the landowner, was the management authority in most cases.

[27]CapeNature and Ezemvelo KZN Wildlife were the first provincial conservation authorities to establish biodiversity stewardship programmes, followed by Mpumalanga Tourism and Parks Agency, Gauteng Department of Agriculture and Rural Development, Northern Cape Department of Environment and Nature Conservation and Eastern Cape Parks. Free State Department of Economic Development, Tourism and Environmental Affairs is in the process of initiating a biodiversity stewardship programme. A national Biodiversity Stewardship Technical Working Group meets regularly to resolve technical and implementation challenges and to share lessons between provinces.

sion Strategy target of expandingthe land-based protected area network by 2.7 million ha by 2013.

Not only are biodiversity stewardship programmes set to make a significant contribution to meeting protected area targets, they are doing so at a fraction of the cost associated with establishing or expanding traditional state-owned protected areas. Experience to date suggests that biodiversity stewardship contracts are approximately ten times cheaper than acquisition. This is partly because the state does not bear the upfront cost of acquiring the land, and also because the landowners themselves bear most of the ongoing management costs, thus mobilising private resources for public benefit.

A further strength of biodiversity stewardship programmes is that they tend to focus on priority ecosystems for protected area expansion, informed by provincial spatial biodiversity plans (see Chapter 12). Landowners are eligible for contract protected areas only if the land concerned is of high conservation value, with a rigorous science-based process in place to assess this. Landowners who would like to participate in a biodiversity stewardship programme, but whose land is assessed as being of lower conservation value, have the option of entering into a biodiversity agreement with the provincial conservation authority concerned. Such biodiversity agreements are considered conservation areas rather than protected areas (see definitions in Panel 4 in Chapter 3).

Provincial biodiversity stewardship programmes have achieved impressive gains with tiny numbers of staff and small budgets. The limiting factor in declaring new contract Nature Reserves and Protected Environments is not lack of willing landowners but rather lack of human resources in conservation authorities, as one biodiversity stewardship officer can support only a certain number of sites effectively. With modestly increased resources, biodiversity stewardship programmes could make even greater contributions to meeting protected area targets and increasing the protection levels of under-protected ecosystems, with potential for significant contributions to the protection of river, wetland and estuarine ecosystems as well as terrestrial ecosystems. Establishment and roll-out of biodiversity stewardship programmes in all provinces is an urgent priority for supporting cost effective expansion of the protected area network.

5. River ecosystems

Chapter summary

River ecosystems	• Ecosystem threat status: 57% of ecosystem types threatened • Ecosystem protection level: 14% of ecosystem types well protected, 50% not protected • Key ecosystem services: fresh water • Key pressures: abstraction of water and changes in flow, pollution, destruction of river banks, invasive alien plants

River ecosystems are vital for supplying fresh water, South Africa's most scarce natural resource. Rivers store and transport water and, combined with manmade storage and transfer schemes, they bring water to urban and rural areas, irrigate croplands, take away waste and provide cultural and aesthetic services. Healthy tributaries help to maintain natural flow pulses and flush pollutants from hard-working larger rivers, contributing to the quantity and quality of water supplies. Contrary to popular perception, fresh water flowing from rivers out to sea is not wasted but is essential for maintaining healthy estuaries as well as coastal and marine ecosystems and the benefits received from them. The main pressure faced by river ecosystems is the abstraction of water from rivers and other alterations to the timing and quantity of flows, for example as a result of dams or transfer schemes between catchments. In addition, pollution of rivers is a serious and growing problem, often exacerbated by destruction of natural vegetation along river banks which results in irreversible damage to rivers and their ability to provide ecosystem services.

Fifty-seven percent of river ecosystem types are threatened (25% critically endangered, 19% endangered and 13% vulnerable). Tributaries tend to be in better ecological condition than main rivers, so the proportion of threatened river ecosystem types is higher if only main rivers are assessed, with 65% threatened (including 46% critically endangered). The proportion of threatened river ecosystem types is higher among lowland and lower foothill rivers than among upper foothills and mountain streams, reflecting the fact that the intensive agriculture and urban areas are often found in lowlands, as well as the accumulation of impacts on rivers as they flow from source to sea.

Only 14% of river ecosystem types are well protected and 50% are not protected at all. Mountain streams are best protected and lowland rivers have the highest proportion of ecosystem types with no protection. Most land-based protected areas were not designed to protect rivers; however, with some adjustments to their design and management, land-based protected areas could make a much greater contribution to protecting river ecosystems.

High water yield areas are sub-quaternary catchments in which mean annual runoff is at least three times more than the average for the related primary catchment. These areas constitute only 4% of South Africa's surface area and are the water factories of the country. Currently only 18% of them have any form of formal protection. Given their strategic importance for water security, options for formal protection of high water yield areas should be explored, for example declaring them as Protected Environments in terms of the Protected Areas Act.

Because rivers are linear ecosystems and are impacted on by land uses and activities throughout their catchments, protected areas alone will seldom do the full job of protecting river ecosystems. This highlights the importance of integrated water resource management tools provided by the National Water Act, including the ecological reserve, classification of water resources and resource quality objectives, which contribute to the protection of freshwater ecosystems. For all rivers, good land-use practices such as keeping natural vegetation intact along river banks can make a vital difference to their ecological integrity.

This chapter presents the results of the assessment of river ecosystems, including their threat status and protection levels. It explains how river ecosystems were delineated, discusses their importance and value, and outlines some of the major pressures that impact on their condition. The methods used to assess ecosystem threat status and ecosystem protection level were explained in Chapter 3 and are not repeated in this chapter. More detail is available in the technical report for the freshwater component of the NBA.

In the NSBA 2004, 120 preliminary river ecosystem types were assessed, and we noted that the types themselves needed to be refined. At that stage, data on river condition was available only for main rivers, so the assessment was limited to main rivers. In 2011 we have assessed 223 river ecosystem types (see Panel 6), and have included both main rivers and smaller tributaries.[28] The results are thus at a finer spatial

[28]Main rivers are defined as quaternary mainstems, or rivers that pass through a quaternary catchment into a neighbouring quaternary catchment. In situations where no river passes through a quaternary catchment, the longest river in the quaternary catchment is the main river. Tributaries are defined as smaller rivers that feed into the main river within a quaternary catchment.

scale, and provide a more complete picture of the state of river ecosystems. The assessment used data developed for the National Freshwater Ecosystem Priority Areas project (NFEPA), a three-year partnership project that concluded in mid-2011. For more on NFEPA see the Atlas of Freshwater Ecosystem Priority Areas in South Africa[29] and the Implementation Manual for Freshwater Ecosystem Priority Areas.[30]

Box 9: River biodiversity assets support human wellbeing

Water is the lifeblood of the planet. Nothing lives without it. As South Africa's most scarce natural resource, fresh water is a vital element for sustainable economic growth, supporting agriculture, energy generation, industry and forestry, as well as domestic use. Rivers play a critical role in storing and transporting water and, combined with manmade storage and transfer schemes, they bring water to urban and rural areas, irrigate croplands, take away waste and provide cultural and aesthetic services.

As viable options to increase the total amount of fresh water available for use are rapidly exhausted, more emphasis will need to be placed on reducing demand and managing water resources more carefully. This includes paying particular attention to managing and conserving freshwater ecosystems that sustain the water resource and are thus inseparable from it. While most people think of water as coming simply from a tap or dam, the quantity, quality and timing of flows of this resource is in fact shaped and controlled by the health of the ecosystems through which it passes. Healthy river ecosystems constitute part of this irreplaceable ecological infrastructure for water resource management, and provide havens for South Africa's rich biodiversity. For example, in the Cape Floristic Region, palmiet sedge plays a critical role in stabilising river banks, reducing sedimentation and providing a clean and usable water resource.

Irrigation is the biggest use of South Africa's water, supporting a large agricultural sector that provides employment and contributes to food security.

While South Africa has achieved considerable success in providing water infrastructure to all households, many people, particularly in rural areas, still rely directly on run-of-river water. This water serves household consumption, livestock and food gardens. River ecosystems are also a source of useful plant materials, and support a riparian habitat that sustains useful biodiversity throughout the country, such as shade and browsing for livestock in arid areas, poles, reeds and firewood. Healthy river systems are essential for supporting rural communities.

Over 60% of water in South Africa is used for agriculture. Primary agriculture contributes 8% of total employment in South Africa, as well as providing a social welfare net to the most vulnerable in society, especially in rural areas. The agricultural sector is a net earner of foreign exchange and provides commodities for significant downstream value addition in agricultural and manufacturing industries.*

The state of freshwater ecosystems is also linked to the health of estuarine and marine ecosystems. Contrary to popular perception, fresh water flowing out to sea is not wasted but is vital for sustaining many of the ecosystem services received from estuarine, coastal and marine environments. For example, reduced freshwater flow into marine environments can affect plankton feeding communities and the birds, fish and mammals that feed on this concentrated food,** as well as affecting beach formation.***

Healthy rivers support rural and urban economies, serve as critical ecological infrastructure and provide a range of socially relevant ser-

[29]Nel, J.L., Driver, A., Strydom, W.F., Maherry, A., Petersen, C., Hill, L., Roux, D.J., Nienaber, S., Van Deventer, H., Swartz, S. & Smith-Adao, L.B. 2011. Atlas of Freshwater Ecosystem Priority Areas in South Africa. *WRC Report* No. TT 500/11. Water Research Commission, Pretoria.

[30]Driver, A., Nel, J.L., Snaddon, K., Murray, K., Roux, D.J., Hill, L., Swartz, E.R., Manuel, J. & Funke, N. 2011. Implementation Manual for Freshwater Ecosystem Priority Areas. *WRC Report* No. 1801/1/11, Water Research Commission, Pretoria.

vices to all South Africans, from commercial farmers and industrialists to urban and rural communities.

* Department of Agriculture, Forestry and Fisheries. 2010. *Draft integrated growth and development plan, 2011 – 2031*. Department of Agriculture, Forestry and Fisheries, Pretoria

** Van Ballegooyen, R.C., Taljaard, S., Van Niekerk, L., Lamberth, S.J., Theron, A.K. & Weerts, S.P. 2007. *Freshwater flow dependency in South African marine ecosystems: A proposed assessment framework and initial assessment of South African marine ecosystems*. Report No. K.V. 191/07. Water Research Commission, Pretoria.

*** Harris, L., Nel, R. & Campbell, E. 2010. *National beach classification and mapping*. Unpublished report. South African National Biodiversity Institute, Cape Town.

Panel 6: Defining river ecosystem types

South Africa has a great diversity of river ecosystems, from the cool, temperate rivers of the Fynbos to the intermittently flowing rivers of the dry interior to the subtropical rivers of the east coast. The country has had a national map of vegetation types for some time, providing a way of defining terrestrial ecosystems (see Panel 5 in Chapter 4).

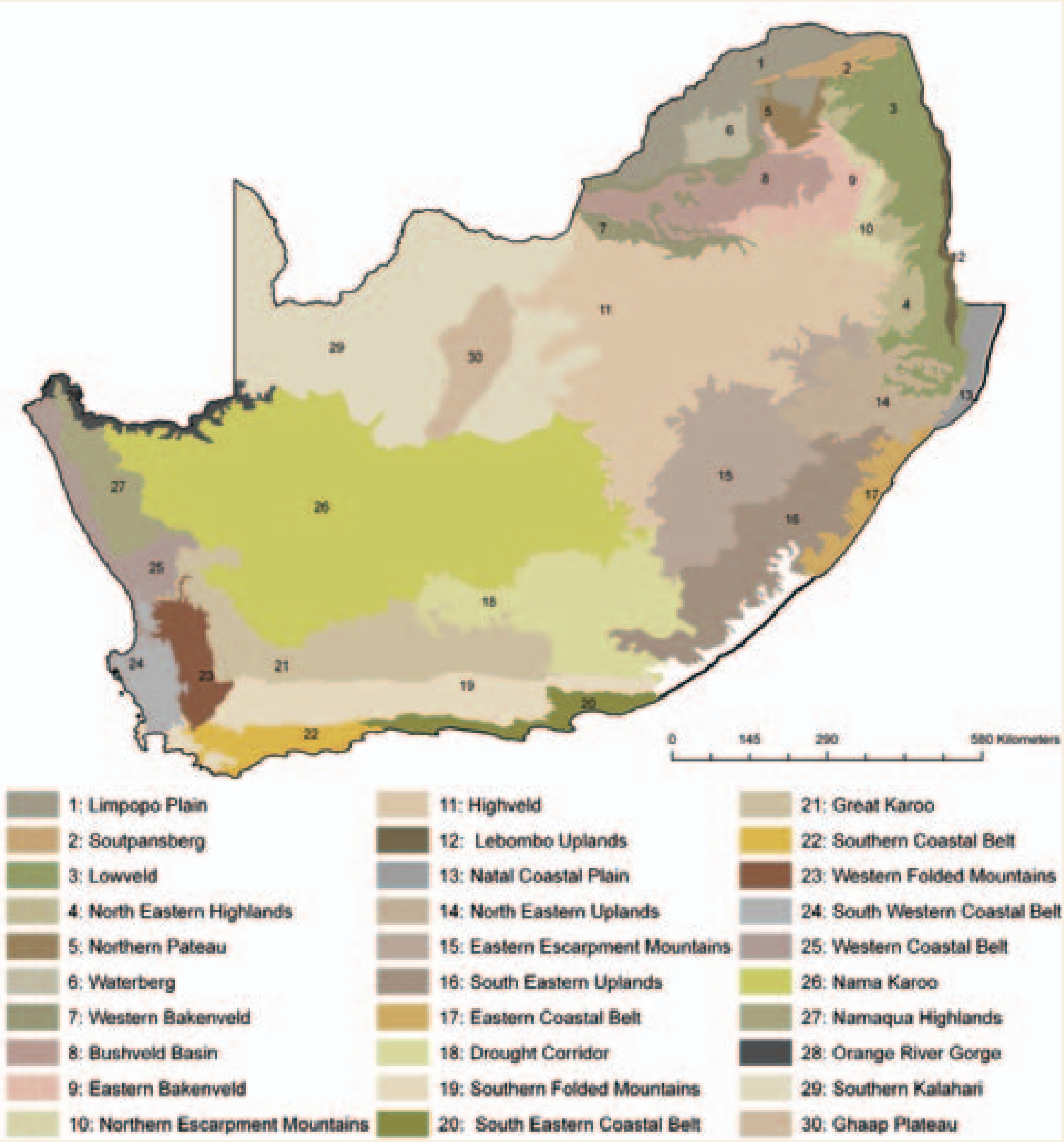


Figure 23.—Level 1 ecoregions of South Africa, one of three factors used to define river ecosystem types.

Now for the first time there is a map of river ecosystem types, developed through the NFEPA project, providing more or less the riverine equivalent of vegetation types.

As noted in Chapter 3, ecosystems can be defined at a range of spatial scales and mapping ecosystems is a complex task, often involving biophysical surrogates for the complex interactions between species and their abiotic environments. River ecosystem types were delineated based on three factors: 31 freshwater ecoregions (e.g. the Highveld which has flat plains and gentle meandering rivers, the Eastern Coastal Belt which has steeply incised rivers and confined valleys—see Figure 23), flow variability (whether a river is perennial, seasonal or ephemeral), and four slope categories (mountain streams, upper foothills, lower foothills and lowland rivers—see Figure 24).

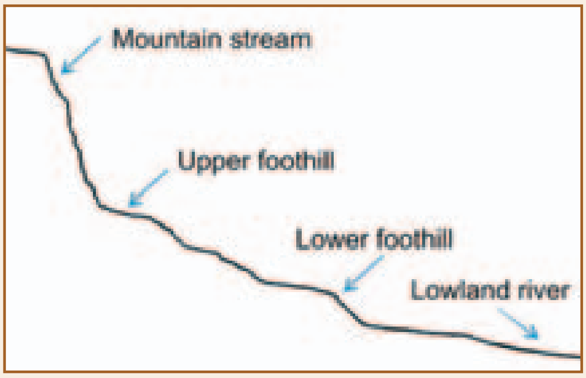
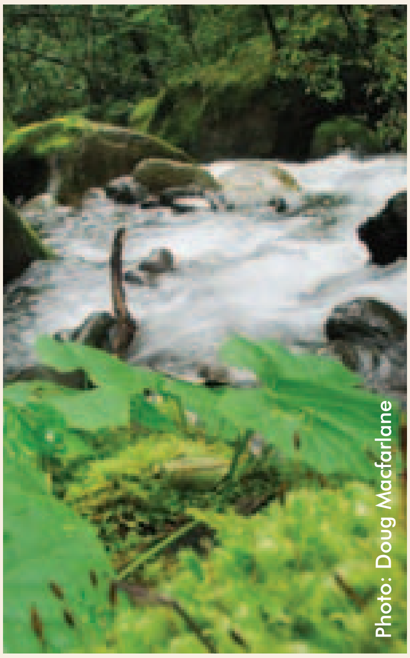
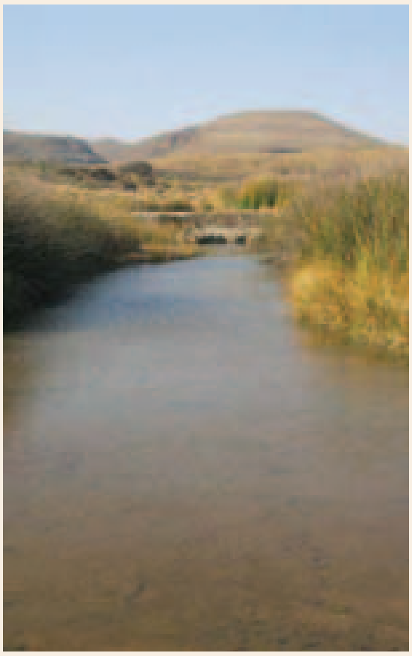


Figure 24.—Schematic showing slope categories for rivers, one of three factors used to define river ecosystem types.

These three factors were combined to identify 223 river ecosystem types that represent the riverine biodiversity of the country. Sections of different rivers that fall within the same river ecosystem type are likely to share broadly similar ecological characteristics and functioning. For more on river ecosystem types see the Atlas of Freshwater Ecosystem Priority Areas in South Africa.[28]

River ecosystem types need to be groundtruthed, and may need to be refined. Biological survey data should be improved and included in this process.



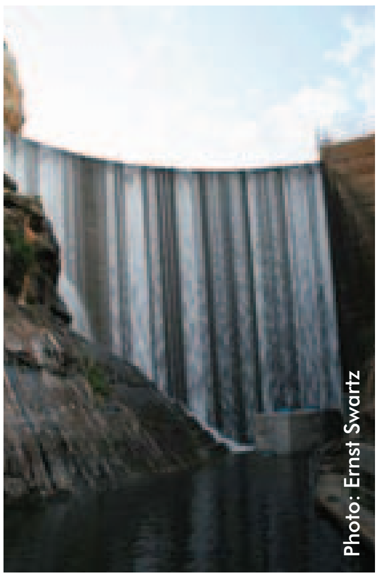


A mountain stream has different ecological characteristics from a lowland river.

Box 10: Key pressures on river ecosystems

Rivers are the lowest point in the landscape, and often the receivers of cumulative impacts from throughout the landscape. Many pressures on river ecosystems interact and exacerbate each other, including alteration of flow, pollution, destruction of river banks, and invasive alien species.

Alteration of flow is one of the biggest pressures on river ecosystems. Flows can be altered by impounding water (e.g. building a dam), by removing water from a river (e.g. for irrigation) or by adding more water through return flows (e.g. from waste water treatment works) or water transfer schemes between catchments. Most large rivers are heavily utilised and large dams have the capacity to store up to two thirds of the country's total annual runoff. Water transfer schemes are widespread across the country to cater for areas where water demand exceeds the natural supply of water. There is also growing concern around the cumulative impact of small farm dams, which have been



Dams alter the flow of rivers, impacting on their ecological functioning.

shown to impact substantially on the quality and quantity of water in South African rivers and can threaten the sustainability and longevity of large dams.

Pollution of water is a serious and growing problem, especially as failing water treatment infrastructure battles to treat the increasing volumes of domestic and industrial effluent from towns and cities. Many industrial processes produce waste containing harmful chemicals that are sometimes discharged directly into sewers, rivers or wetlands. Pollution from agricultural pesticides and fertilizers washing into rivers or leaching into groundwater is a major problem, exacerbated by decreased dilution capacities that result from over-abstraction of water. These problems can increase the salinity and nutrient loads of water resources, processes respectively known as 'salinisation' and 'eutrophication'. Salinisation and eutrophication directly affect human health and the utility of water resources for agriculture and industry.

Destruction of river banks, for example by bulldozing or planting of crops, often results in irreversible damage to freshwater ecosystems and their ability to provide ecosystem services. The strips of natural vegetation along river banks (also called riparian zones) provide a filter that protects rivers, including water quality, from the impacts of land use in the surrounding catchment. It is vital to keep this natural vegetation along river banks intact.

Invasive alien plants impact on river habitat and water yield, consuming an estimated 7% of South Africa's total annual runoff. The Working for Water programme in South Africa has created considerable awareness of the problems associated with invasive alien plant water use. There is less awareness about the problems caused by **invasive alien fish** such as bass and trout, often introduced for aquaculture or recreational fishing, which disrupt ecosystem functioning and are the number one threat to indigenous fish species. (See Chapter 11 for more on invasive alien species.)

Changes in rainfall and temperature as a result of **climate change** are likely to have a large impact on river flows. Keeping freshwater ecosystems healthy will help them adapt to these changes with the least disruption to ecosystem services.

Land management throughout catchments influences the health of river ecosystems. This is why an integrated approach to water resource management and the establishment of effective Catchment Management Agencies is so essential. Water resources cannot be managed in isolation from the land-based activities that surround them.

Eutrophication is caused by increased nutrient loads, for example as a result of fertilizers washing into rivers, and impacts on water quality.

5.1 River ecosystem threat status

As explained in Chapter 3, ecosystem threat status tells us about the degree to which ecosystems are still intact, or alternatively losing vital aspects of their structure, function and composition, on which their ability to provide ecosystem services ultimately depends.

The value of river ecosystems for human wellbeing and the economy is immense (see Box 9). The methods used to assess ecosystem threat status and ecosystem protection were explained in Chapter 3 and apply to all environments. Yet river ecosystems are under pressure from a range of human activities (see Box 10). Because impacts accumulate as one moves downstream, larger main rivers tend to be more heavily impacted than tributaries. Larger rivers also tend to be 'harder working', for example more likely to have dams constructed on them, water abstracted directly from them or pollutants discharged into them. This is reflected in the condition of rivers, shown in Figure 25, with only a third of total length of main rivers still in good ecological condition compared with over half of the total length of tributaries. 'Good ecological condition' is equivalent to the A and B Present Ecological State categories used by the Department of Water Affairs, as discussed in Chapter 3, and takes into account a range of factors including flow, inundation, water quality, stream bed condition, introduced instream biota, and riparian or stream bank condition. Data on the ecological condition of rivers was compiled, updated and reviewed by regional experts as part of the NFEPA project.[29, 30]

A single river ecosystem type can include some river reaches that are in good ecological condition and others that are in poor condition. This is why the NBA does not simply assess the condition of rivers but takes the analysis further to look at the proportion of each ecosystem type that remains in good ecological condition, giving an assessment of ecosystem threat status for river ecosystem types. See Chapter 3 for more on how ecosystem threat status is calculated.

Figure 26 shows the map of river ecosystem threat status for the country. As might be expected, the critically endangered and endangered ecosystem types are con-

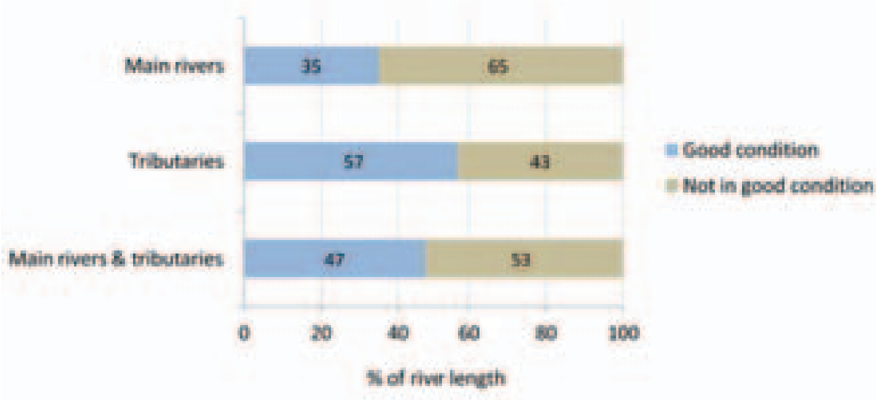


Figure 25.—Percentage of river length in good ecological condition (equivalent to A or B Present Ecological State category), for main rivers and tributaries. Main rivers tend to be harder working and more heavily impacted by human activities than tributaries.

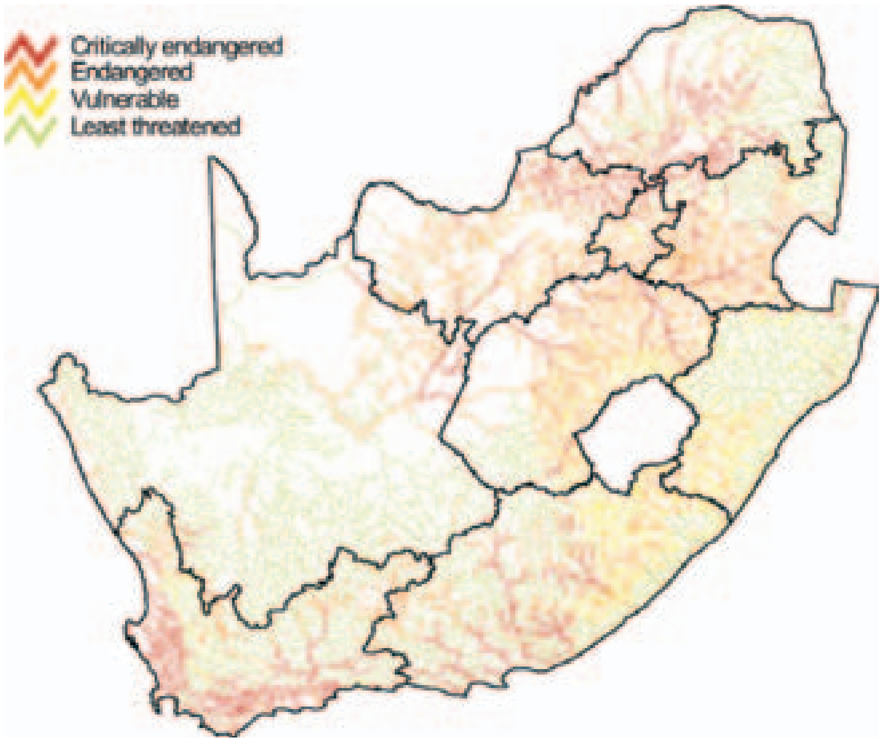


Figure 26.—Map of ecosystem threat status for river ecosystem types. Critically endangered and endangered ecosystem types are concentrated around major cities and in production landscapes, where pressures on water resources are highest and catchments have lost much of their natural habitat.

FAQ: Are threatened river ecosystems safe for human use?

A threatened river ecosystem type is one that has very little of its length remaining in good ecological condition. While the cumulative effect of having many rivers in poor ecological condition means less water of lower quality available for human use, there is no direct link between the ecosystem threat status of a river ecosystem type and the water quality in any particular stretch of river—and in turn how this relates to human health and the safety of drinking water. Even threatened river ecosystem types have some remaining reaches in good ecological condition, and some rivers that are in fair or poor ecological condition may nevertheless provide water that is safe to drink. The ecological condition of a river is based on a range of factors, not all of which are related to water quality and human health. For example, a river ecosystem may be heavily impacted by invasive alien vegetation, but not polluted by dangerous toxins. In summary, this means that there is not a direct relationship between the ecosystem threat status of an individual river and its safety for human use.

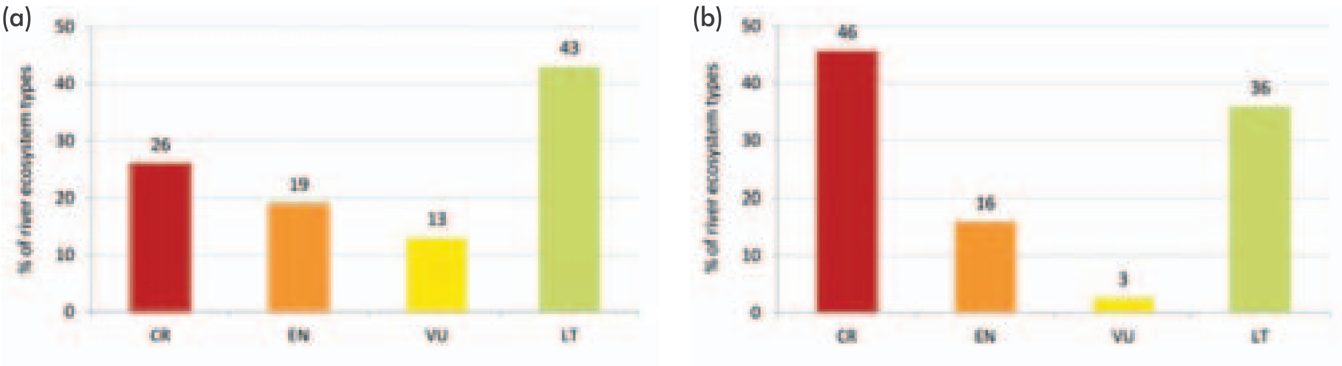


Figure 27.—Summary of river ecosystem threat status for (a) all rivers (main rivers and tributaries combined), and (b) main rivers only. Because tributaries tend to be in better ecological condition than main rivers, the proportion of threatened river ecosystem types is higher if only main rivers are assessed.

centrated around major cities and in production landscapes, where pressures on water resources are highest and catchments have lost much of their natural habitat to land uses such as urban development, cultivation, forestry and mining.

Of South Africa's 223 river ecosystem types, 57% are threatened, with 26% critically endangered, 19% endangered and 13% vulnerable, as summarised in Figure 27a. If the assessment is limited to main rivers, excluding tributaries, as shown in Figure 27b, a higher proportion of river ecosystem types are threatened with a startling 46% critically endangered.

As explained in Panel 6, slope category was one of the factors used to define river ecosystem types. A breakdown of ecosystem threat status by slope category, shown in Figure 28, reveals that the proportion of threatened ecosystem types is higher among lowland rivers and lower foothills than among upper foothills and mountain streams, with 44% of lowland river ecosystem types critically endangered compared to only 13% of mountain stream ecosystem types. This is similar to the finding for terrestrial ecosystems that lowland ecosystems tend to be the most threatened, and reflects that fact that lowlands are often intensively used

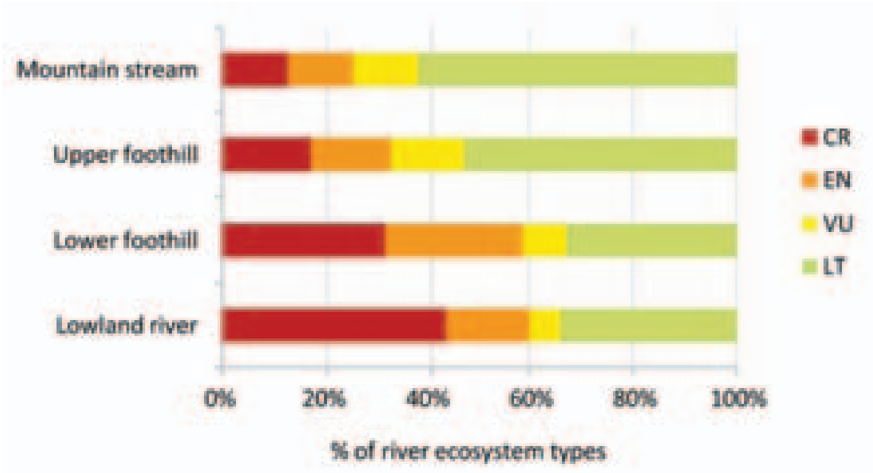


Figure 28.—Ecosystem threat status for river ecosystem types, by river slope category. Lowland rivers have the highest proportion of critically endangered types, reflecting the fact that intensive agriculture and urban areas are often found in lowlands, as well as the accumulation of impacts on rivers as they flow from their source in the mountains to the sea.

landscapes with multiple pressures on ecosystems—lowlands are where the most intensive agricultural and urban areas tend to be found, for example. For rivers, pressures also accumulate from source to sea, so upstream impacts add to the load experienced by the river downstream.

Threatened river ecosystems are not evenly distributed between the country's 19 Water Management Areas.[31] Figure 29 shows that the Berg Water Management Area of the Western Cape has an alarming proportion of critically endangered river ecosystem types, far higher than the rest of the country. Eighty-one percent of its river length is critically endangered compared to the next highest Water Management Area, the Breede, at 50%. Also of concern is the Crocodile (West) and Marico Water Management Area at 49%. Conservation action in these Water Management Areas should focus on maintaining the last remaining rivers that are still in good ecological condition and rehabilitating some of the moderately modified rivers. Maps of Freshwater Ecosystem Priority Areas (see Chapter 12) provide strategic spatial priorities for doing exactly this. Securing healthy rivers, combined with strategic rehabilitation of some rivers, is an excellent investment in maintaining the ecological infrastructure on which the quantity and quality of water supplies depend.

[31]The delineation of Water Management Areas (WMAs) is based on catchments, which means that WMA boundaries do not align with provincial or municipal boundaries. WMAs provide the basis for water resource management structures such as Catchment Management Agencies, which are currently in the process of being established.

Lowland rivers are often heavily impacted, for example by destruction of their banks which has a dramatic impact on ecological functioning and the ability of a river to provide ecosystem services

Although this 2011 assessment of river ecosystem threat status has come a long way from the 2004 assessment, it could be further strengthened. The chief limiting factor, as for terrestrial ecosystems, is data on the condition of river ecosystems. This can be improved through revitalising the River Health Programme, which monitors the condition of rivers around the country, increasing the number of monitoring points to ensure that all river ecosystem types are covered and ensuring sampling at regular intervals (see Chapter 13 for more on this).

5.2 River ecosystem protection levels

As explained in Chapter 3, ecosystem protection level tells us whether ecosystems are adequately protected or under-protected. By protected, we mean included in a protected area recognised by the Protected Areas Act, such as a National Park or a Nature Reserve (see Panel 4 in Chapter 3).

The NSBA 2004 highlighted some of the challenges of assessing ecosystem protection levels for rivers. Rivers are linear systems that seldom fall entirely within the boundaries of a protected area, and are impacted on by activities that take place throughout entire catchments, beyond the boundaries of protected areas. Boundaries of protected areas are frequently demarcated by a river—should such a river be considered protected or not? In spite of these challenges, rivers that flow through protected areas are often in better condition downstream of the protected area than upstream, highlighting the positive impact that good land management can have on river condition and the important role of land-based protected areas in protecting rivers. As explained in Chapter 3, for the purpose of this analysis if a river was not in good ecological condition it was not considered to contribute towards the protection level for that river ecosystem type, even if it fell within the boundary of a protected area, in order to take account of these complex issues of connectivity and catchment impacts.

The NBA 2011 assessed ecosystem protection levels for main rivers and tributaries, and found a pattern similar to that found for main rivers only in 2004. Figure 30 shows the map of river ecosystem protection levels for the country. As summarised in Figure 31, only 14% of river ecosystem types are well protected. Half have no protection, and nearly another third are poorly protected. These results are broken down by river slope category in Figure 32, which shows that mountain streams are best protected, and lowland rivers have the highest proportion of ecosystem types with no protection. As highlighted earlier (see Figure 28), lowland rivers are also the most threatened of the river slope categories. These high levels of threat combined with low

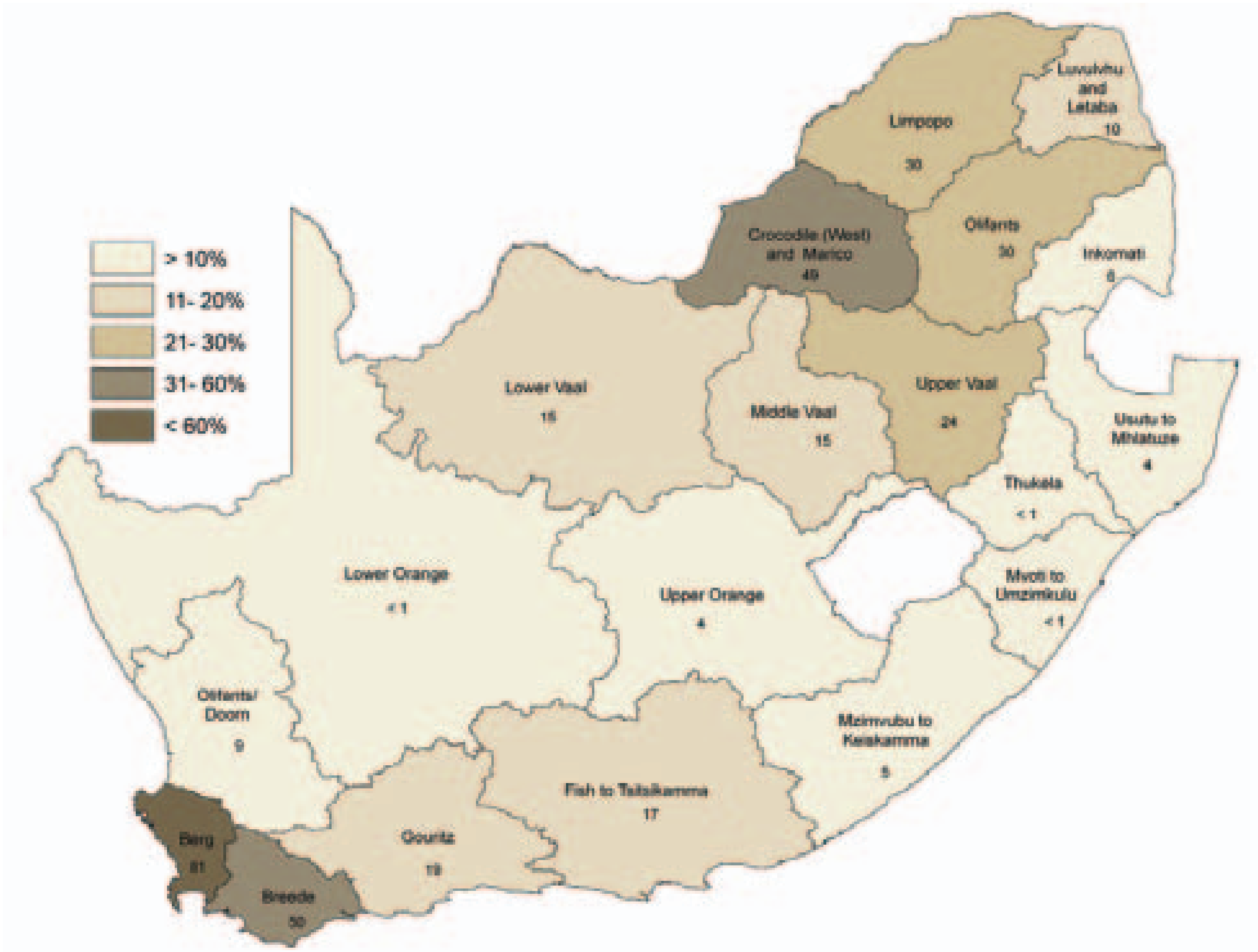


Figure 29.—Percentage river length containing critically endangered ecosystems within each Water Management Area. In Water Management Areas with high proportions of threatened river ecosystem types, conservation action should focus on maintaining the last remaining rivers that are still in good ecological condition and rehabilitating some of the moderately modified rivers.

levels of protection make good land management in lowland river sub-catchments especially important. Practices such as keeping natural vegetation intact along river banks and clearing invasive alien plants can make a vital difference to the ecological integrity of these rivers.

Most land-based protected areas have been designed to protect terrestrial ecosystems, yet some simple changes could help to make protected areas work better for river ecosystems too:

- Avoiding using a river as the boundary of a protected area. Instead, include the river and its riparian area in the protected area.
- Encouraging expansion of existing protected areas to incorporate whole river reaches

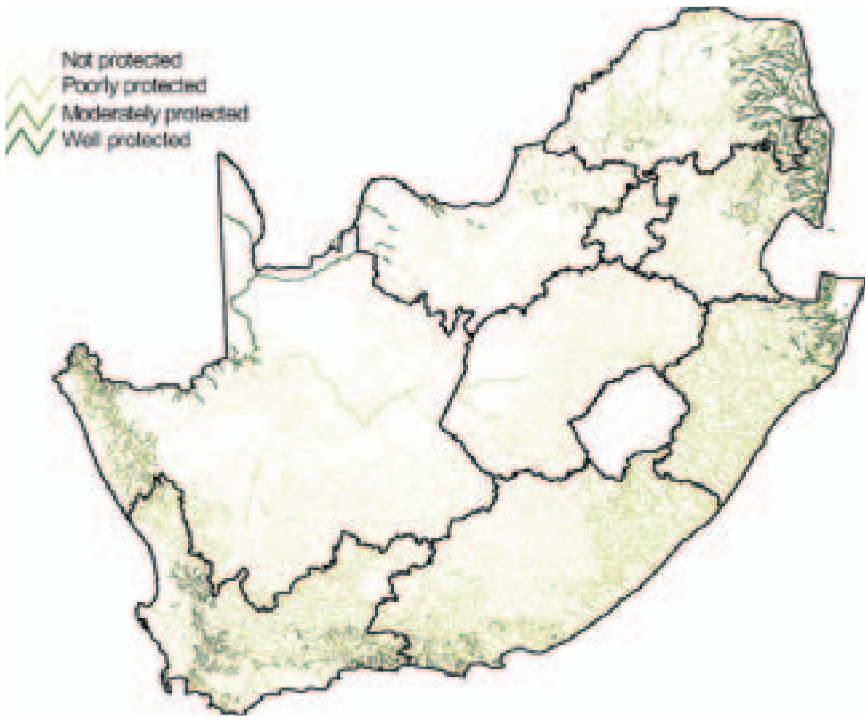


Figure 30.—Map of ecosystem protection levels for river ecosystem types. Rivers are linear systems that seldom fall entirely within the boundaries of a protected area, and are impacted on by activities that take place throughout entire catchments, beyond the boundaries of protected areas.

that are currently only partially protected. Sometimes this is possible with a relatively modest adjustment to an existing protected area boundary.

- Incorporating natural large-scale catchment processes into protected areas where possible. Ensure that rivers are well managed within protected areas, enabling them to recover from the impact of activities upstream as they flow through the protected area.
- Avoiding development of visitor infrastructure (such as chalets, roads, bridges) on or adjacent to priority freshwater ecosystems in protected areas.
- Promoting new protected areas for the last remaining free-flowing rivers (see Chapter 12). There are only 25 remaining free-flowing rivers longer than 100 km in South Africa—all other long rivers have been dammed in some way. Free-flowing rivers helped to determine priority areas for protected area expansion in the National Protected Area Expansion Strategy 2008.

Protected areas, no matter how river-friendly their design and management, are unlikely ever to fully protect river ecosystems. Because of their inherent connectivity, rivers are influenced by human activities that occur upstream, downstream and in the surrounding landscape. A whole catchment approach to river protection is therefore required. However, it is seldom feasible to place whole catchments under protection. Rivers in protected areas are almost always influenced by activities that occur upstream in unprotected areas and it is necessary to manage these impacts so that they do not impact the ecological condition of the downstream protected reaches.

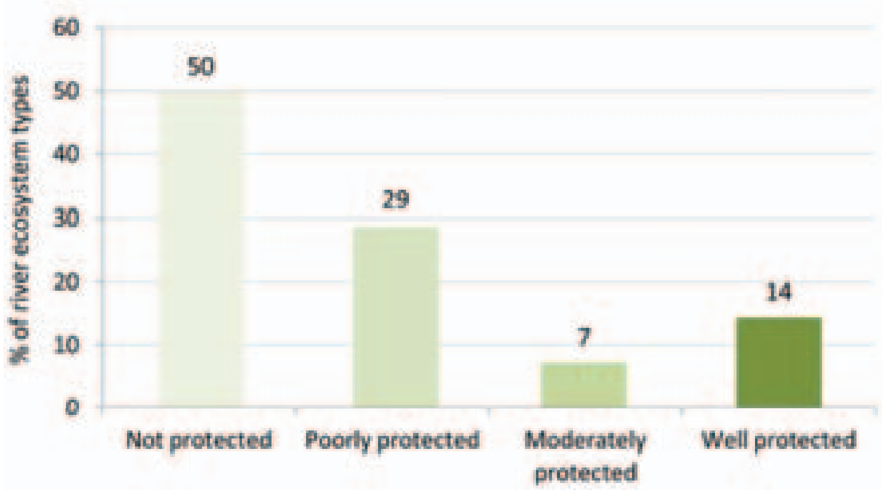


Figure 31.—Summary of ecosystem protection levels for river ecosystem types (main rivers and tributaries). Most land-based protected areas were not designed to protect rivers.

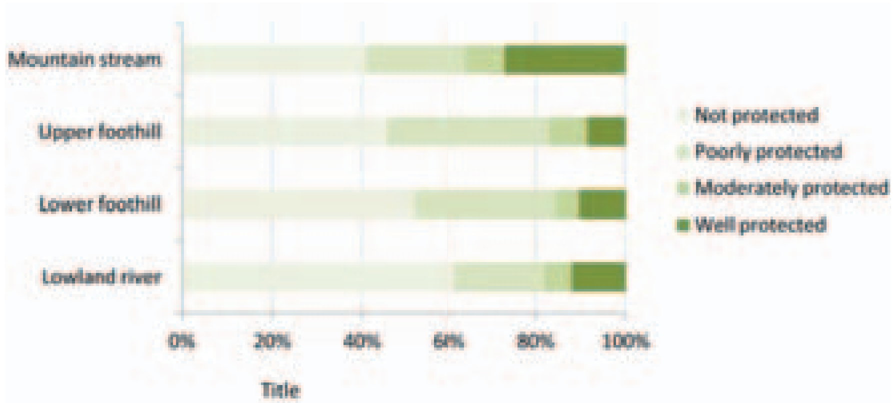


Figure 32.—Ecosystem protection levels for river ecosystems types, by river slope category. Mountain streams are best protected whereas lowland rivers have the highest proportion of ecosystem types with no protection.

Fortunately, South Africa's National Water Act (Act 36 of 1998), globally acclaimed for its progressive approach to managing water resources, provides several tools for the protection of freshwater ecosystems.[32] These include the ecological reserve, classification of water resources, and resource quality objectives. Ideally, river ecosystems should be considered fully protected only if an ecological reserve is gazetted for managing the river in a good ecological condition (A or B Present Ecological State category), and the reserve is implemented effectively to maintain the river in this condition. To date, ecological reserves have been determined for only a handful of rivers in South Africa and have yet to be gazetted. In future, we would like to see water legislation and protected area legislation working hand in hand to protect South Africa's rivers.

A small proportion of sub-quaternary catchments in South Africa have been identified as high water supply areas, making up just 3.9% of the country, as shown in Figure 33 and discussed further

[32]The term 'protection' has different meanings in land use and water resource contexts in South Africa, sometimes causing confusion. In the water resource context, 'protection' of water resources means managing the resource and associated ecosystem according to a level that ensures sustainable use. This term emphasises the need to balance protection and utilisation in a sustainable and equitable manner through appropriate water resource management. Protection in this sense is therefore an inclusive strategy, applicable to all water resources, and does not apply only to formally protected areas. In the NBA, the term 'protection' refers to formal protection in terms of the Protected Areas Act.

Rivers are connected longitudinal systems that are impacted on by activities throughout the catchment, reinforcing the need for protection of rivers through a range of mechanisms, drawing on both protected area legislation and water legislation.

in Chapter 12. These are areas in which the mean annual runoff is at least three times greater than the related primary catchment. They are the water factories of the country, in which any land uses that reduce stream flow (for example, plantation forestry) as well as activities that affect water quality (such as timber mills, mining, overgrazing) should be strongly avoided. Currently only 18% of high water yield areas have any form of formal protection, some of them as Mountain Catchment Areas declared in terms of the Mountain Catchment Areas Act (Act 63 of 1970). Although the Protected Areas Act recognises Mountain Catchment Areas, there is lack of consensus on their administration and responsible regulating authority. Given the strategic importance of high water yield areas for South Africa's water security, options for extending and strengthening their protection should be explored, for example declaring them as

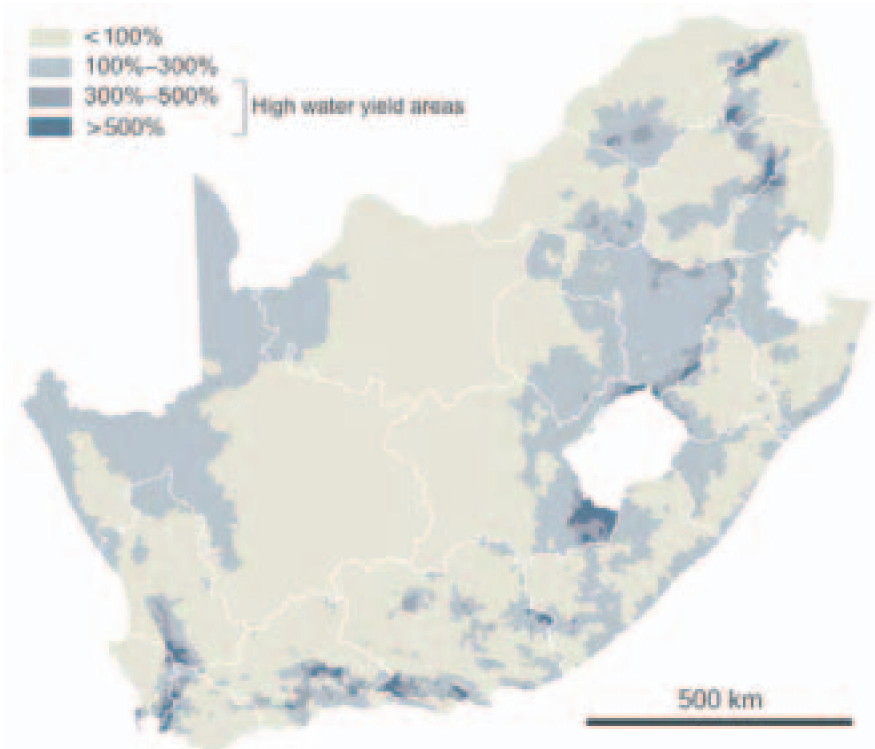


Figure 33.—High water yield areas are sub-quaternary catchments where mean annual runoff is at least three times greater than the related primary catchment. They are the water factories of the country, of strategic importance for South Africa's water security, but currently have low levels of formal protection.

Protected Environments in terms of the Protected Areas Act. In many cases, only part of the sub-quaternary catchment concerned would require formal protection.

Although the National Protected Area Expansion Strategy 2008 incorporated priority areas for river ecosystems in the identification of focus areas for land-based protected area expansion, explicit protected area targets for river ecosystems and high water yield areas were not set. Future revisions of the NPAES will be able to address river ecosystems more comprehensively.

As highlighted in Chapter 4, biodiversity stewardship programmes are making significant contributions to the protection of terrestrial ecosystems through the declaration of contract protected areas on land which remains in private or communal hands. An explicit freshwater focus within biodiversity stewardship programmes could extend this contribution to freshwater ecosystems as well.

6. Wetland ecosystems

Chapter summary

Wetland ecosystems

- Ecosystem threat status: 65% of ecosystem types threatened
- Ecosystem protection level: 11% of ecosystem types well protected, 71% not protected
- Key ecosystem services: water purification, flood regulation
- Key pressures: cultivation, urban development, dam construction, changes in water flow, pollution, invasive alien plants

Wetland ecosystems are vital for purifying water and regulating water flows, acting as sponges that store water and release it slowly, filtering pollutants and easing the impact of droughts and floods in the process. They also support a rich diversity of species, which have both intrinsic and economic value. The main pressures faced by wetland ecosystems include cultivation, urban development, dam construction and poor grazing management, combined with catchment-wide impacts such as disruption of freshwater flow and pollutants and sediment from surrounding land uses.

It is not possible to map the historical occurrence of wetlands in South Africa, and in substantial parts of the country outright loss of wetlands is estimated to be more than 50% of the original wetland area. Approximately 300 000 wetlands remain, making up only 2.4% of South Africa's surface area.

The NBA 2011 provides the first ever national assessment of wetland ecosystems. A disturbing 65% of wetland ecosystem types are threatened (48% critically endangered, 12% endangered and 5% vulnerable), making wetlands the most threatened of all ecosystems. Floodplain wetlands have the highest proportion of critically endangered ecosystem types, followed by valley-head seeps and valley-bottom wetlands. These wetland classes, especially floodplain wetlands, are often associated with highly productive land and are often the ones that are dammed, drained or bulldozed for agricultural purposes.

Fortunately, wetlands are more resilient than many other ecosystems. As long as they have not been irreversibly lost to cultivation or concrete, many wetlands that are in poor condition can be rehabilitated to at least a basic level of ecological and hydrological functioning, thus restoring ecosystem services such as water purification and regulation of water supply.

Only 11% of wetland ecosystem types are well protected, with 71% not protected at all, reflecting the fact that wetland ecosystems have not been taken systematically into account in establishing and expanding land-based protected areas. There is clearly scope for the protected area network to play a bigger role in protecting South Africa's wetlands.

As with rivers, protected areas alone are unlikely ever to do the full job of protecting wetlands, which are vulnerable to impacts in their catchments beyond the boundaries of protected areas. This highlights the importance of integrated water resource management in securing the quality, quantity and timing of freshwater flows on which the functioning of wetlands depends. For all wetlands, keeping a buffer of natural vegetation intact around the wetland can go a long way towards reducing the impacts of damaging land-use practices in the catchment.

Wetlands are exceptionally high-value ecosystems that make up only a small fraction of the country. Given their strategic importance for ensuring water quality and regulating water supplies, investments in conserving, managing and restoring wetlands are likely to generate disproportionately large returns.

This chapter presents the results of the assessment of wetland ecosystems, including their threat status and protection levels. It explains how wetland ecosystems are defined, discusses their importance and value, and outlines some of the major pressures that impact on their ecological condition. The methods used to assess ecosystem threat status and ecosystem protection level were explained in Chapter 3 and are not repeated in this chapter. More detail is available in the technical report for the freshwater component of the NBA.

In the NSBA 2004 lack of data meant that we were unable to assess the status of wetland ecosystems at all. Tremendous progress has been made in the intervening years in the development of a National Wetland Inventory, a national wetland classification system, and a preliminary set of 791 wetland ecosystem types (see Panel 7). As a result, for the first time we are able to present a systematic national assessment of wetland ecosystem status. The assessment relied heavily on work done as part of the National Freshwater Ecosystem Priority Areas project (NFEPA), which dealt with both rivers and wetlands. For more on NFEPA see the Atlas of Freshwater Ecosystem Priority Areas in South Africa,[33] and the Implementation Manual for Freshwater Ecosystem Priority Areas.[34]

Unlike for most other ecosystems, we are unable to map **historical occurrence** of wetlands across the county. This means that the assessment of threat status and protection level is for currently existing wetlands only, not taking into account those wetlands that have already been irreversibly lost (for example, wetlands that have been cultivated, mined or replaced by shopping centres, houses, car parks, airports and so on). Based on historic data available in some places, outright loss of wetlands is estimated to be more than 50% of the original wetland area in substantial parts of the country.[35] About 300 000 wetlands remain, covering a total area of 2.9 million hectares or 2.4% of South Africa's surface area.

Box 11: Wetland biodiversity assets support human wellbeing

Wetlands constitute irreplaceable natural infrastructure for managing water resources, as well as providing a range of other ecosystem services. Society cannot rely solely on complex and expensive engineering solutions to provide drinking water and to cleanse waste water. The ecosystem services provided by wetlands include their ability to improve water quality and contribute to the maintenance of baseflows in rivers. In the context of climate change, with predicted increases in the variability and intensity of rainfall events, wetlands have the potential to play a more important role than ever before in mitigating extreme episodes like floods and droughts. Wetlands are warehouses of biodiversity, supporting a rich diversity of species that have both economic and intrinsic value. Many of these species are used for food, craft manufacture, medicines, building material and fuel, both for subsistence and commercially. The health and wellbeing of people thus depend on maintaining healthy wetlands and other freshwater ecosystems that provide these vital ecosystem services.

In a semi-arid country like South Africa, wetlands are particularly important for supporting agricultural productivity, improving water quality, sustaining baseflows, attenuating floods, combating desertification and decreasing vulnerability to droughts.

The natural extent of wetlands in South Africa is low, and individual wetlands tend to be small, with approximately 300 000 remaining wetlands covering only 2.4% of the country. This means that the consequences of wetland destruction are greater than if wetlands were larger and more extensive. It also means that managing and conserving the tiny proportion of the country's surface area covered by wetlands can make a big contribution to improving water quality, especially in hard working catchments, and to enhancing resilience to climate change by improving flood and drought regulation.

Specific examples of the value of wetland ecosystems in South Africa include the following:

Wetlands make up a very small proportion of South Africa's surface area but provide exceptionally valuable ecosystem services, including purifying water and regulating floods.

- Wetlands in heavily industrialised parts of the country are irreplaceable as water purifiers. For example, the peatlands of the Klip River in southern Johannesburg have absorbed the pollution of 100 years of gold mining in the western Witwatersrand, as well as more recent industrial and urban pollution, resulting in a higher water quality for downstream users than would be the case had there been no wetlands. Degradation of these wetlands has not only reduced their ability to purify water, but is also resulting in the release of trapped pollutants.*

[33]Nel, J.L., Driver, A., Strydom, W.F., Maherry, A., Petersen, C., Hill, L., Roux, D.J., Nienaber, S., Van Deventer, H., Swartz, S. & Smith-Adao, L.B. 2011. *Atlas of Freshwater Ecosystem Priority Areas in South Africa*. WRC Report No. TT 500/11. Water Research Commission, Pretoria.

[34]Driver, A., Nel, J.L., Snaddon, K., Murray, K., Roux, D.J., Hill, L., Swartz, E.R., Manuel, J. & Funke, N. 2011. *Implementation Manual for Freshwater Ecosystem Priority Areas*. WRC Report No. 1801/1/11, Water Research Commission, Pretoria.

[35]Kotze, D.C., Breen, C.M. & Quinn, N. 1995. Wetland losses in South Africa. In G.I. Cowan (ed.) *Wetlands of South Africa*. Department of Environmental Affairs and Tourism, Pretoria.

- Peat-containing wetlands are the most important long-term carbon store in the terrestrial biosphere. Degradation of peatlands is a major and growing source of anthropogenic greenhouse gas emissions, equivalent to more than 10% of global fossil fuel emissions.** There are at least 30 000 ha of peatlands in South Africa, more than two thirds in KwaZulu-Natal. An estimated 40 000 to 60 000 m^3 of peat is used annually, for example in the mushroom and nursery industries.***
- The vital role played by many wetlands in agro-pastoral production systems and local livelihoods, through the provision of highly productive agricultural land, grazing, fish, fibre and medicines, underpins the health and wellbeing of many rural communities. In the Sand River catchment in Mpumalanga, the Manalana wetland is the only source of food and income for about 25% of the surrounding population, and acts as a safety net that buffers households from slipping further into poverty during times of shock or stress. The wetland has been rehabilitated and now contributes provisioning services, such as food, grazing and construction materials, conservatively estimated at R3 466 per year to some 70% of local households, in an area where 50% of households survive on an income of less than R5 700 per year.****

Wetland-derived ecosystem services are especially important for the poorest and most vulnerable sectors of the population. It is the rural poor who are most directly dependent upon natural ecosystems such as wetlands for their survival, and who suffer disproportionately in terms of health, economic and general wellbeing from wetland degradation and loss. There is thus a very direct link between the return on environmental investment, and the welfare and survival of the poorest.

* McCarthy, T.S. & Venter, J.S. 2006. Increasing pollution levels on the Witwatersrand recorded in the peat deposits of the Klip River wetland. *South African Journal of Science* 102: 27–34; McCarthy, T.S., Arnold, V., Venter, J. & Ellery, W.N. 2007. The collapse of Johannesburg's Klip River wetland. *South African Journal of Science* 103: 1–7.

** Parish, F., Sirin, A., Charman, D., Joosten, H., Minayeva, T., Silvius, M. & Stringer, L. (eds). 2008. *Assessment on Peatlands, Biodiversity and Climate Change: Main Report*. Global Environment Centre, Kuala Lumpur and Wetlands International, Wageningen.

*** Grundling. P.L. & Grobler, R. 2005. Peatlands and mires of South Africa. *Stapfia* 85, zugleich Katalogeder OÖ. Landesmuseen Neue Serie 35: 379–396.

**** Pollard, S.R., Kotze, D.C. & Ferrari, G. 2008. Valuation of the livelihood benefits of structural rehabilitation interventions in the Manalana Wetland. In D.C. Kotze & W.N. Ellery, *WET-OutcomeEvaluate: An evaluation of the rehabilitation outcomes at six wetland sites in South Africa*. WRC Report No. TT 343/08. Water Research Commission, Pretoria.

Panel 7: Defining wetland ecosystem types

Wetlands are those parts of the landscape where water accumulates long enough and often enough to influence the characteristics of the soil and the composition of plant communities in these areas. The Convention on Wetlands of International Importance (Ramsar Convention), to which South Africa is a contracting party, takes a broad view of wetlands that encompasses all aquatic ecosystems, including rivers, lakes, estuaries and some marine areas. However, the National Water Act (Act 36 of 1998) defines wetlands more narrowly as, "transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil". This definition restricts itself to those wetland types colloquially known mainly as marshes or vleis. South Africa's National Wetland Map 4 (see below) contains wetlands as defined in the National Water Act, but also includes open water bodies, both natural and artificial, including lakes, pans and dams.

Wetlands are not easy to map at a national scale as there are thousands of them and they are often difficult to recognise and delineate based on remotely sensed imagery such as satellite images. Nevertheless, huge progress has been made in recent years, coordinated by the National Wetland Inventory based at SANBI. Through the NFEPA project, SANBI's National Wetland Map 3 was augmented with finer scale wetland maps for regions where these were available, to produce National Wetland Map 4 (also known as the NFEPA Wetland Map) of about 300 000 wetlands, covering a total area of 2.9 million hectares or 2.4% of South Africa's surface area. This is the most comprehensive national wetland data layer to date.

NFEPA used the national wetland classification system[36] to classify these 300 000 wetlands into wetland ecosystem types, based on a combination of two factors: landscape setting and wetland vegetation

[36]SANBI. 2009. *Further Development of a Proposed National Wetland Classification System for South Africa*. Primary Project Report. Prepared by the Freshwater Consulting Group (FCG), South African National Biodiversity Institute, Pretoria. This report provides a hierarchical wetland classification system which had not yet been applied at the national scale prior to NFEPA.

groups. Landscape setting (e.g. whether a wetland occurs on a slope, a plain or a valley floor) was used to identify seven different hydro-geomorphic classes of wetland:

- Seeps (wetlands on slopes formed mainly by the discharge of sub-surface water).
- Valley-head seeps (seeps located at the head (closed end) of a valley; often the source of streams).
- Channelled valley bottoms (valley floors with one or more well defined stream channels, but lacking characteristic floodplain features).
- Unchannelled valley bottoms (valley floors with no clearly defined stream channel).
- Floodplains (valley floors with a well-defined stream channel, gently sloped and characterised by floodplain features such as oxbow depressions and natural levees).
- Depressions (basin-shaped areas that allow for the accumulation of surface water; an outlet may be absent (e.g. pans), thereby isolating the depression from the stream channel network).
- Flats (extensive areas characterised by level, gently undulating or uniformly sloping land with a very gentle gradient).

'Hydro-geomorphic' means related to hydrology (the source and movement of water) and geomorphology (the position of the wetland in the landscape). Figure 34 shows schematically how the hydro-geomorphic classes of wetland relate to different landscape settings. An example of the hydro-geomorphic classes for the Overberg region of the Western Cape is shown in Figure 35.

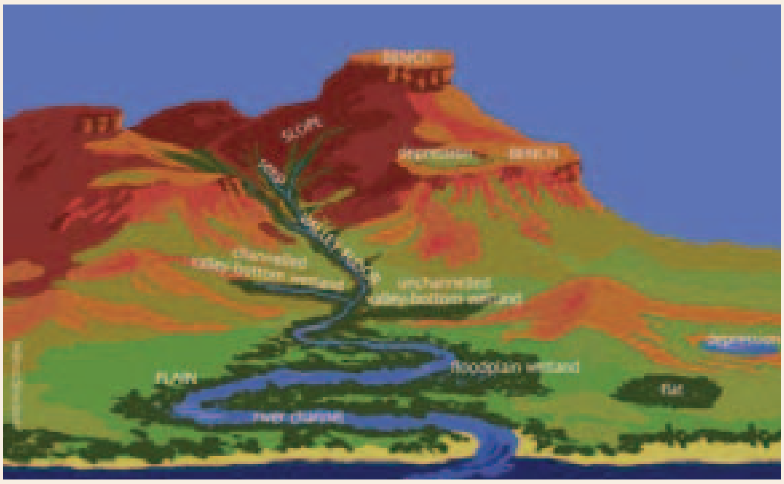


Figure 34.—Schematic showing how the seven hydro-geomorphic classes of wetland relate to landscape setting.

Wetland vegetation groups, based on groupings of national vegetation types (see Panel 5 in Chapter 4), reflect differences in geology, soils and climate, providing an indication of the regional context in which a wetland occurs and thus its ecological characteristics. One hundred and thirty-three wetland vegetation groups were combined with the seven hydro-geomorphic classes to produce 791 wetland ecosystem types that represent the diversity of wetlands across the country. Wetlands of the same ecosystem type are expected to share similar functionality and ecological characteristics. For example, seeps function differently to valley-bottom wetlands; valley-bottom wetlands in the mesic Highveld Grassland have different characteristics to valley-bottom wetlands in sandstone Fynbos.

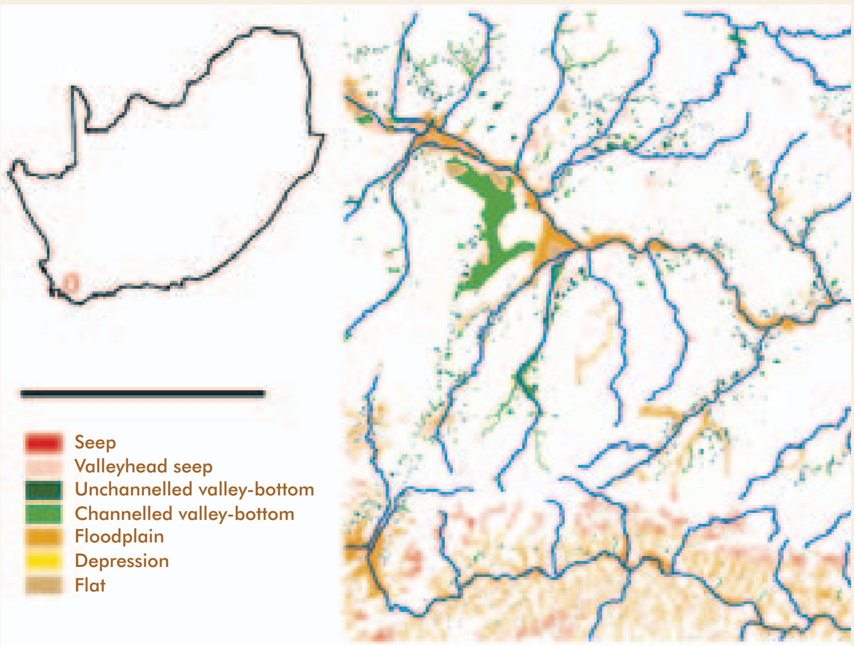


Figure 35.—Part of the Overberg region (Western Cape) showing hydro-geomorphic classes of wetland. These were combined with vegetation groups to derive wetland ecosystem types.

The development of a national map of wetland ecosystem types is a major achievement. Nevertheless, these wetland ecosystem types should be seen as preliminary, with considerable room for improvement of the underlying map of wetlands, which will continue to be updated and expanded through the National Wetland Inventory, as well as for refining the wetland types.

6.1 Wetland ecosystem threat status

As explained in Chapter 3, ecosystem threat status tells us about the degree to which ecosystems are still intact, or alternatively losing vital aspects of their structure, function and composition, on which their ability to provide ecosystem services ultimately depends.

Wetland ecosystems are critical for storing water, regulating water supply, and improving water quality, making it easy to see their socio-economic value (Box 11). Yet many wetland ecosystems have already been irreversibly lost, and wetlands continue to be lost and degraded as a result of a range of human activities (Box 12).

It is difficult to map historical occurence of wetlands, but substantial amounts of South Africa's wetland area have undoubtedly been irreversibly lost. Of the remaining wetland area, 45% is in poor condition. This wetland, for example, has been cultivated.

Wetland condition describes the extent to which a wetland has been modified by human activity. For most wetlands across the country there is no field survey data on which to base an assessment of wetland condition, so we have modelled (or estimated) wetland condition based on the proportion of natural vegetation within and surrounding each wetland (up to 500 m from the wetland edge). This provides a good proxy for wetland condition—the more natural vegetation, the better the condition of the wetland is likely to be. For riverine wetlands, linked directly to rivers, the condition of the river was also taken into account. The same Department of Water Affairs Present Ecological State categories were used for wetlands as for rivers, ranging from A (natural, unmodified) through to F (critically/extremely modified) (see Table 2 in Chapter 3). Wetlands are considered to be in good ecological condition if their Present Ecological State category is A or B.

As mentioned, it is very difficult to assess accurately how much of South Africa's wetland area has already been irreversibly lost. However, we know it is substantial, especially in urban areas and intensively cultivated areas. **Over and above this irreversible loss** that has already taken place, the analysis revealed that **approximately 45% of the remaining wetland area in South Africa is in a heavily or critically modified condition**,[37] owing to human impacts such as damming, draining, mining and bulldozing of wetlands.

A single wetland ecosystem type can include some wetlands that are in good ecological condition and others that are in poor condition. This is why the NBA does not simply assess the condition of wetlands but takes the analysis further to look at the proportion of each wetland ecosystem type that remains in good ecological condition, giving an assessment of ecosystem threat status for wetland ecosystem types. See Chapter 3 for more on how ecosystem threat status is calculated.

Figure 36 shows the map of wetland ecosystem threat status for the country. Consistent with the picture for river ecosystems, there is a band of critically endangered and endangered ecosystems along the escarpment belt and around major cities. The pattern in wetland ecosystem threat status is frequently influenced by the condition of rivers. However, the turnover in diversity of wetland ecosystem types is higher than for river ecosystem types, and therefore even when a river ecosystem type is not threatened, the associated wetland ecosystem types may be threatened. This pattern is particularly evident in parts of the Eastern Cape and Limpopo, where wetland ecosystem types display a higher level of threat than river ecosystems.

Of South Africa's 791 wetland ecosystem types, 48% are critically endangered, 12% are endangered, 5% are vulnerable and 35% are least threatened, as shown in Figure 37, making wetlands the most threatened ecosystems of all in South Africa. This is based on an analysis of remaining wetlands only and does not take into account those that have already been irreversibly lost. If we were able to take those previously lost wetlands into account the proportion of threatened wetland ecosystem types would be far higher.

[37] Equivalent to the D, E or F Present Ecological State categories.

Box 12: Key pressures on wetland ecosystems

Several pressures contribute to the loss and degradation of wetlands, some of them occurring at the wetland site and others related to land management in the wider catchment.[38]

The most prevalent on-site causes of wetland loss and degradation are:

- Cultivation (e.g. sugar cane, fruit orchards, wheat).
- Urban development.
- Dam construction.
- Poor grazing management causing erosion.

Other on-site pressures include road construction, forestry plantations, dumping of solid waste, burning, mining and toxic waste disposal. Coal mining, which provides most of South Africa's energy supply and earns foreign exchange through exports, presents a particular challenge for wetland health. The close proximity of many shallow coal seams to wetlands means that open cast coal mines frequently destroy hundreds of hectares of wetlands to remove the coal beneath them, compromising the water purification and flood prevention role that wetlands play and exacerbating the problems with water quality that already exist in heavily mined catchments.

The most prevalent off-site causes of wetland degradation are:

- Disruption of the flow regime (changes to the amount and timing of flows of freshwater to the wetland, for example as a result of water abstraction, effluent discharge, and dams in the catchment).
- Deterioration of water quality in associated rivers as a result of polluting activities in the surrounding catchment.
- Poor grazing management or poor crop production practices in the catchment that result in an increased sediment load being deposited in the wetland.

Until the 1980s, agricultural policy in South Africa deliberately encouraged draining and cultivation of wetlands. Although this has changed and there is much more awareness today about the value of wetlands, the loss of wetlands that resulted cannot entirely be reversed.

Shallow coal deposits are frequently found beneath wetlands. Mining these deposits, such as shown here in the Delmas-Ogies area of Mpumalanga, usually results in large-scale wetland destruction, with significant accompanying loss of ecosystem services.

The health of rivers and wetlands is linked. A river in poor condition is likely to affect the condition of associated wetlands, degrading them to a fair or poor condition. Similarly, destruction of wetlands has an impact on river condition because the wetlands are no longer able to filter pollutants from surrounding land uses to prevent them ending up in the river. Buffers of natural vegetation around wetlands can play a major role in keeping wetlands healthy and well-functioning, even if land uses in the surrounding catchment are not wetland-friendly.

[38]The information presented here draws on two useful sources that provide an overview of wetlands: Kotze *et al*. 1995 (see footnote 34); Collins, N.B. 2005. *Wetlands: The basics and some more*. Free State Department of Tourism, Environmental and Economic Affairs, Bloemfontein.

Figure 38 shows that there are variations within the overall picture for wetland ecosystem types. Floodplain wetlands have the highest proportion of critically endangered ecosystem types, followed closely by valley-head seeps and valley-bottom wetlands. These wetland classes, especially floodplain wetlands, are often associated with highly productive land, and are often the ones that are dammed, drained or bulldozed for agricultural purposes.

This first national assessment of wetland ecosystem threat status is an important achievement and provides a baseline for future assessments. Areas for improvement in future assessments include refining the wetland map and wetland ecosystem types, as well as gathering data on wetland condition. This would improve application of these results at the site scale. Methods for measuring wetland condition across large areas need to be established, and a strategic nationally coordinated programme to obtain field data should be rolled out across the provinces, to complement the River Health Programme (see further discussion in Chapter 13). The need for better data notwithstanding, we are confident that the overall picture provided by this national assessment is robust. Improvements in data will not change the take-home message: South Africa's wetlands are in trouble.

The poor state of wetlands has direct implications for water quality and quantity, as well as the ability to adapt to climate change. Ecosystem services provided by healthy wetlands, such as their ability to purify water and their role in mitigating droughts and regulating floods, are likely to have eroded substantially in areas with high concentrations of threatened wetland ecosystem types.

On the positive side, wetlands tend to be more resilient than many other ecosystems. As long as they have not been irreversibly lost to cultivation or concrete, many wetlands that are in poor condition can be rehabilitated to at least a basic level of ecological and hydrological functioning, thus restoring ecosystem services such as water purification and regulation of water supply. The Working for Wetlands programme does just this, providing jobs and contributing to livelihoods at the same time.

In addition to rehabilitating wetlands, priority wetlands that are still in good ecological condition should be kept that way. Maps of Freshwater Ecosystem Priority Areas (see Chapter 12) provide a framework to assist with priori-

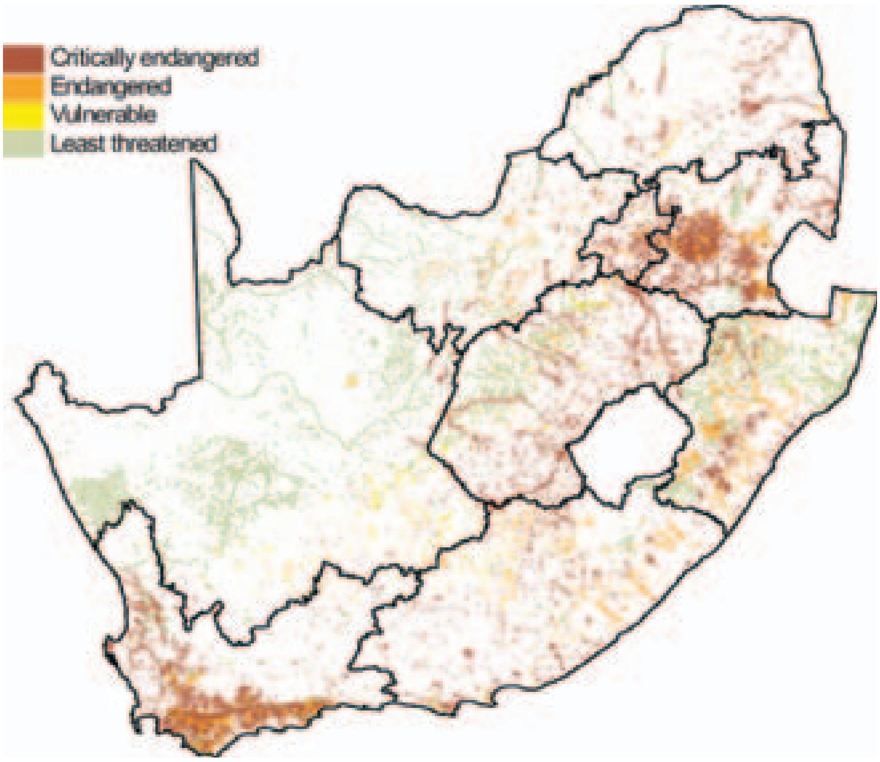


Figure 36.—Map of ecosystem threat status for wetland ecosystem types. Consistent with the picture for rivers, high numbers of critically endangered and endangered wetland ecosystem types are associated with production landscapes and urban centres. In parts of the Eastern Cape and Limpopo wetland ecosystem types display higher levels of threat than river ecosystems. Outlines of wetlands have been accentuated for visual clarity.

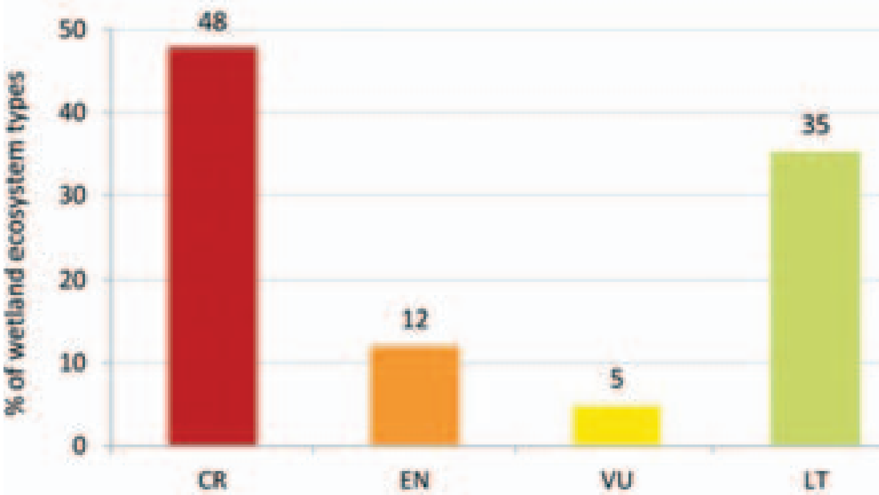


Figure 37.—Summary of ecosystem threat status for wetland ecosystem types. Sixty-five percent of wetland ecosystem types are threatened, including 48% critically endangered, making wetlands the most threatened of all South Africa's ecosystems.

Wetlands that are in poor condition may be able to be rehabilitated to at least a basic level of ecological and hydrological functioning.

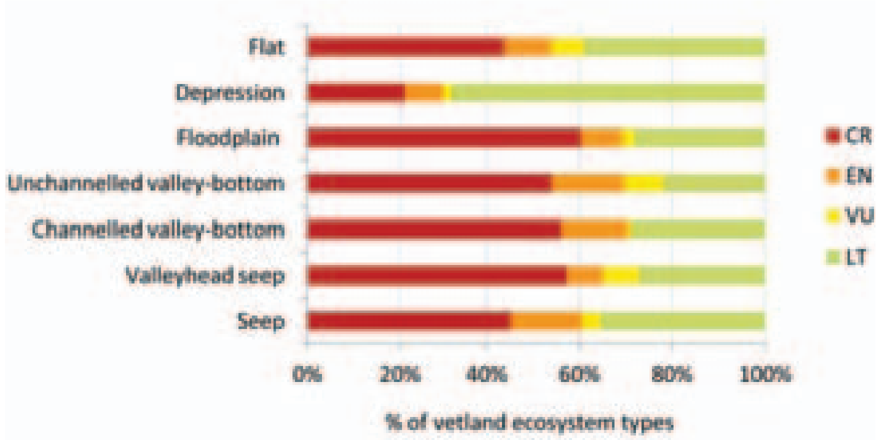


Figure 38.—Ecosystem threat status for wetland ecosystem types, by hydro-geomorphic class of wetland. Floodplain wetlands have the highest proportion of critically endangered types, followed closely by valley-head seeps and valley-bottom wetlands. These wetland classes are often associated with highly productive land and are often dammed, drained or bulldozed for agricultural purposes.

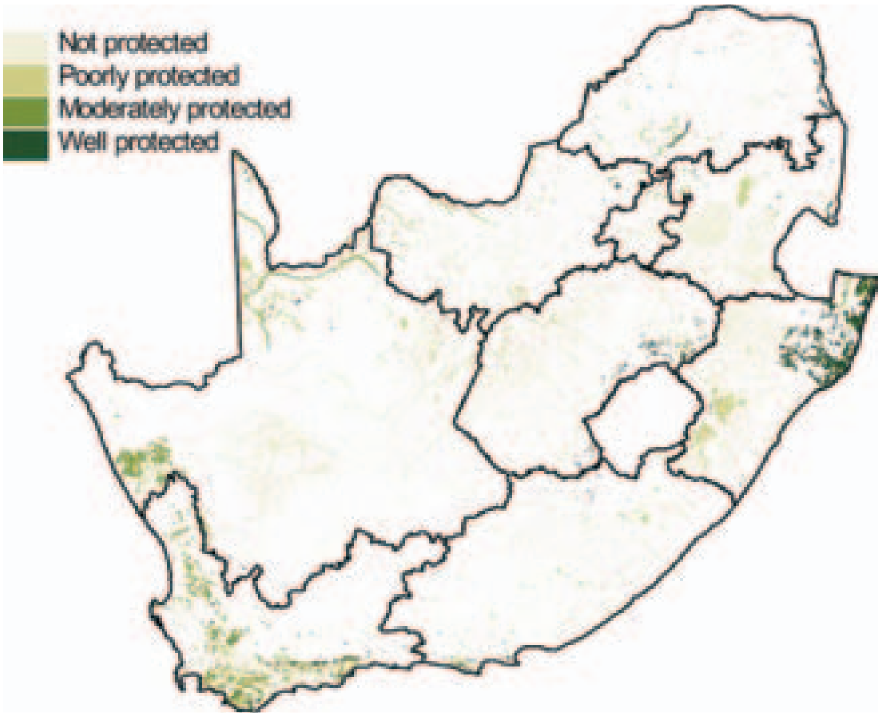


Figure 39.—Map of ecosystem protection levels for wetland ecosystem types. Wetland ecosystem types in the arid interior are strikingly under-protected. Outlines of wetlands have been accentuated for visual clarity.

tising wetlands both for rehabilitation and for protection, as discussed further below.

6.2 Wetland ecosystem protection levels

As explained in Chapter 3, ecosystem protection level tells us whether ecosystems are adequately protected or under-protected. By protected, we mean included in a protected area recognised by the Protected Areas Act, such as a National Park or a Nature Reserve (see Panel 4 in Chapter 3).

The NSBA 2004 did not include an assessment of wetlands, making this the first national assessment of wetland protection levels. Perhaps unsurprisingly, the results show that wetland ecosystems are severely under-protected. As summarised in Figure 40, over 70% of South Africa's wetland ecosystem types have no protection and only 11% are well protected. Figure 39 shows the map of wetland ecosystem protection levels for the country. Wetland ecosystem types in the lowveld region and northern KwaZulu-Natal are relatively well protected by the Kruger National Park and iSimangaliso Wetland Park respectively, and the mountain catchment areas in the Western Cape provide protection for some wetland ecosystem types. Wetland ecosystem types in the arid interior are strikingly under-protected.

Breaking the results down by hydro-geomorphic class of wetland, as shown in Figure 41, reveals no clear pattern but does highlight that floodplain wetlands have the highest proportion of wetland types with no protection. Floodplain wetlands also have the highest proportion of critically endangered types, and are often impacted on by agricultural activities. Their low levels of protection combined with high levels of threat suggest that particular attention should be paid to retaining the ecological functioning of remaining floodplain wetlands.

For the purpose of this analysis, as for rivers, if a wetland was not in good ecological condition it was not considered to contribute towards the protection level for that wetland ecosystem type even if it fell within a protected area. This was done to take account of catchment-wide impacts on wetlands, often originating from outside the boundaries of protected areas.

Wetland ecosystems are seldom taken explicitly into account in establishing and expanding protected areas. The analysis presented here provides the tools to change this, and to ensure that a representative sample of wetland ecosystem types is included in the protected area network. The National Protected Area Expansion Strategy 2008 was not able to incorporate wetlands owing to insufficient data at the time the strategy was developed, but future revisions of the NPAES will be able to address wetlands more explicitly. However, as with rivers, it is important not to assume that simply because a wetland or wetland ecosystem type has been included in the protected area network it has been adequately secured. Wetlands are highly vulnerable to impacts in their catchments, which usually extend beyond the boundaries of protected areas.

The Convention on Wetlands of International Importance (Ramsar Convention), to which South Africa is a contracting partner, provides a way of designating wetlands of international significance; however, these wetlands do not automatically receive protection under South African law. Twenty Ramsar sites have been designated in South Africa, of which 18 are formally protected in terms of the Protected Areas Act, mostly in provincial nature reserves. Seven of the 20 are estuaries, discussed further in Chapter 7. The two that are not formally protected are both estuaries: the Orange River Mouth in the Northern Cape and Verlorenvlei in the Western Cape. It is concerning that even for just these few wetlands there is not adequate wetland condition data to help with their management. Ramsar wetlands should be high priorities for future monitoring and adaptive management.

Two of South Africa's Ramsar sites, Blesbokspruit in Gauteng and the Orange River Mouth, have been listed on the Ramsar Convention's Montreux Record, a register of Ramsar sites under threat. On-site activities, which could have been curtailed through the formal protection status, have certainly played a role in the degradation of these sites. However, in both cases impacts originating upstream have also fundamentally transformed the sites through modification of natural flow regimes. See Chapter 7 for more on the Orange River Mouth.

The solution to protecting a representative spread of wetland ecosystem types lies in a combination of measures for on-site protection, and measures implemented upstream and in the surrounding catchment to secure the quality, quantity and timing of water upon which the wetland's character and functioning depend.

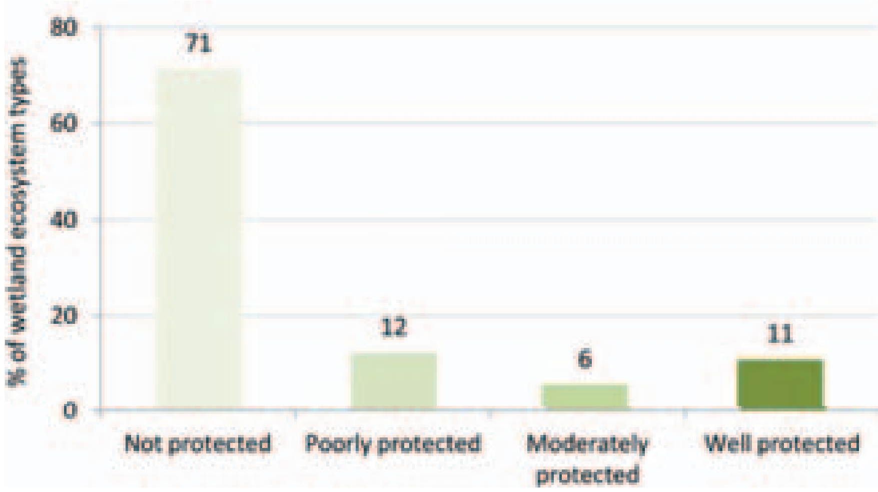


Figure 40.—Summary of ecosystem protection levels for wetland ecosystem types. Wetlands are severely under-protected, with only 11% of wetland ecosystem types well protected.

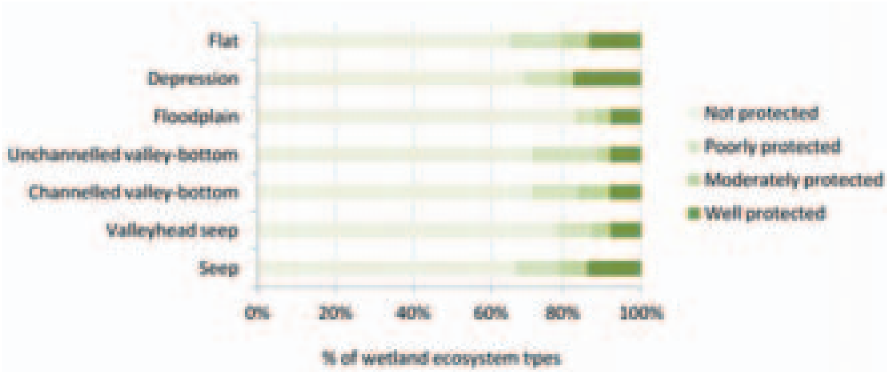


Figure 41.—Ecosystem protection levels for wetland ecosystem types, by hydrogeomorphic class of wetland. Floodplain wetlands have the highest proportion of wetland types with no protection, and are often impacted on by agricultural activities.

Verlorenvlei is one of two Ramsar sites in South Africa that have no formal protection in terms of South African law.

This highlights the importance of the approach of integrated water resource management enshrined in the National Water Act, especially through resource directed measures such as the ecological reserve, classification of water resource and setting of resource quality objectives. In addition to the National Water Act, other laws such as the Conservation of Agricultural Resources Act (Act 43 of 1983) and National Environmental Management Act (Act 107 of 1998) provide sufficient mechanisms for on-site and off-site protection of wetlands. However, capacity to enforce, coupled with sufficient information to make prudent choices about the sometimes inevitable trade-offs between development and loss of ecosystem services, remains a challenge.

As highlighted in Chapter 4, biodiversity stewardship programmes are making significant contributions to the protection of terrestrial ecosystems through the declaration of contract protected areas on land which remains in private or communal hands. An explicit freshwater focus within biodiversity stewardship programmes could extend this contribution to wetlands as well.

7. Estuarine ecosystems

Chapter summary

Estuarine ecosystems

- Ecosystem threat status 43% of ecosystem types threatened
- Ecosystem protection level: 33% of ecosystem types well protected, 59% not protected
- Key ecosystem services: nurseries for fish, recreation, raw materials such as reeds and sedges
- Key pressures: decrease in freshwater reaching estuaries, inappropriate land use and development, fishing and bait collection, pollution, invasive alien species

Estuaries are formed where fresh water from rivers runs out to sea, although the mouths of some estuaries periodically close off from the sea. They are often focal points for coastal development and recreation, including water sports, fishing and holiday-making. Estuaries provide nursery areas for many commercially important fish species, and deliver sediments that form and maintain beaches and provide nutrients for marine food webs. Estuaries face multiple pressures from human activities, often resulting from development too close to the estuary as well as the cumulative impacts of land uses throughout the catchment that feeds the estuary. Reductions in the quantity and quality of fresh water that reaches an estuary, for example as a result of dams higher up in the catchment, can impact severely on its ecological condition and ability to provide ecosystem services.

The NBA 2011 mapped the estuarine functional zone for each of South Africa's 291 estuaries for the first time, including the open water area of each estuary as well as the associated floodplain, totalling about 170 000 ha for all estuaries. Nested within this, the total area of estuarine habitat, including the open water area and adjacent habitats such as salt marshes and mangroves, is about 90 000 ha. The St Lucia Lake system in northern KwaZulu-Natal accounts for more than half of South Africa's estuarine area.

Forty-three percent of estuary ecosystem types are threatened (39% critically endangered, 2% endangered and 2% vulnerable). The proportion of threatened types is highest in the cool temperate region (the west coast, which has relatively few estuaries) and lowest in the warm temperate region (south and southeast coast, including the many small estuaries along the Wild Coast, most of which are in good ecological condition).

Only 33% of estuary ecosystem types are well protected and 59% have no protection at all. To be fully protected, an estuary should be protected from the land side with a land-based protected area, from the aquatic side with a no-take marine or estuarine protected area, and have its freshwater flow requirements met using legal mechanisms in the National Water Act. For many estuaries, partial protection is adequate and can take various forms that still allow for some direct use of the estuary.

South Africa's flagship estuary, St Lucia, is currently in poor ecological condition in spite of the fact that it forms part of a World Heritage Site, the iSimangaliso Wetland Park. The artificial separation of the uMfolozi River Mouth from Lake St Lucia several decades ago, combined with other factors such as drought, have led to reductions in freshwater flow to St Lucia. This has resulted in the estuary being closed to the sea for much of the last decade, unable to fulfil its role as the most important nursery area for marine fish along the southeast African coastline, among other impacts. The iSimangaliso Wetland Park Authority has prioritised the restoration of St Lucia and has initiated measures to facilitate the re-linking of St Lucia and uMfolozi and to monitor the responses of the system. Restoring the ecological health of St Lucia is challenging but feasible and should be seen as a national priority.

In addition to the ecosystem threat status and protection level assessments, a national set of 120 priority estuaries was identified by the NBA 2011 through the first ever National Estuary Biodiversity Plan. These estuaries are priorities for the development of Estuary Management Plans in terms of the Integrated Coastal Management Act, and should ultimately be either fully or partially protected.

This chapter presents the results of the assessment of estuarine ecosystems, including their threat status and protection levels. It explains how estuary ecosystem types are defined, discusses their importance and value, and outlines some of the major pressures that impact on their condition. The methods used to assess ecosystem threat status and ecosystem protection level were explained in Chapter 3 and are not repeated in this chapter. More detail is available in the technical report for the estuary component of the NBA.

The NSBA 2004 assessed ecosystem threat status for 13 broad groups of estuarine ecosystems, representing 259 estuaries. At that stage, spatial data for estuaries was limited to points (dots) along the coastline—the actual extent of most estuaries had not been mapped. A major advance in the NBA 2011 has been to map the estuarine functional zone for each of 291 estuaries, which includes the open water area of each estuary as well as its associated floodplain. Figure 42 shows the difference between point data for estuaries and delineation of the estuarine functional zone, which enables much more meaningful assessment of the state of estuarine ecosystems.[39] In 2011 we also developed a more detailed set of 46 estuary ecosystem types (see Panel 8), enabling greater resolution in the assessment.

South Africa's total estuarine area is about 90 000 ha (equivalent to about one tenth of the area of the Kruger National Park). South Africa's largest estuary, the St Lucia Lake system with an area of just over 50 000 ha, makes up more than half of this area.[40] This means than any statistics reported **by area** for South Africa's estuaries are subject to the 'St Lucia effect', with the results for St Lucia dominating the scores. For this reason, we have reported all estuary statistics by estuarine area as well as by number of estuary ecosystem types.

Box 13: Estuarine biodiversity assets support human wellbeing

Estuaries are formed where fresh water from rivers runs out to sea, and are either permanently or periodically open to the sea. The influence of the tides and the changing mixture of freshwater and seawater make estuaries special ecosystems that are important for a range of ecological processes and ecosystem services.

Perhaps the most obvious economic contribution of estuaries is as nursery sites for inshore marine fisheries. It is estimated that about half of the 160 species of fish that occur in South African estuaries are utilised in subsistence, recreational or commercial fisheries. At least 60% of these species are entirely or partially dependent on estuaries. Depending on bioregion and fishery sector, up to 83% of the catch by inshore fisheries may comprise estuary-associated species.* The total value of estuary fisheries and the contribution of estuary fish to the inshore marine fisheries was estimated to be R1.2 billion per year in 2011.** The value of the Knysna estuary to subsistence fisheries alone was estimated to be at least R0.7–R1.1 million per year in 2005.***

The St Lucia Lake system, South Africa's flagship estuary, has particular ecological significance as a nursery ground for marine species which spawn at sea and whose juveniles are either wholly or partially dependent on St Lucia to complete their life cycles. The estuary is the most important juvenile fish nursery on the southeast African coastline, contributing to the fish population of a large area of the offshore continental shelf particularly adjacent to the Thukela Bank and Richards Bay area. In addition it is an important nursery ground for juvenile penaeid prawns that come from South Africa's

(a) (b)

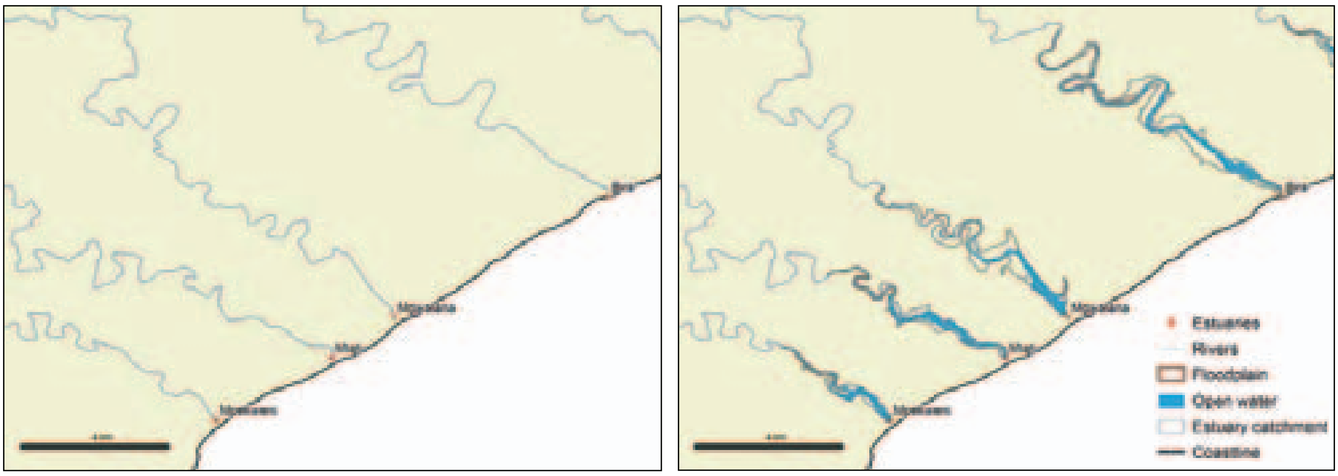


Figure 42.—(a) In the NSBA 2004, spatial data on estuaries was limited to points along the coastline; (b) in the NBA 2011 the actual extent of the estuarine functional zone has been mapped for each estuary, including the open water area and the floodplain. An example from the Eastern Cape is shown. This spatial data layer is useful not only for the NBA but also for planning in coastal municipalities and provinces, for EIAs, and for supporting the implementation of the Integrated Coastal Management Act.

[39]The spatial data layer of the estuarine functional zone is useful for a range of other applications as well. For example, the existence of this layer made it possible for the EIA regulations published in July 2010 to refer to the estuarine functional zone as a sensitive area that triggers certain EIA requirements. It will also enable estuaries to be included more meaningfully in municipal spatial planning, and will support the implementation of the Integrated Coastal Management Act.

[40]The St Lucia Lake system is made up of the St Lucia and uMfolozi estuaries. St Lucia is fed by five river systems with many feeder streams and wetlands.

only breeding population on the Thukela Banks.# Results from research in the near-shore marine environment have now linked population decreases in some adult breeding stocks to the closure of the St Lucia Lake system.##

The Knysna estuary is an economic asset for the Eden District.

Estuaries provide a range of other services to society beyond fisheries. Many estuaries provide raw materials such as reeds and sedges for crafts and fencing, firewood, timber and poles from mangrove forests. These goods are particularly important in rural localities where surrounding populations are predominantly poor. It has been estimated that vegetation harvesting from the St Lucia Lake system is worth over R4.7 million every year.###

Estuaries provide a significant buffer against floods with a total open water area of just over 60 000 ha and flood plain storage, as represented by the estuarine functional zone of approximately 170 000 ha. The sand berms that develop in front of more than 75% of South Africa's estuaries during low-flow periods provide significant protection against coastal storms. Estuaries also play an important role in the treatment of wastes, in particular providing this service to a number of urban centres that dispose waste water into them.

Estuaries attract people, providing visitors with safe bathing areas, a place for water sports, and beautiful scenery. According to a 2005 study, over 840 000 people visit the Knysna estuary annually, more than half of whom are overnight visitors. The aesthetic value of the Knysna estuary is believed to add an additional R150–R200 million to property prices per annum.***

* Lamberth S.J. & Turpie J.K. 2003. The role of estuaries in South African fisheries: economic importance and management implications. *African Journal of Marine Science* 25: 131–157.

** Van Niekerk L. & Turpie J.K. (eds). 2012. *National Biodiversity Assessment 2011: Technical Report. Volume 3: Estuary Component*. CSIR Report Number CSIR/NRE/ECOS/ER/2011/0045/B. CSIR, Stellenbosch. Figure updated from Lamberth & Turpie 2003.

*** Turpie, J., Clark, B., Napier, V., Savy, C. & Joubert, A. 2005. *The Economic Value of the Knysna Estuary, South Africa*. A report submitted to Marine and Coastal Management, Department of Environmental Affairs and Tourism.

Box on St Lucia in NBA estuary component technical report, provided by Prof. D. Cyrus.

Mann, B.Q. & Pradervand, P. 2007. Declining catch per unit effort of an estuarine dependent fish, *Rhabdosargus sarba* (Teleostei: Sparidae), in the marine environment following closure of the St Lucia Estuarine System, South Africa. *African Journal of Aquatic Science* 32: 133–138.

Collings, S.L. 2009. Economic Consequences of Ecological Change: Restoration options for the Mfolozi Floodplain and implications for Lake St Lucia, South Africa. MSc thesis, Rhodes University, Grahamstown.

Panel 8: Defining estuary ecosystem types

South Africa has a great diversity of estuaries, from cool temperate estuaries on the west coast, where salt marshes are the dominant vegetation, to subtropical estuaries on the east coast with their mangroves and swamp forests. In addition, different estuaries have different mouth states, ranging from permanently open estuaries to those that only open to the sea from time to time.

The NSBA 2004 used 13 estuary groups based on Whitfield's 1992 South African Estuarine Classification System, with by far the majority of estuaries falling into two of the 13 groups. In the NBA 2011 we have classified South Africa's 291 estuaries into 46 estuarine ecosystem types. The 46 estuary ecosystem types enable greater resolution in the assessment than the Whitfield classification, particularly of temporarily open/closed estuaries, which make up the bulk of South Africa's estuaries.

As noted in Chapter 3, ecosystems can be defined at a range of scales and classifying ecosystems is a complex task, often involving biophysical surrogates for the complex interactions between species and their abiotic environments. The 46 estuarine ecosystem types were based on four factors: estuary size, mouth status, salinity structure, and catchment type (related to freshwater input). The size of an estuary is related to a range of estuarine characteristics such as tidal flows and diversity of habitat types within the estuary. Mouth status means whether the estuary is permanently open to the sea or whether it closes from time to time. Salinity structure refers to whether the estuary is marine dominated, freshwater dominated, or mixed, and depends on the runoff from the catchment as well as the volume of the estuary. The type of freshwater input from the catchment can be predominantly clear, turbid, or black water (from tannin rich, nutrient poor rivers). Examples of estuary ecosystem types based on these four factors are Large Closed Mixed Clear estuaries, Small Closed Fresh Black, and Large Open Marine Turbid. Estuaries of the same type are expected to share similar functionality and ecological characteristics. Some types are more sensitive to change and some more resilient than others.

The 46 estuary ecosystem types can be grouped according to the three biogeographic regions along South Africa's coast: cool temperate (west coast, 12 estuary ecosystem types, 34 estuaries), warm temperate (south and southeast coast, 18 estuary ecosystem types, 124 estuaries) and subtropical (east coast, 16 estuary ecosystem types, 134 estuaries). The biogeographic regions reflect oceanic conditions and influence species diversity in estuaries.

These estuary ecosystem types should be refined based on higher resolution data on catchment hydrology, bathymetry, sediment structure, and water column characteristics such as turbidity and salinity. There is also a need for improved biological data such as estuarine invertebrate data, which has not been systematically collected and would assist with validating the estuary ecosystem types.

7.1 Estuarine ecosystem threat status

As explained in Chapter 3, ecosystem threat status tells us about the degree to which ecosystems are still intact, or alternatively losing vital aspects of their structure, function and composition, on which their ability to provide ecosystem services ultimately depends.

Estuaries have many uses and functions (see Box 13), which also means they face multiple, cumulative pressures (see Box 14). Estuary condition describes the extent to which an estuary has been modified by human activity, and is influenced by activities that take place throughout the catchment that feeds the estuary, not just at the site of the estuary itself. Condition is measured by the Department of Water Affairs' Estuarine Health Index, using the same Present Ecological State categories as those for rivers and wetlands, ranging from A (natural, unmodified) through to F (critically/extremely modified) (see Table 2 in Chapter 3). Estuaries are considered to be in good ecological condition if their Present Ecological State category is A or B, fair condition if C or D, and poor condition if E or F.

Figure 43(a) shows a breakdown of estuary condition based on **number** of estuaries. It provides a relatively rosy picture, with most estuaries in good or fair ecological condition. However, the estuaries in good condition are often the smaller ones. Bigger estuaries tend to be in poor condition, with St Lucia, South Africa's biggest estuary by far, being a case in point.[41] Figure 43(b) shows a breakdown of estuary condition by estuarine **area**, and provides a less positive picture, with St Lucia dominating the poor ecological condition of estuaries along the subtropical east coast, and almost no estuarine area on the temperate west coast in good condition.

Estuaries along the south and southeast coast tend to be

[41] St Lucia is currently in an E ecological category. The uMfolozi estuary, which makes up part of the St Lucia Lake System, is in a D ecological category.

healthier than those in the rest of the country. The numerous small estuaries along the Wild Coast have the best overall health. The KwaZulu-Natal south coast has the highest number of estuaries in a poor condition, largely as a result of loss of natural habitat, discharge of waste water and artificial breaching related to development pressures in the estuarine functional zone. In general, urban estuaries tend to be in fair to poor health along the intensively developed areas of the Cape southwest coast, around Port Elizabeth, and almost all of the KwaZulu-Natal coast.

Six South African estuaries have been designated as wetlands of international significance under the Convention on Wetlands of International Importance (Ramsar Convention), to which South Africa is a contracting party:[42] Heuningnes (also known as De Mond State Forest), Kosi, Orange (Gariep), the St Lucia Lake System, Verlorenvlei and Wilderness. These estuaries collectively represent just over 57 000 ha. Only two of these estuaries, Wilderness and Kosi, are in good ecological condition, with the remaining ones in fair to poor condition. Below we discuss two of the Ramsar estuaries in more detail: St Lucia, which is the largest estuary and in poor condition; and the Orange River Mouth, which is listed on the Montreux Record.

Although situated within the iSimangaliso Wetland Park protected area, a World Heritage Site, St Lucia is impacted upon by activities in its catchment and reduction in freshwater flows from the rivers feeding the lake, much of which occurs beyond the borders and jurisdiction of the protected area. The most significant impact has been the artificial separation of the uMfolozi River Mouth from Lake St Lucia, dating from the 1950s, reducing freshwater inflow to the lake by more than half in low flow periods. Com-

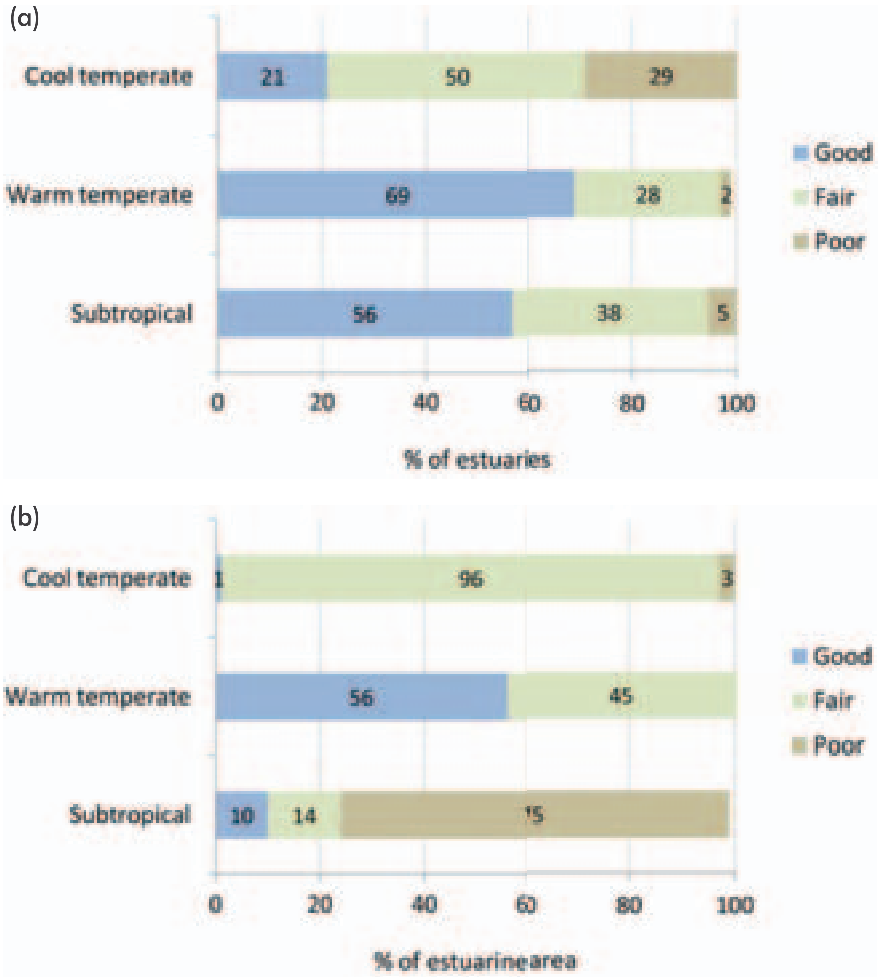


Figure 43.—Condition of cool temperate, warm temperate and subtropical estuaries, based on (a) number of estuaries, and (b) estuarine area. In the subtropical region, estuaries in poor condition include St Lucia, which accounts for more than half of South Africa's estuarine area.

Estuaries on the south and southeast coast tend to be in better ecological condition than those elsewhere in the country.

[42]The Ramsar Convention takes a broad view of wetlands that encompasses all aquatic ecosystems, including rivers, lakes, estuaries and some marine areas. South Africa has 20 Ramsar sites, of which six are estuaries.

bined with drought conditions, this has resulted in St Lucia being closed to the sea for much of the last decade, unable to fulfil its role as the most important nursery area for marine fish along the southeast African coastline, among other impacts. Fortunately, this is a reversible state of affairs: it is feasible to restore St Lucia to a fair or even good ecological condition through the re-linking with the uMfolozi, thereby increasing freshwater flow to the lake and providing for a stable mouth regime that will restore the ecological functioning of the system. The iSimangaliso Wetland Park Authority has prioritised the restoration of St Lucia and has raised funds through the Global Environment Facility to investigate and implement long-term solutions. Supported by Ezemvelo KZN Wildlife, it has initiated measures to facilitate the re-linking of St Lucia and uMfolozi and to monitor the responses of the system to management measures, thereby reversing a 60-year management approach. The St Lucia Lake system is a national asset and restoring its health should be seen as a national priority.

The Orange River Mouth is one of two sites that South Africa has listed on the Ramsar Convention's Montreux Record, a register of Ramsar sites under threat. On-site activities such as mining and road development have played

Box 14: Key pressures on estuaries

Estuaries face pressures from three main sources: activities that take place in and around the estuary, changes to the flow of fresh water into the estuary, and land use practices throughout the catchment that feeds the estuary. They are often a focal point for the cumulative impact of pressures from all three of these sources. On the upside, estuaries can also provide a focal point for collaborative action to improve ecosystem management.

Change in freshwater flow is one of the biggest pressures on many estuaries. In most cases, the change is a **decrease in the quantity of fresh water that reaches the estuary**, often combined with a decrease in water quality. Large dams, small dams, direct abstraction of water from rivers, invasive alien plants in the catchment, and land uses such as plantation forestry all lead to decreases in freshwater flows to estuaries. In estuaries that close, a decrease in flow means that the estuary mouth does not open as frequently as it should, leading to a range of problems including increased back-flooding and possible damage to property (see discussion of mouth manipulation below). In 2010 there were two examples of estuaries that closed for the first time ever: the Kobonqaba in the Eastern Cape and Uilkraals in the Western Cape. Mouth closure at the Kobonqaba caused die-back of 90% of the estuary's white mangrove trees, an important resource for the local community. Altogether, approximately 40% of the flow from South Africa's 20 largest catchments no longer reaches the estuaries concerned. Important processes that can be compromised through altered fresh water flow include nursery functions, maintenance of coastal habitats, environmental cues, productivity and food webs.

Inappropriate land use and development in and around the estuary (in the estuarine functional zone), including low-lying developments; land reclamation; mining; infrastructure development such as roads, bridges and jetties; or the remodelling of part of an estuary for harbour or marina construction (involves dredging). Harbours and marinas usually involve major alteration of estuarine habitats and tidal flows.

Development in the estuarine functional zone impacts on the ecological functioning of an estuary.

Poor agricultural practices such as ploughing in floodplains and overgrazing can cause increased sediment loading in estuaries. An example is the sugar farming along the KwaZulu-Natal coast that encroaches onto river banks, resulting in sedimentation of estuaries as well as pollution of coastal aquatic systems.

Mouth manipulation, for example artificial breaching (the most pervasive one), channelisation, redirecting or diverta role in the degradation of the Orange River Mouth. However, the impacts originating upstream have fundamentally transformed the estuary, through modification of natural flow regimes, with large dams situated over 1 000 km upstream exerting a powerful influence over the dynamics of the estuary. Not only are the large dams reducing floods to the estuary, but the hydroelectric power schemes are also elevating winter baseflow. The result is that the Orange River Mouth has not closed in nearly 20 years. This, in turn, is causing the soil salinities to increase dramatically resulting in die-off of the extensive salt marshes in the

The St Lucia Lake system is made up of the St Lucia and uMfolozi estuaries. St Lucia is fed by five river systems with many feeder streams and wetlands.

ing the outlet. In most cases, the need for mouth manipulation stems from inappropriate development in the estuarine functional zone. Nearly 75% of all estuaries in South Africa close. When an estuary is closed, the water level in the estuary rises above sea level, called back-flooding. Mouth manipulation is often driven by an increase in closed mouth conditions as a result of reduced freshwater inputs, which can lead to back-flooding, increasing the pressure on authorities to manipulate the mouth. Changes in mouth dynamics, such as the manipulation of mouths to maintain constant water levels of prevent flooding of holiday homes, removes the natural stresses than maintain estuarine processes and functioning. Ultimately it leads to infilling and loss of habitat.

Over-exploitation of estuarine resources such as fish. All the large systems in South Africa are heavily overexploited, especially in terms of their linefish. Fishing effort is especially high in some estuaries such as Olifant, Berg, Bot and Kosi. Key nursery areas and collapsed fish stock should be avoided. Bait collection (e.g. mud-prawns and sand-prawns, pencil bait and bloodworm) can also damage estuaries. Bait populations are often quite resilient, but the concern is often habitat loss and destruction due to inappropriate gear, for example bait-digging with spades.

Pollution of estuaries is a large and growing problem. Sources of pollution include agricultural fertilizers, herbicides and pesticides from irrigation return flows, waste water treatment works that discharge either directly into the estuary or just upstream, industrial effluent such as heavy metals and oils (for example, organic-rich fish factory effluent along the West Coast), and stormwater which is often contaminated with litter, toxins and untreated sewage. A new concern is desalination plants, which generate a brine effluent.

Aquaculture and mariculture. Waste from mariculture activities can lead to pollution of estuarine and coastal waters, including nutrient enrichment from disposal of faecal matter. Erection of inlet and effluent pipelines can result in the degradation of riparian areas and sensitive dunes. Large areas of indigenous vegetation may be removed to make way for infrastructure related to aquaculture or mariculture. An even greater threat is the spread of disease to wild populations and genetic contamination of wild populations that affects their ability to survive.

Catchment health is an important factor in estuary health. For example, if there is little natural vegetation in a catchment, and much of its water is used for agricultural or industrial purposes, the estuary linked to that catchment is likely to be in a poor condition. A general trend is that estuaries fed by larger catchments tend to be in poorer health than estuaries in neighbouring smaller catchments. This is partly because larger catchments have larger rivers, and larger rivers tend to be more heavily utilised, and partly because estuaries fed by larger catchments are usually larger, and thus attract more coastal development and other economic activity.

Smaller estuaries (and their related smaller catchments) generally tend to be subjected to fewer pressures. If there are no direct development pressures such as urban development on these smaller estuaries, they tend to be healthy. In contrast, large estuaries are often subject to more catchment-related pressures as well as more direct development pressures.

lower reaches. Over the past ten years some progress have been made towards restoring tidal flooding in previously closed off areas through the partial removal of a mining access road. New plans are afoot to remove this obstruction completely, but the most important requirement is to decrease baseflows in winter, which would allow for mouth closure and back flooding of the salt marshes to lower soil salinities.

A single estuary ecosystem type can include some estuaries in good ecological condition and others in poor condition. This is why the NBA does not simply assess the condition of estuaries but takes the analysis further to look at the proportion of each estuary ecosystem type that remains in good ecological condition, giving an assessment of ecosystem threat status for estuary ecosystem types. See Chapter 3 for more on how ecosystem threat status is calculated.

Ecosystem threat status for estuary ecosystem types is summarised in Figure 44. As with all the statistics for estuaries, the results differ dramatically depending on whether they are reported by estuarine area or number of estuary ecosystem types, because of the St Lucia effect. By proportion of estuarine area, 79% is critically endangered, 1% endangered, less than 1% vulnerable and 21% least threatened. By number of estuarine ecosystem types, 39% (18 of the 46 types) are critically endangered, 2% endangered (one type), 2% vulnerable (one type) and 57% least threatened (26 types). Whether the results are reported by estuary ecosystem type or estuarine area, the proportion of threatened ecosystem types is highest in the cool temperate region and lowest in the warm temperate region. Should the ecological condition of St Lucia improve, the results reported by area would improve dramatically.

Like wetlands, estuaries tend to be relatively resilient ecosystems and often respond well to restoration and rehabilitation efforts. However, past a certain point even the most resilient of estuaries will not be able to recover the ecological functioning that is critical for ongoing provision of estuarine ecosystem services.

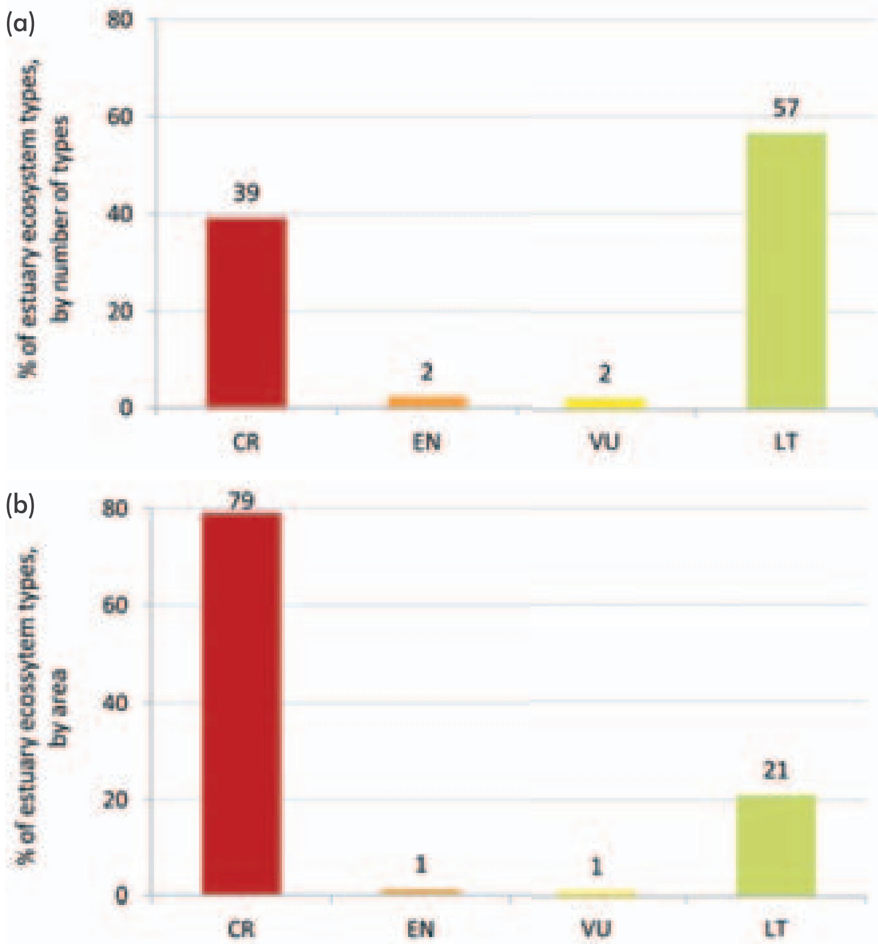


Figure 44.—Summary of ecosystem threat status for estuary ecosystem types, (a) by number of ecosystem types, and (b) by area of ecosystem types. The poor condition of St Lucia, South Africa's largest estuary, contributes to the high proportion of threatened estuary ecosystem types reported by area.

The work done for the estuary component of the NBA 2011 included a National Estuary Biodiversity Plan, the first of its kind, which identified a set of 120 national priority estuaries (see Chapter 12). These estuaries are priorities for the development of Estuary Management Plans in terms of the Integrated Coastal Management Act (Act 24 of 2008). Ultimately they should be partially or fully protected, as discussed below. In addition, urgent attention should be focused on maintaining the health of the last remaining healthy examples of critically endangered and endangered estuary ecosystem types.

The assessment of ecosystem threat status for estuaries would be strengthened by a more complete assessment of estuary condition, based on better data on freshwater flow to estuaries, better data on pollution especially from the immediate surrounds of the estuary and the river reach directly above the estuary, updated data on fishing pressures in estuaries, and improved land cover data. It is important for data-driven assessments of the ecological condition of estuaries to take place at regular intervals.

7.2 Estuarine ecosystem protection levels

As explained in Chapter 3, ecosystem protection level tells us whether ecosystems are adequately protected or under-protected. By protected, we mean included in a protected area recognised by the Protected Areas Act, such as a National Park, Nature Reserve or Marine Protected Area (see Panel 4 in Chapter 3).

The NSBA 2004 highlighted that some estuarine ecosystem groups were better protected than others, and that almost no individual estuaries were fully protected. In 2011 we were able to assess protection levels based on estuarine area, not just numbers of estuaries, following the advances in estuary mapping since 2004.

Protecting an estuary is not easy. It involves meeting the freshwater flow requirements of the estuary, in terms of both quantity and quality of water; ensuring that there is no inappropriate development in the estuarine functional zone; **and** preventing unsustainable exploitation of estuarine species (such as fishing and bait collection). Ideally, an estuary needs to be protected from the land side with a land-based protected area and from the aquatic side with a no-take marine or estuarine protected area, thus making estuaries difficult to protect fully. Fortunately, as discussed above, estuaries are relatively resilient and in some cases partial protection rather than full protection is adequate. Measures for achieving partial protection are discussed below.

Sixty percent of South Africa's estuarine area of 90 000 ha, or 69 out of 291 estuaries, currently has some form of protection, either full or partial. This seems at first glance like a healthy picture. However, most of this area is accounted for by South Africa's largest estuary, the St Lucia Lake system, which falls within the iSimangaliso Wetland Park but, as discussed above, is currently in poor condition. The remaining protected estuaries make up just 10% of South Africa's estuarine area, reflecting the fact that protected estuaries are often the smaller ones. Only 14 estuaries have full no-take protection.

It is not only the St Lucia Lake system that is protected by law but in poor condition in practice. Other estuaries to which this applies are uMngeni, uMhlanga, Seekoei, Heuningnes, Sand, Wildevoëlvlei, Diep and Orange. As explained in Chapter 3, if an ecosystem is not in good ecological condition, it is not considered to contribute towards the protection level for that ecosystem type. This has a dramatic impact on the results for estuary ecosystem protection levels. Figure 45 shows that 59% of South Africa's estuary ecosystem types have no protection and a third of estuary ecosystem types are well protected. However, if the results are reported by area, only 14% of estuary ecosystem types are well protected. If degraded estuaries that currently have some form of protection (St Lucia, uMfolozi, uMngeni, uMhlanga, Seekoei, Heuningnes, Sand, Witvoëlvlei and Diep) were to be restored to good ecological condition, the results of the estuarine ecosystem protection level analysis presented below would improve dramatically, with the proportion of well protected estuary ecosystem types increasing to 46% of the number of types and over 70% by area. This shows that a number of protected areas are currently in the right locations to protect estuarine ecosystems and that with management interventions significant progress in protection levels of estuaries could be achieved in the relatively short term.

A breakdown by biogeographical region, shown in Figure 46, reveals that the cool temperate region has the highest numbers

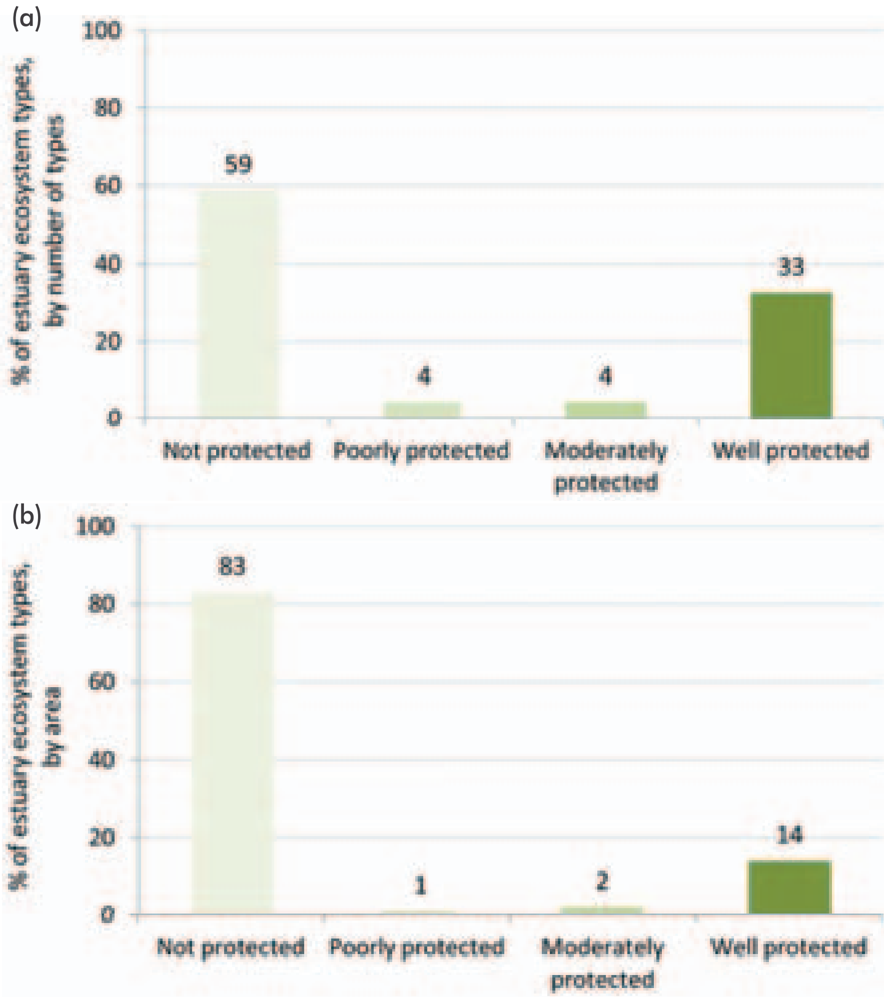


Figure 45.—Summary of ecosystem protection levels for estuary ecosystem types (a) by number of ecosystem types, and (b) by area of ecosystem types. Estuaries that are not in good ecological condition are not considered to contribute to the protection level for that estuary ecosystem type. If the health of degraded estuaries within protected areas were to improve, the proportion of well protected estuaries would increase substantially.

of unprotected estuary ecosystem types, whether by number of types or by area.

As noted above, the work done for the estuary component of the NBA 2011 included a National Estuary Biodiversity Plan which identified a national set of 120 priority estuaries, 58 of which require full protection, and 62 of which require partial protection (see Chapter 12). Full protection of an estuary requires including it in a no-take protected area and ensuring that its freshwater flow requirements are met, as discussed above. Partial protection can be achieved through a range of measures, for example, zonation to establish one or more no-take zones, closed seasons, bans on night fishing (when bigger fish that make up the breeding stock tend to be caught), bag limits or restrictions on certain types of fishing gear. Different measures are appropriate for different estuaries, depending on their ecological characteristics and socio-economic role. All priority estuaries, whether they require full or partial protection, are priorities for determining and implementing freshwater flow requirements and for developing Estuary Management Plans in terms of the Integrated Coastal Management Act. All estuaries, whether priority estuaries or not, benefit from having intact buffers of natural vegetation along the estuary perimeter, which filter sediment and pollutants from surrounding land uses and help to maintain the ability of the estuary to provide ecosystem services.

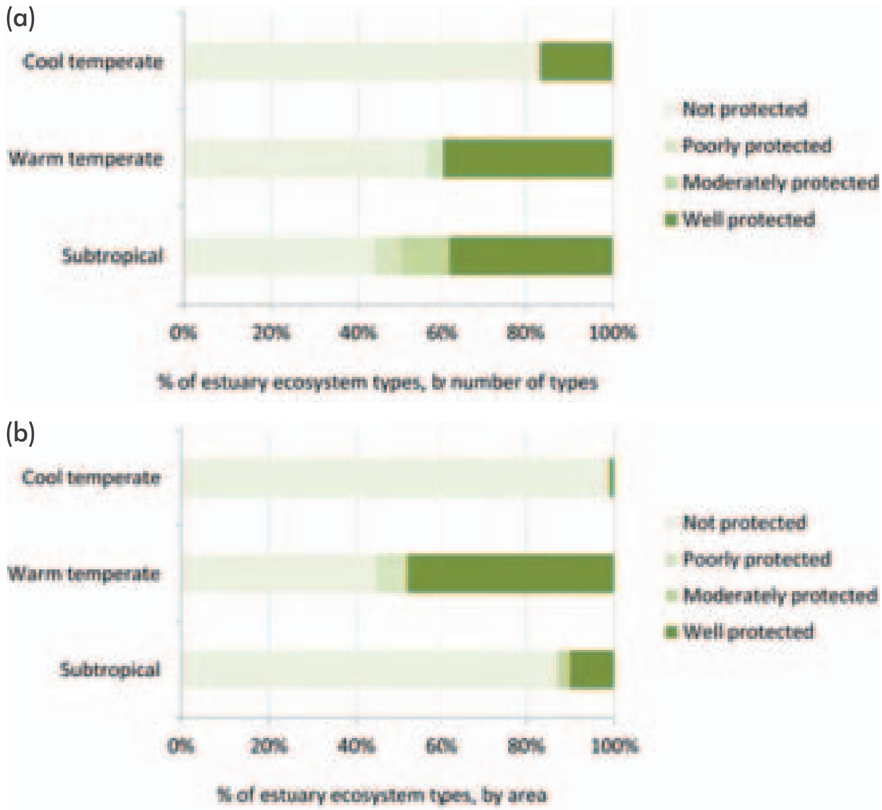


Figure 46.—Ecosystem protection levels for estuary ecosystem types by biogeographical region, (a) by number of ecosystem types, and (b) by area of ecosystem types. The cool temperate region has the highest numbers of unprotected estuary ecosystem types, whether the results are reported by number of types or by area.

In Section 7.1 we highlighted Ramsar estuaries that are in poor condition. There are two Ramsar estuaries that have no formal protection in terms of the Protected Areas Act—Verlorenvlei and the Orange River Mouth. These two estuaries should be top priorities for protected area expansion, as well as for having their freshwater flow requirements met. An initiative is currently underway to declare the Orange River Mouth and surrounding area a protected area, with longer term plans to develop a Transfrontier Conservation Area in partnership with Namibia.

In addition to expanding the estuarine protected area estate, attention should be paid to restoring those estuaries that are currently protected by law but in poor condition in practice, as highlighted in the discussion above. Together, these actions will allow the achievement of national protection objectives for estuaries.

The Orange River Estuary is one of two Ramsar estuaries that have no formal protection in terms of the Protected Areas Act.

8. Marine and coastal ecosystems

Chapter summary

Coastal & inshore ecosystems	• Ecosystem threat status: 58% of ecosystem types threatened • Ecosystem protection level: 9% of ecosystem types well protected, 16% not protected • Key ecosystem services: fishing, recreation, ecotourism, protection from the impacts of storms • Key pressures: fishing, coastal development, decrease in freshwater reaching the coast and sea, invasive alien species
Offshore ecosystems	• Ecosystem threat status: 41% of ecosystem types threatened • Ecosystem protection level: 4% of ecosystem types well protected, 69% not protected • Key ecosystem services: fishing, recreation, trade and transport • Key pressures: fishing, mining (e.g. diamonds, oil and gas), shipping

Marine and coastal ecosystems form the basis for South Africa's fishing industry, support key mining activities and provide an array of opportunities for recreation, tourism and settlements, with the coast in particular being a focus for human activity and development. They are also exceptionally diverse, straddling three oceans, with habitats ranging from cool-water kelp forests to subtropical coral communities and a vast array of species. Pressures on marine and coastal ecosystems are multiple, and tend to be more intense along the coast and inshore, which are more accessible to people than the open ocean. Coastal development is the biggest pressure on coastal ecosystems, and fishing is the biggest pressure in most inshore and offshore ecosystems. Fishing not only impacts on the targeted species and those caught as by-catch—and thus on food webs and ecosystem dynamics—but also causes direct damage to marine habitats in some cases. For example, trawling of the seabed can be likened to ploughing in the terrestrial environment, with severe impacts that may be irreversible in some habitats.

The NBA 2011 mapped and classified marine and coastal habitat types for the first time in South Africa, providing the basis for the first national assessment of marine and coastal ecosystems at a meaningful scale. The assessment covered South Africa's mainland Exclusive Economic Zone, which extends 200 nautical miles offshore.

For coastal and inshore ecosystem types, 58% are threatened (24% critically endangered, 10% endangered and 24% vulnerable), compared with 41% of offshore ecosystems types (11% critically endangered, 8% endangered and 22% vulnerable), reflecting the fact that coastal and inshore ecosystems are more heavily impacted by human activities. Nearly a quarter of South Africa's population lives within 30 km of the coast, and already nearly a fifth of the coast has some form of development within 100 m of the shoreline. Such development not only puts people and property directly at risk, but also compromises the ability of coastal ecosystems to buffer the impacts of sea-level rise and sea storms, all the more important in the face of climate change. In the offshore environment, habitat types along the shelf edge (the steep area where the ocean floor drops off into the continental slope and abyss) are particularly threatened because of the concentration of pressures such as trawling and long-lining on this narrow, highly productive area.

Currently the marine protected area network is focused almost entirely on the coast and inshore, providing almost no protection to offshore ecosystems. Only 9% of coastal and inshore ecosystem types are well protected, but the majority have at least some form of protection, with only 16% not protected at all. In the offshore environment, only 4% of ecosystem types are well protected and 69% are not protected at all.

Marine protected areas (MPAs) are often divided into zones, including no-take zones where no extractive use (such as fishing) is allowed, and extractive use zones where various forms of harvesting are permitted. Because fishing is the biggest pressure on marine ecosystems, the degree of protection provided by no-take zones is higher. Coastal MPAs that allow extractive use can actually become nodes of increased exploitation by fishers, rather than providing protection. Increasing the number and size of strategically placed no-take zones in existing MPAs would result in a substantial increase in the proportion of well protected coastal and inshore ecosystem types. A national coastal biodiversity plan is an urgent priority to identify coastal ecosystem priority areas, including priorities for consolidating, zoning and expanding coastal MPAs. In the offshore environment, the recently completed Offshore Marine Protected Area project identifies focus areas for offshore marine protection.

The role of marine protected areas and other spatial management measures in supporting sustainable fisheries is emphasised in the ecosystem approach to fisheries management. Implementing this approach is a priority in South Africa, as discussed further in Chapter 10.

Box 15: Marine and coastal biodiversity assets support human wellbeing

Coastal and marine ecosystems have been shown to be among the greatest contributor of ecosystem services to human wellbeing worldwide. The marine environment had an estimated total global value of ecosystem services of close to US$21 trillion in 1994, almost double the value provided by the sum of terrestrial ecosystems at the same time.*

South Africa's coastal resources were estimated to be worth at least US$11 billion in 2009, equivalent to 3.6% of the country's GDP.**

Fisheries, which depend wholly on marine resources, make a significant contribution to the South African economy, with a total annual production of 600 000 tonnes valued at approximately R6 billion, about 27 000 people employed in the commercial fishing industry, and an estimated 28 000 households engaged in subsistence fishing.***

Ecotourism based on South Africa's marine and coastal environment has developed significantly over the last ten years. At a local scale, the recreational value of the beaches in and around Cape Town is calculated to be between R70 and R86 million per year.[#] Tourism along the Garden Route coast is estimated to be around 9.4 million visitor days per year, with visitors spending in order of R950 million.**

The marine protected area along the Garden Route coast contributes significantly to added value in the area, with a recreational value of around R9 million annually. Furthermore, the value that the marine protected area brings through providing a safe breeding ground for fish is estimated to be around R33 million per year.**

Intact coastal habitats are critical in both climate change mitigation and adaptation. Coastal habitats such as mangroves, salt marshes and seagrass beds sequester an estimated 120–329 million tonnes of carbon annually; the upper limit approximately equivalent to the annual release of greenhouse gases by Japan.[##] They have also been shown to be important for adapting to impacts of climate change such as sea-level rise and storm surges.

Coastal ecotourism contributes to South Africa's economy.

In order to contribute to wise decisions around resource allocation and smart development paths, better understanding the value, economic and social, of marine and coastal ecosystem services at a national level must be a priority.

* Costanza, R., D'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Niell, R.V., Paruelo, J., Raskin, R.G., Sutton, P. & Van den Belt, M. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387: 253–260.

** Turpie, J.K. 2012. *Maximising the Value of South Africa's Coast*. Research Brief, Environment for Development Programme, University of Gothenberg.

*** Department of Agriculture, Forestry and Fisheries. 2010. *Draft integrated growth and development plan, 2011 – 2031*. Department of Agriculture, Forestry and Fisheries, Pretoria.

De Wit, M., Van Zyl, H., Crookes, D., Blignaut, J., Jayiya, T., Goiset, V. & Mahumani, B. 2009. *Investing in Nature Assets: A Business Case for the Environment in the City of Cape Town*. Report for the City of Cape Town.

Secretariat of the Convention on Biological Diversity. 2010. *Global Biodiversity Outlook 3*. Convention on Biological Diversity, Montréal.

This chapter presents the results of the assessment of marine and coastal ecosystems, including their threat status and protection levels. It explains how marine and coastal ecosystems are defined, discusses their importance and value, and outlines some of the major pressures that impact on their condition. The methods used to assess ecosystem threat status and ecosystem protection level were explained in Chapter 3 and are not repeated in this chapter. More detail is available in the technical report for the marine and coastal component of the NBA.

The NSBA 2004 assessed threat status for 34 broad marine biozones, providing a broad-scale preliminary assessment which relied heavily on expert scoring of pressures on marine ecosystems. Since 2004, enormous progress has been made in mapping marine and coastal habitats as well as quantifying pressures on marine and coastal ecosystems. In 2011 we assessed ecosystem threat status for 136 marine and coastal habitat types (see Panel 9) based on comprehensive data on marine and coastal pressures, providing much more meaningful results to inform decision-making. The assessment relied heavily on data developed for the Offshore Marine Protected Area project (OMPA), a four-year partnership project that concluded in 2010.[43]

South Africa's marine territory extends 200 nautical miles offshore to include the Exclusive Economic Zone (EEZ). In addition to the mainland EEZ, South Africa's territory includes the Prince Edward Islands and their EEZ. The NBA 2011 covers South Africa's coast and mainland EEZ but not the Prince Edward Islands EEZ. Ideally, future NBAs should be extended to include the Prince Edward Islands territory. This would require substantial additional investment in mapping and classifying habitats as well as mapping pressures in this extended territory.

Panel 9: Defining marine and coastal ecosystem types

Mapping and classifying ecosystems is not straightforward in any environment, and for marine ecosystems the task is especially complex. Many marine ecosystems are not visible—they cannot be easily viewed with satellite images or aerial photographs; some are three-dimensional; some, especially pelagic (water column) ecosystems, are not fixed in space.

Although the NSBA 2004 identified 34 marine biozones, they were at such a broad scale that they did not provide a map of ecosystem types equivalent to those we have in other environments. Groundbreaking work since 2004 has enabled the development of a national marine and coastal habitat classification, which defines and maps 136 marine and coastal habitat types. These marine and coastal habitat types provided the basis for the ecosystem assessment in the NBA 2011, and are more or less the equivalent of terrestrial vegetation types, river ecosystem types or wetland ecosystem types.

At the broadest level, marine and coastal environment is divided into the **coastal and inshore** environment, stretching from 500 m inland to a depth of 30 m, and the **offshore** environment, stretching from a depth of 30 m to 200 nautical miles offshore (the edge of South Africa's EEZ). The coastal and inshore environment includes the coast itself (500 m inland to 5 m depth—the point where wave action ceases to impact) as well as inshore habitats (from 5 m depth to 30 m depth). The offshore environment includes **benthic** (seabed) habitats as well as **pelagic** (water column) habitats.

Factors used to classify coastal and inshore habitat types included substrate (e.g. rocky, sandy, muddy, gravel, mixed), wave exposure (sheltered, exposed or very exposed), grain size (important for

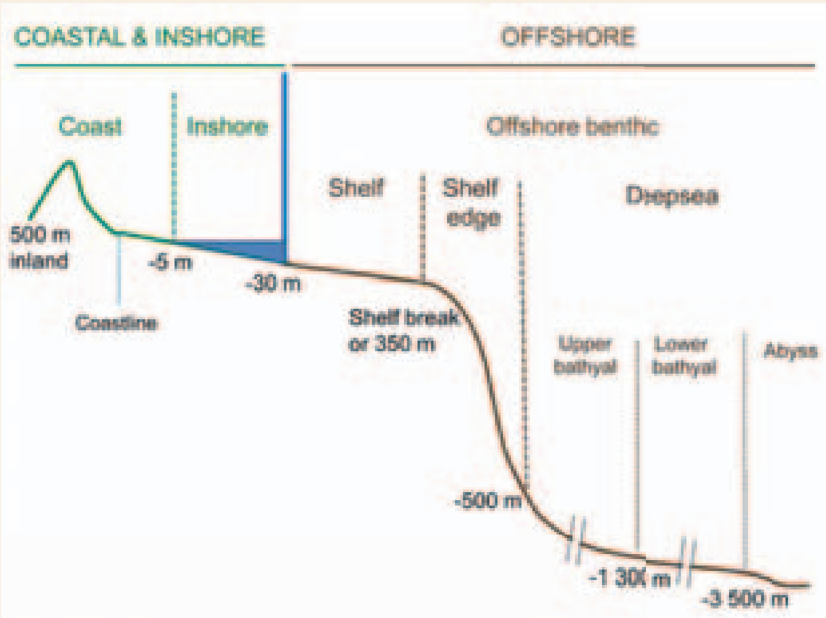
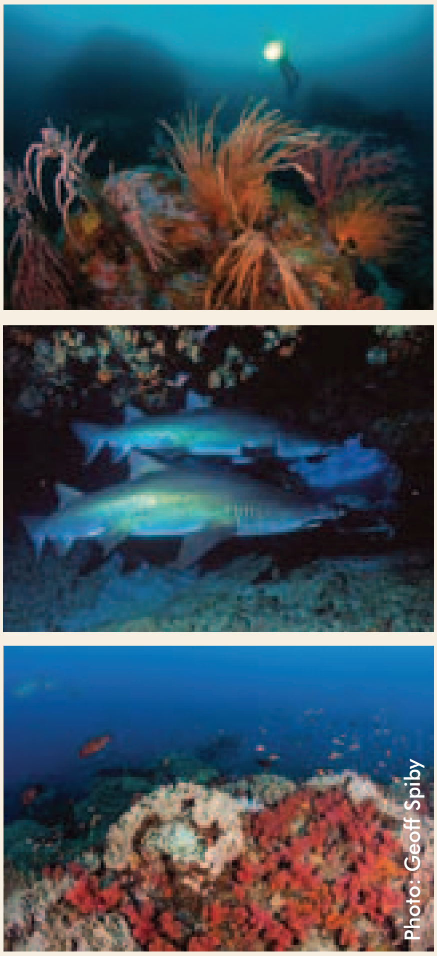


Figure 47.—Schematic diagram showing key divisions in the national marine and coastal habitat classification (not drawn to scale).

[43] Sink, K.J., Attwood, C.G., Lombard, A.T., Grantham, H., Leslie, R., Samaai, T., Kerwath, S., Majiedt, P., Fairweather, T., Hutchings, L., Van der Lingen, C., Atkinson, L.J., Wilkinson, S., Holness, S. & Wolf, T. 2010. *Spatial planning to identify focus areas for offshore biodiversity protection in South Africa*. Unpublished Report. South African National Biodiversity Institute, Cape Town.



South Africa's inshore habitat types, from 5 m to 30 m depth, include several types of reefs, such as Agulhas Inshore Reef, Natal Inshore Reef and Delagoa Inshore Reef (all shown here).

determining beach type), and biogeography (ecoregions, such as Namaqua, Agulhas, Delagoa). Coastal and inshore habitat types do not include estuaries, as these are dealt with in their own component of the NBA 2011 (see Chapter 7).*

Factors used to classify offshore benthic habitats included depth and slope (shelf, shelf edge, deep sea), substrate (e.g. hard or unconsolidated soft and gravel habitats), geology (e.g. sandy, muddy, gravel, reef, hard grounds, canyons and ferro-manganese deposits), and biogeography. In the offshore environment, depth influences a range of other factors such as light, temperature, currents, food supply and oxygen availability.

Factors used to classify offshore pelagic ecosystems included sea surface temperature, primary productivity and chlorophyll content, depth, turbidity, frequency of eddies, and distribution of temperature and chlorophyll fronts.

The resulting 136 marine and coastal habitat types consist of 58 coastal and inshore habitat types (including three island-associated habitat types), 62 offshore benthic habitat types, and 16 offshore pelagic habitats. Marine or coastal habitats of the same type are likely to share broadly similar ecological characteristics and functioning. The three-dimensional nature of the marine environment means that it is not possible to show all these ecosystems on a single map, so coastal, inshore and offshore benthic habitats are shown on one map (see Figure 49) and offshore pelagic habitats on another (see Figure 48).

To facilitate meaningful analysis, the 136 marine and coastal habitat types have been grouped into 14 broad ecosystem groups. Coastal and inshore ecosystem groups include rocky coast, sandy coast, mixed shores, rocky inshore, soft and gravel inshore, island-associated, and lagoon. Offshore

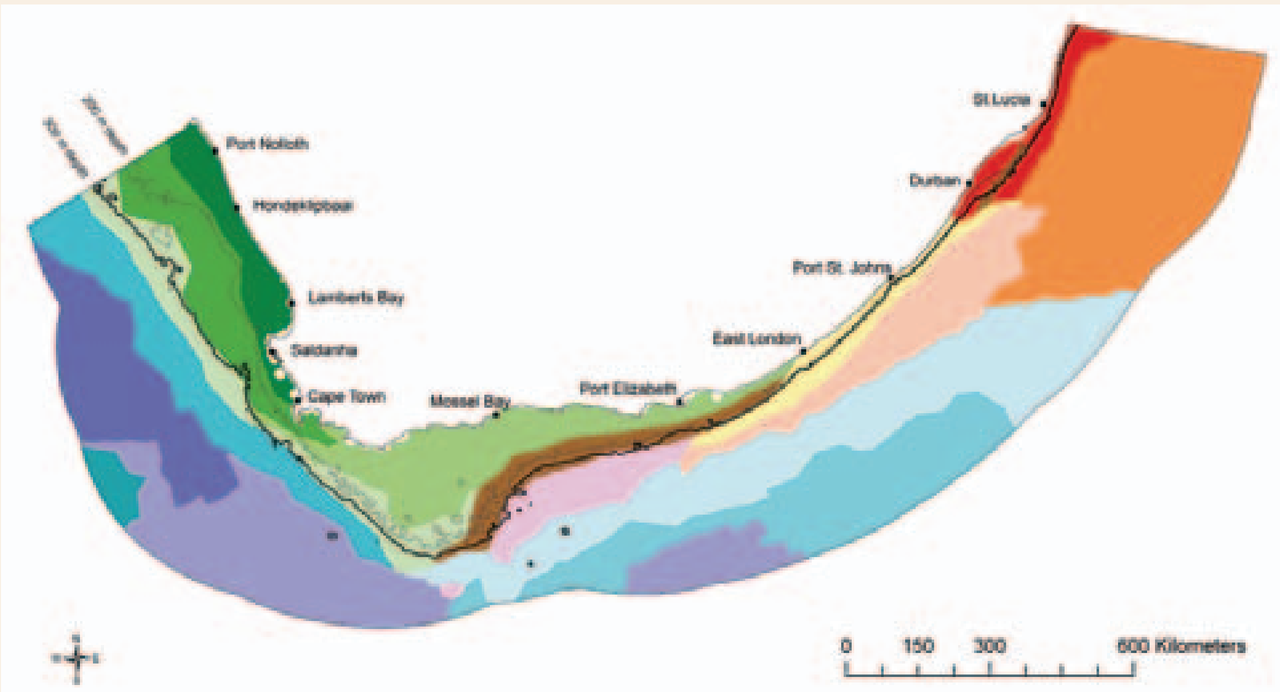


Figure 48.—Offshore pelagic (water column) habitat types in South Africa, nested within pelagic bioregions and biozones.

ecosystem groups include rocky shelf, soft and gravel shelf, rocky shelf edge, soft and gravel shelf edge, seamounts, deepsea sediments, and offshore pelagic habitat types.

The national marine and coastal habitat classification and map should be considered work in progress. The offshore pelagic classification especially should be considered preliminary. As available data improves, the delineation of habitat types will be refined.

* Coastal habitats include South Africa's one lagoon, Langebaan. Langebaan Lagoon is not considered an estuary as it receives freshwater input from groundwater rather than from a river.

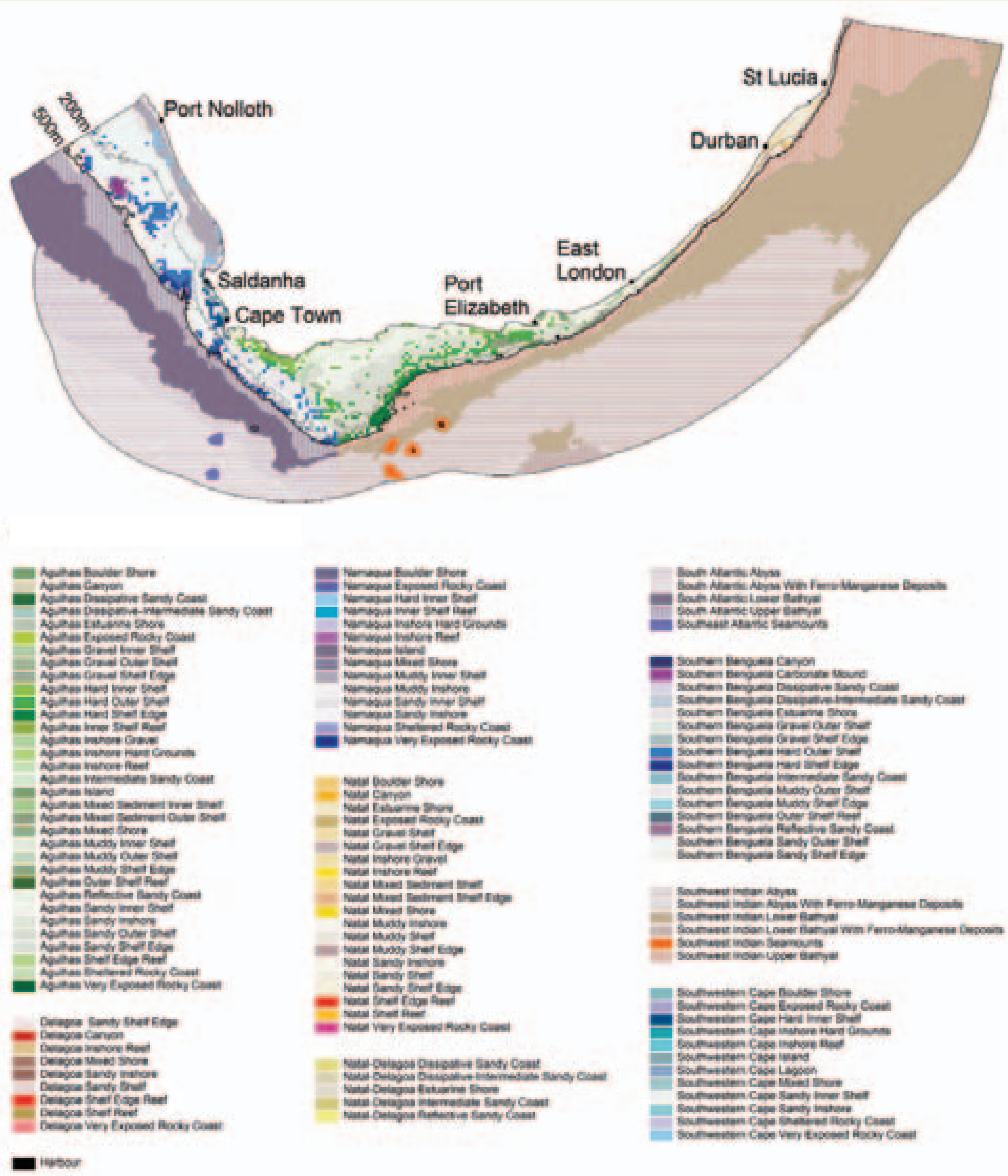


Figure 49.—Coastal, inshore and offshore benthic (seabed) habitat types in South Africa. Habitats with hard or rocky substrates are shown in solid colours; habitats with sandy, muddy, gravel or mixed substrates are shown in hatched colours. Different groups of colours represent biogeographic divisions.

8.1 Marine and coastal ecosystem threat status

As explained in Chapter 3, ecosystem threat status tells us about the degree to which ecosystems are still intact, or alternatively losing vital aspects of their structure, function and composition, on which their ability to provide ecosystem services ultimately depends.

Marine and coastal ecosystems are important for many aspects of social and economic development (see Box 15). Perhaps precisely because of this, some marine and coastal ecosystems are under great pressure from human activities (see Box 16).

Box 16: Key pressures on marine and coastal ecosystems

Marine and coastal ecosystems experience pressures from a range of human activities, especially those related to extractive use of living marine resources (fishing) and coastal development. Others include invasive alien species, mining, shipping, waste water discharge, and reduction in freshwater flow from rivers. Mariculture is an emerging pressure in the marine environment.

Fishing, including commercial, recreational, subsistence and illegal fishing, is by far the biggest pressure on most inshore and offshore ecosystems. On the whole, pressure from fishing is increasing globally as demand for fish grows and fishing technology advances. In many cases the resources on which fisheries ultimately depend—the species that are harvested—are overexploited and in decline. Although depleted fish stocks can recover in some cases if fishing effort is reduced, this can be a lengthy process and is not always successful. Fishing impacts not only on the species that are targeted for harvesting, but also on species that are caught as by-catch and species that are incidentally killed or harmed in the process, such as albatrosses, turtles, dolphins and sharks. In some cases, fishing causes damage to marine habitats. See Chapter 10 for more on harvested marine species.

Invasive alien species are a growing concern in the marine environment. Of 84 alien marine species that have been identified along South Africa's coast, eight are known to be invasive, including the Mediterranean mussel, which occupies nearly two-thirds of the coastline, and the European shore crab. Invasive species disrupt food webs and ecosystem dynamics, and can result in additional economic costs in the shipping and mariculture sectors. See Chapter 11 for more on invasive species.

Mining in the marine and coastal environment in South Africa consists mainly of diamond mining on the west coast and offshore region; oil and gas exploration and production, concentrated on the Agulhas Bank off the south coast; and dune mining for heavy metals such as titanium, mainly in northern KwaZulu-Natal. Diamond mining occurs on beaches, in the surf zone and in deep water, with different methods used for each of these, often causing habitat damage. Phosphate mining is an emerging pressure on the west coast. The greatest threat from the oil industry is the possibility of an oil spill. Although the probability is low, the environmental consequences would be severe. Mining equipment in the ocean can introduce, host and spread invasive species, with potentially serious biodiversity and economic impacts.

South Africa is a maritime nation with several major ports and considerable ship traffic. Thousands of vessels pass around Cape Point every year, including one of the highest concentrations of oil tankers and cargo ships in the world. The main ecosystem-related impacts of **shipping** come from oil spills that result from shipping accidents, and invasive alien species introduced and spread through ballast water discharge, hull fouling and dumping of waste materials. More than 22 m tonnes of ballast water are discharged in South African ports and harbours annually, and although South Africa adopted the international Ballast Water Convention in 2008 is it not yet consistently implemented. Many countries have banned the practice of cleaning ships' hulls at sea, including in-water cleaning in ports and harbours. Such a ban has not been implemented in South Africa.

Waste water discharge into the marine environment is concentrated around cities and coastal settlements and has increased dramatically in the last two decades, with currently about 70 point sources discharging into estuaries, the surf zone or offshore. Sources include municipal waste water (such as domestic sewage), effluent from fish processing operations, waste water from paper and pulp plants, chemical works and other industries, and cooling water from power stations. There are few long-term monitoring programmes of the impact of waste water discharge on the receiving environment, especially in estuaries and the surf zone.

Freshwater flow reduction to the coastal and marine environment occurs when water is abstracted from rivers or dammed higher up in the catchment and does not reach the estuary concerned or the ocean. Altogether, approximately 40% of the flow from South Africa's 20 largest catchments no longer reaches the sea, with the greatest reductions along the west coast. This leads

Fishing is the greatest pressure on most inshore and offshore ecosystems.

to decreased sediment supply to the coast, which can accelerate beach erosion and even lead to loss of beach habitat, and can impact on subtidal habitats, such as mud flats and submarine fans, with implications for fisheries (e.g. sole and white steenbras). Fresh water reaching estuaries and the ocean is also important because it provides nutrients for marine food webs, and signals for spawning, recruitment and migration of some species, for example helping juvenile fish find their way to estuaries where they live in a sheltered environment until they reach adulthood. Recent research has shown links between freshwater flow and fisheries catch data, with correlations evident as much as 40 km offshore.

Coastal development is the greatest pressure on coastal ecosystems, causing habitat loss, interrupting physical and biological process, and compromising ecosystem resilience, all of which result in loss of coastal ecosystem services. Ideally no development should take place in the littoral active zone—the geologically functional unit made up of the dunes, beach and surf zone. When it does, a vicious cycle often develops. These buildings and structures eventually require defence by seawalls, which increase the vulnerability of buildings at the edge of the wall, ultimately leading to a gradual hardening of the coast and further loss of resilience. Coastal development also reduces the ability to adapt to climate change, for example by preventing the natural landward migration of sandy beaches in response to sea-level rise. Beaches become trapped in a coastal squeeze, becoming narrower and eventually being lost as sea levels rise. Development too close to the shoreline not only compromises coastal ecosystems but it also makes people particularly vulnerable to the effects of sea-level rise and extreme coastal storms.

Mariculture is an emerging pressure in the marine and coastal environment. Although mariculture can sometimes provide options for easing pressure on over-exploited marine resources, it can also have serious negative impacts if not appropriately undertaken and managed, for example causing declines in water quality through nutrient enrichment and pollution, incubation of parasites and pathogens which may then transfer to wild stocks, introduction and spread of invasive alien species, and degradation of marine habitats. Impacts of mariculture depend on the species farmed, the method used, stocking density, feed type, husbandry practices, and the hydrography of the site, among other factors. Land-based operations are by far preferable to in situ marine operations from the point of view of the integrity of wild marine resources and ecosystems.

Climate change is likely to exacerbate the impacts of some of these pressures as well as causing additional stress on marine and coastal ecosystems, for example linked to changes in ocean temperature, acidity and sea-level rise.

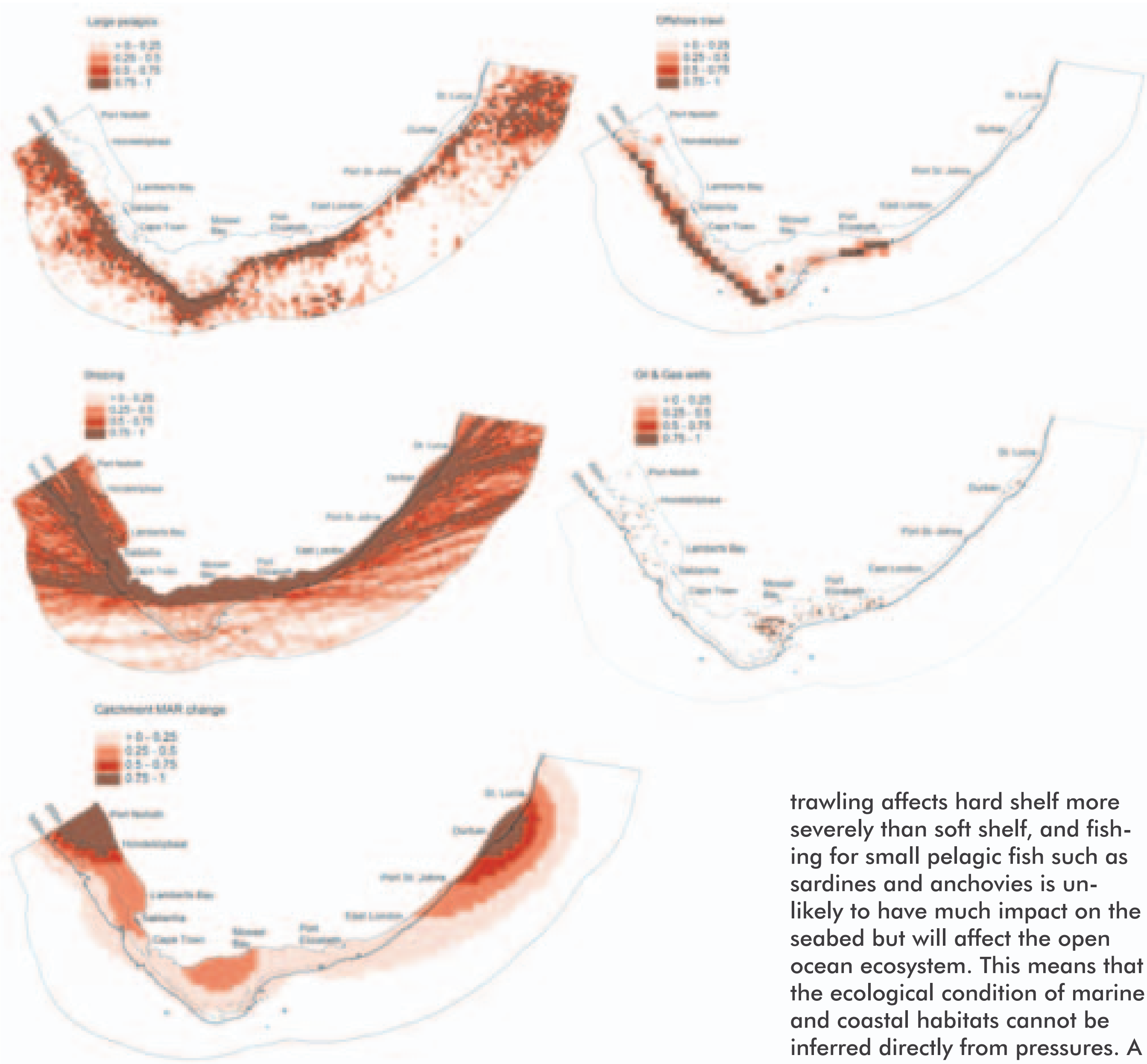


Figure 50.—The NBA 2011 mapped 27 different pressures on marine and coastal ecosystems, five of which are shown here: large pelagic longline fishery, offshore demersal trawl fishery, shipping, oil and gas wells, and reduction of freshwater flow to the coastal and marine environment. Fishing is the biggest pressure on marine ecosystems.

The ecological condition of marine and coastal ecosystems describes the extent to which they have been modified by human activity. For most marine and coastal ecosystems there is no field survey data on which to base an assessment of condition, so we have estimated their condition based on the pressures that they face, as explained below.

We mapped the intensity of 27 pressures on marine and coastal ecosystems, including 18 types of extractive marine living resource use (13 commercial fisheries, commercial kelp harvesting, two types of recreational fishing, subsistence harvesting and shark nets), petroleum activities, diamond and titanium mining, shipping, coastal development, disturbance associated with coastal access, waste water discharge, mariculture, invasive alien species and the reduction of freshwater flow into marine ecosystems. Maps of some of these pressures are shown in Figure 50.

Different marine and coastal habitats respond differently to the same pressure. For example, trawling affects hard shelf more severely than soft shelf, and fishing for small pelagic fish such as sardines and anchovies is unlikely to have much impact on the seabed but will affect the open ocean ecosystem. This means that the ecological condition of marine and coastal habitats cannot be inferred directly from pressures. A pressure-impact matrix was used to score the impact of each pressure on each marine or coastal habitat type. This matrix was then used to develop a map of ecological condition (good, fair or poor) at the site scale, using a 5′ grid (roughly 8 km by 8 km). Figure 51 shows the results.

The condition of large areas within the marine environment is good or fair. However, some areas are heavily impacted, with impacts tending to be concentrated on particular habitat types. This is why the NBA does not simply assess the condition of marine and coastal habitat types but takes the analysis further to look at the proportion of each marine or coastal habitat type that remains in good ecological condition, giving an assessment of ecosystem threat

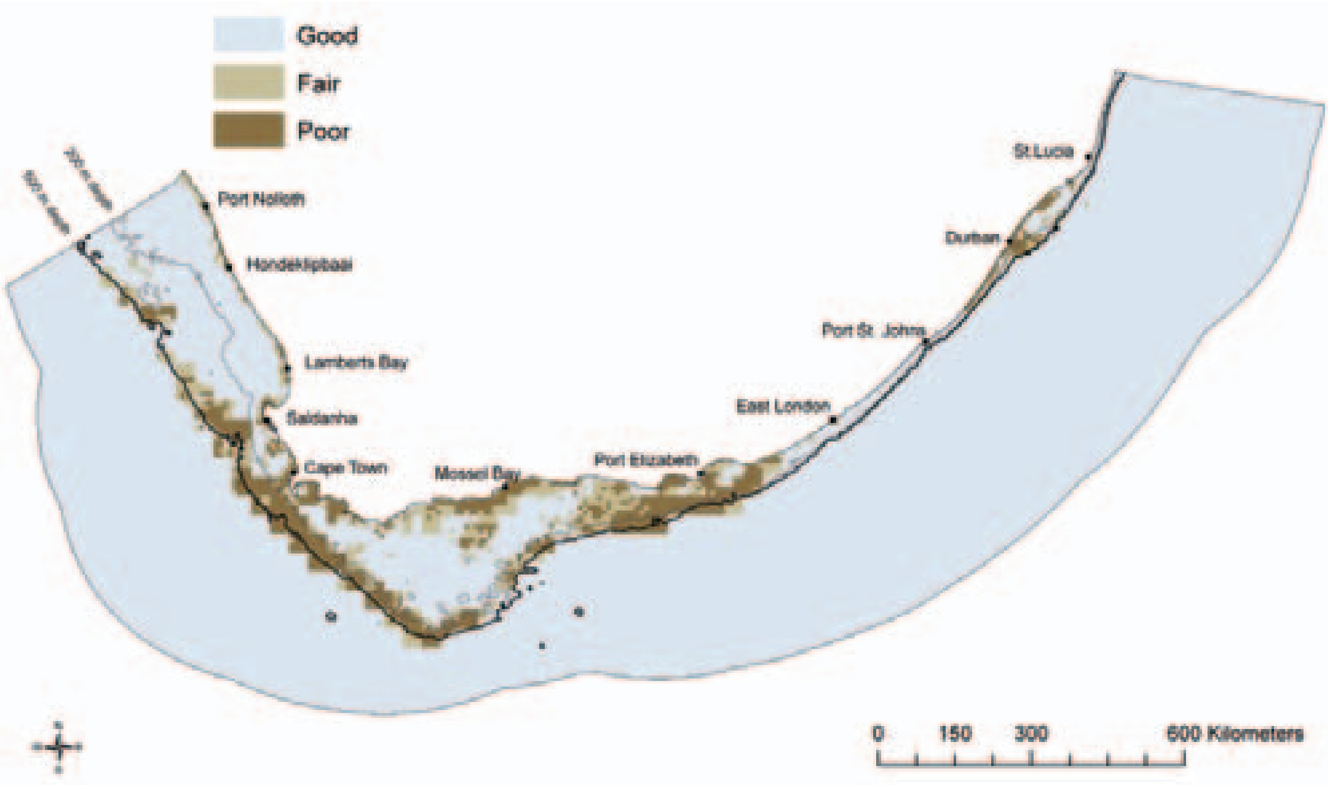


Figure 51.—Map of ecological condition in the coastal, inshore and offshore benthic (seabed) environment. Areas of poor condition tend to be concentrated on particular habitat types, especially along the coast and the shelf edge (the steep area where the ocean floor drops off into the continental slope and abyss).

status for marine and coastal habitat types. See Chapter 3 for more on how ecosystem threat status is calculated.

Maps of marine and coastal ecosystem threat status are shown in Figure 52 and Figure 53. Of South Africa's 136 marine and coastal habitat types, 47% are threatened. Seventeen percent of the 136 are critically endangered, 7% endangered, and 23% vulnerable, as summarised in Figure 54. Many of these threatened habitat types are relatively small, leaving more than 70% of the overall area of South Africa's mainland marine territory least threatened. Large areas of the ocean are used, and many of them are not threatened. In the offshore environment especially, this reflects that fact that pressures on marine ecosystems tend to be concentrated on particular habitat types that have limited extent, such as trawling on the shelf edge or mud habitats and linefishing on reefs. This is different from the terrestrial or freshwater environments, where pressures tend to be less focused on specific ecosystem types.

A higher proportion of coastal and inshore habitat types are threatened than offshore habitat types, as shown in Figure 55. This reflects two factors. Firstly, for many human activities the coast is more accessible than offshore areas, so intensity of impacts is often greater along the coast and inshore than offshore. Secondly, many different pressures emanating from the terrestrial, freshwater and marine environments come together along the coast, creating cumulative impacts.

Mapping of coastal development pressure for the NBA 2011, based on a fine-scale data layer of all coastal buildings, revealed that 17% of South Africa's coast has been developed within 100 m of the shoreline, concentrated especially around Durban (both north and south) and in the Western Cape. Development within 100 m of the shoreline is inappropriate development that not only compromises ecosystem integrity but also puts people and property directly at risk and hampers the ability to adapt to climate change.[44]

Within coastal, inshore and offshore environments, some broad ecosystem groups are more threatened than others, as shown in Figure 56. In the coastal and inshore environment, rocky coasts, rocky inshore habitats (reefs and hard grounds) and island-associated habitats stand out as particularly threatened. Rocky habitat types are often the focus of extractive uses such as linefishing and rock lobster

[44]In terms of the Integrated Coastal Management Act, the coastal protection zone is defined as the area within 100 m inland of the high water mark in urban areas, and within 1 km inland of the high water mark in rural areas. The coastal protection zone is established to manage, regulate and restrict the use of land that is adjacent to the shoreline, in order to protect people, property and economic activities from the risks and threats which may arise from dynamic coastal processes such as wave and wind erosion, coastal storm surges, flooding and sea-level rise, among other objectives.

Within the coastal and inshore environment, rocky coasts are particularly threatened.

fishing, and tend to recover less easily from impacts than sandy habitat types. In the offshore environment, habitat types along the shelf edge (the steep area where the ocean floor drops off into the continental slope and abyss) are particularly threatened because of the concentration of pressures such as trawling on this narrow, highly productive area. Offshore, the Southern Benguela and Agulhas ecoregions have the most threatened habitats. Along the coast and inshore, many habitats in Namaqualand and the southwestern Cape are threatened.

On the positive side, many of the impacts on marine ecosystems, especially offshore, can be managed in principle, for example by establishing marine protected areas or fisheries management areas. Such measures could conserve the last remaining healthy examples of threatened ecosystems and allow for recovery in some cases. There is a need to develop a map of marine ecosystem priority areas for the offshore environment, to guide efforts to manage and conserve marine ecosystems (see Chapter 12 for more on this).

The relatively high proportion of threatened coastal and inshore habitat types highlights the need for integrated management of the coastal environment, reinforcing the importance of the Integrated Coastal Management

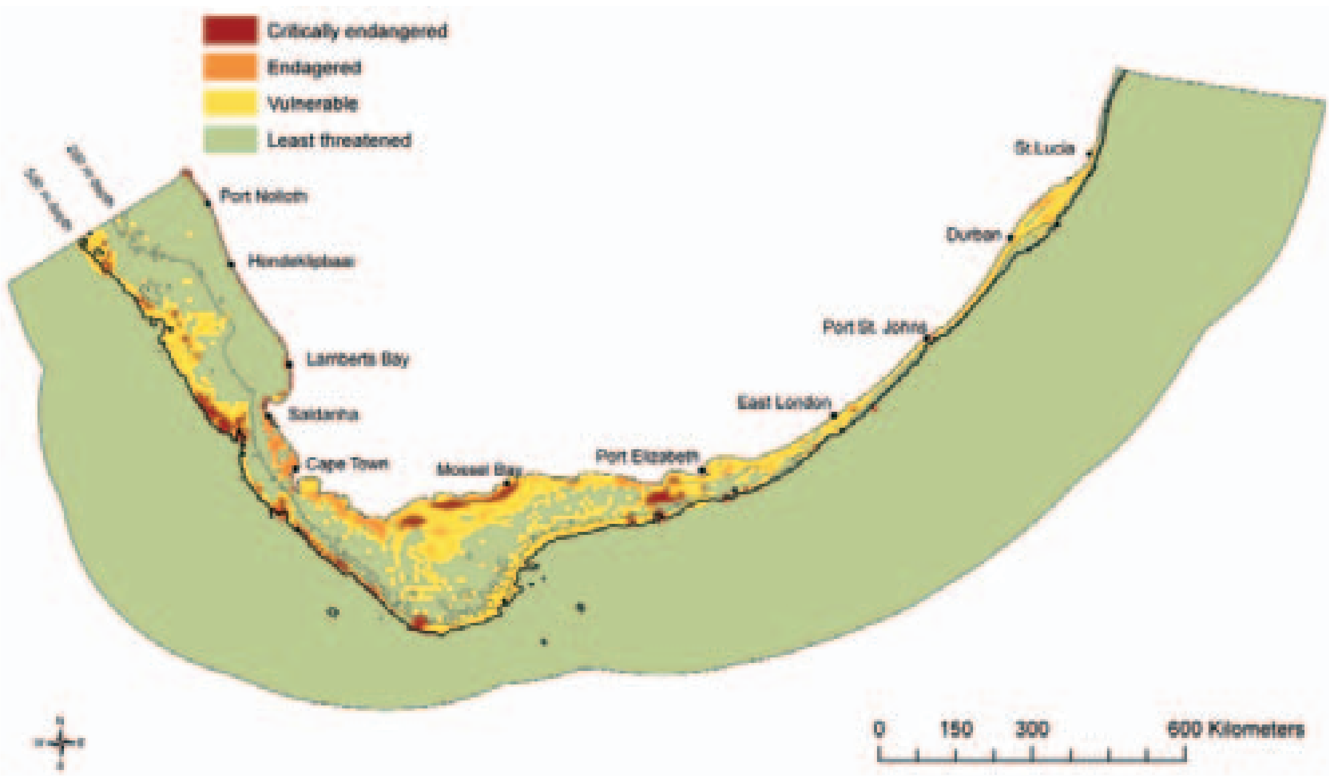


Figure 52.—Map of ecosystem threat status for coastal, inshore and offshore benthic habitat types. Along the coast and inshore, many habitats in Namaqualand and the southwestern Cape are threatened. In the offshore environment, habitat types along the shelf edge are particularly threatened because of the concentration of pressures such as trawling and long-lining on this narrow, highly productive area.

Figure 53.—Map of ecosystem threat status for offshore pelagic habitat types, also showing island-associated habitat types.

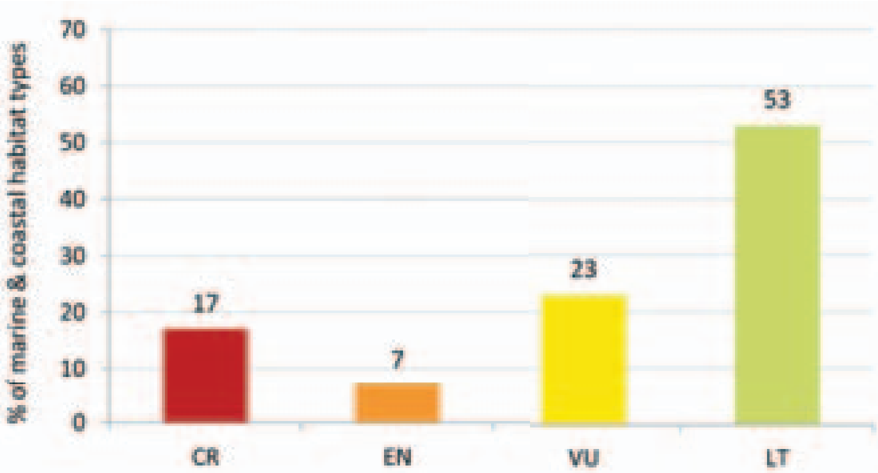


Figure 54.—Summary of ecosystem threat status for marine and coastal habitat types. Forty-seven percent of marine and coastal habitat types are threatened.

Act (Act 24 of 2008) and the tools it has introduced for coastal management. Recommendations of the NBA include supporting the implementation of the Integrated Coastal Management Act through:

- Ensuring that the refinement of the boundaries of the coastal protection zone and coastal public property take ecological factors into account, assisted by the maps of coastal and marine habitat types presented in the NBA.
- Identifying coastal ecosystem priority areas through a systematic national coastal biodiversity plan that integrates terrestrial, freshwater, estuarine and marine aspects, and covers at least the entire coastal protection zone. Such a coastal biodiversity plan would build on the work on ecosystem-based adaptation presented in Chapter 9, identifying in more detail coastal areas where it is critical to keep natural habitat intact to assist with adapting to the impacts of climate change. See Chapter 12 for more on the need for a national coastal biodiversity plan.

Major strides were made in the marine and coastal assessment between the NSBA 2004 and NBA 2011. To further strengthen the assessment the habitat classification and map should be refined, and the assessment of ecological condition should be supported by in situ measurements and groundtruthing.

8.2 Marine and coastal ecosystem protection levels

As explained in Chapter 3, ecosystem protection level tells us whether ecosystems are adequately protected or under-protected. By protected, we mean included in a protected area recognised by the Protected Areas Act, which includes Marine

Protected Areas declared in terms of the Marine Living Resources Act (Act 18 of 1998) (see Panel 4 in Chapter 3).

The NSBA 2004 assessed protection levels of 34 broad marine biozones, highlighting that offshore ecosystems and the Namaqua coast were almost completely unprotected. The enormous progress in mapping and classifying marine and coastal ecosystem types since 2004 means that we are now able to make a much more meaningful assessment of protection levels of 136 marine and coastal habitat types. The high-level picture remains the same, with offshore ecosystems and the Namaqua coast the least protected of all; however, we are able to highlight much more specifically which habitat types are under-protected.

Marine protected areas are often divided into zones, including no-take zones where no extractive use (such as fishing) is permitted, and extractive use zones where various forms of harvesting use are permitted. Figure 12 in Chapter 3 shows existing marine protected areas and includes this distinction, which is important because fishing is the biggest pressure on marine ecosystems. The degree of protection provided by no-take zones is higher than that provided by extractive use zones. The National Protected Area Expansion Strategy 2008 sets explicit targets for no-take marine protected areas as a subset of the total targets for marine protected areas.

Because of this important distinction between no-take and extractive use zones in marine protected areas, marine and coastal habitat types were not considered well protected in this assessment unless their biodiversity target had been met in a protected area **and**

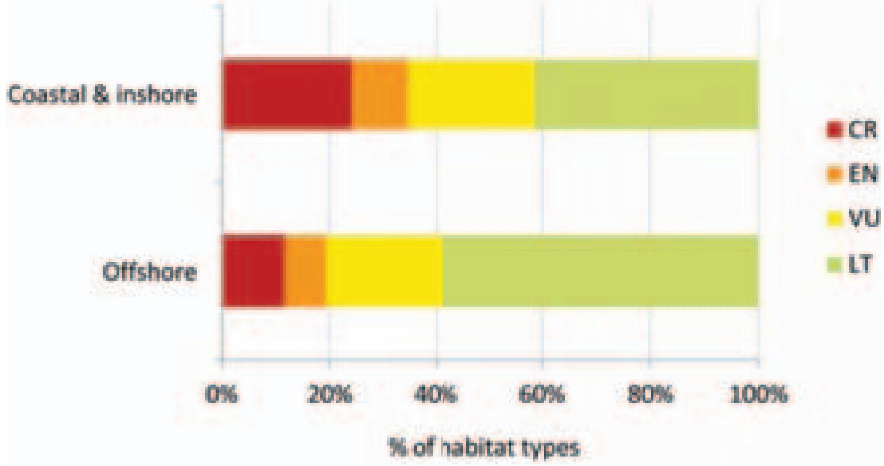


Figure 55.—Ecosystem threat status by coastal and inshore vs. offshore habitat types. A higher proportion of coastal and inshore habitat types are threatened than offshore habitat types, reflecting the fact that the coast is more accessible than offshore areas for many human activities, and also that many different pressures emanating from the terrestrial, freshwater and marine environments come together along the coast, creating cumulative impacts.

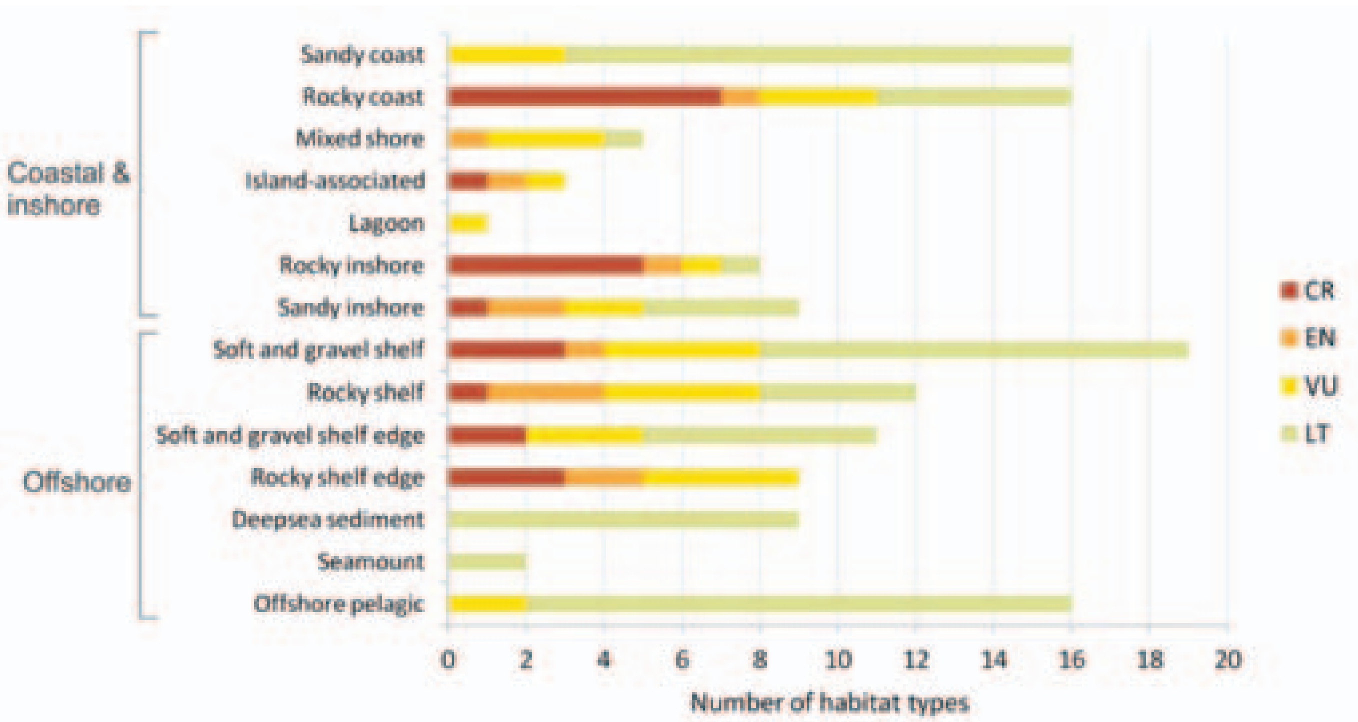


Figure 56.—Ecosystem threat status by broad ecosystem group in the marine and coastal environment. In the coastal and inshore environment, rocky coasts, rocky inshore habitats (reefs and hard grounds) and island-associated habitats stand out as particularly threatened. Rocky habitat types are often the focus of extractive uses such as linefishing and rock lobster fishing, and tend to recover less easily from impacts than sandy habitat types.

at least 15% of the habitat type was in a no-take zone in a marine protected area.

Since 2004, two additional marine protected areas have been declared, both in the Agulhas bioregion: the Still Bay Marine Protected Area in 2008, which includes the Goukou estuary and is a good example of an integrated marine and estuarine protected area; and the Amathole Marine Protected Area, which was declared in late 2011 and not included in the analysis of ecosystem protection levels for the NBA 2011.[45]

Currently, 23.2% of South Africa's coastline falls within marine protected areas or land-based protected areas, with only 9% of the coastline in no-take marine protected areas or zones. Offshore, less than one percent of the mainland EEZ is protected. As in other environments, looking simply at the overall area protected does not reveal much, so an analysis of protection levels for different habitat types is required. Forty-five percent of marine and coastal habitat types have no protection, and only 6% of habitat types are well protected, as shown in Figure 57. Figure 58 shows a map of ecosystem protection levels in coastal, inshore and offshore benthic habitats. The map of ecosystem protection levels in offshore pelagic habitats has not been included here, as all but two pelagic habitat types are not protected, with the remaining two poorly protected.

Figure 59 compares ecosystem protection levels for coastal and inshore environments with offshore environments, and shows clearly that overall levels of protection are higher along the coast, with a substantial proportion of coastal and inshore habitats being moderately protected. This is not surprising given that a relatively high proportion of South Africa's coastline has some form of protection while offshore

No-take zones with MPAs provide a much greater degree of protection for marine ecosystems than extractive use zones within MPAs.

protection is close to zero. What is perhaps more surprising is the very small proportion of well protected habitat types in the coastal environment. This reflects the fact that less than a third of marine protected areas are no-take. In fact, coastal MPAs that allow extractive use can actually become nodes for increased exploitation by recreational, subsistence and even commercial fishers, thus contributing to over-exploitation rather than providing protection. In some cases fishing competitions for threatened fish species are even held inside coastal MPAs. Figure 60 shows that within the coastal and inshore environment, mixed shores and sandy coast types are the best protected broad ecosystem types, but even for these only a small proportion of habitats are well protected.

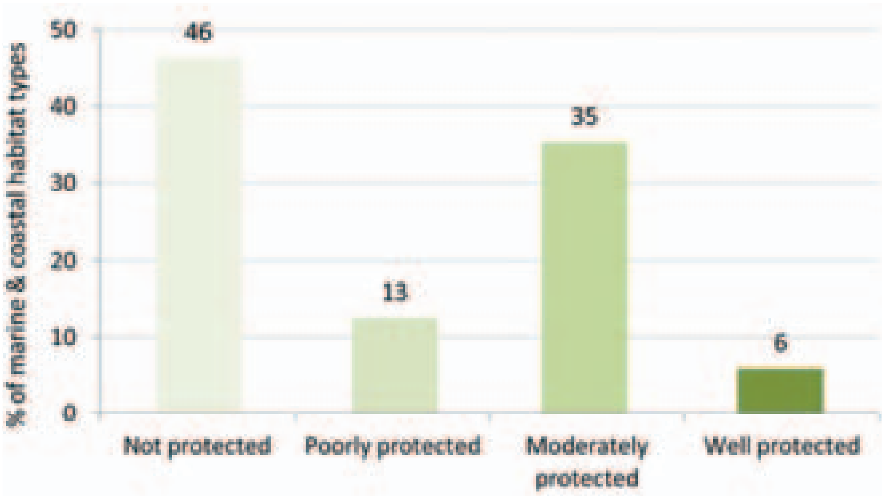
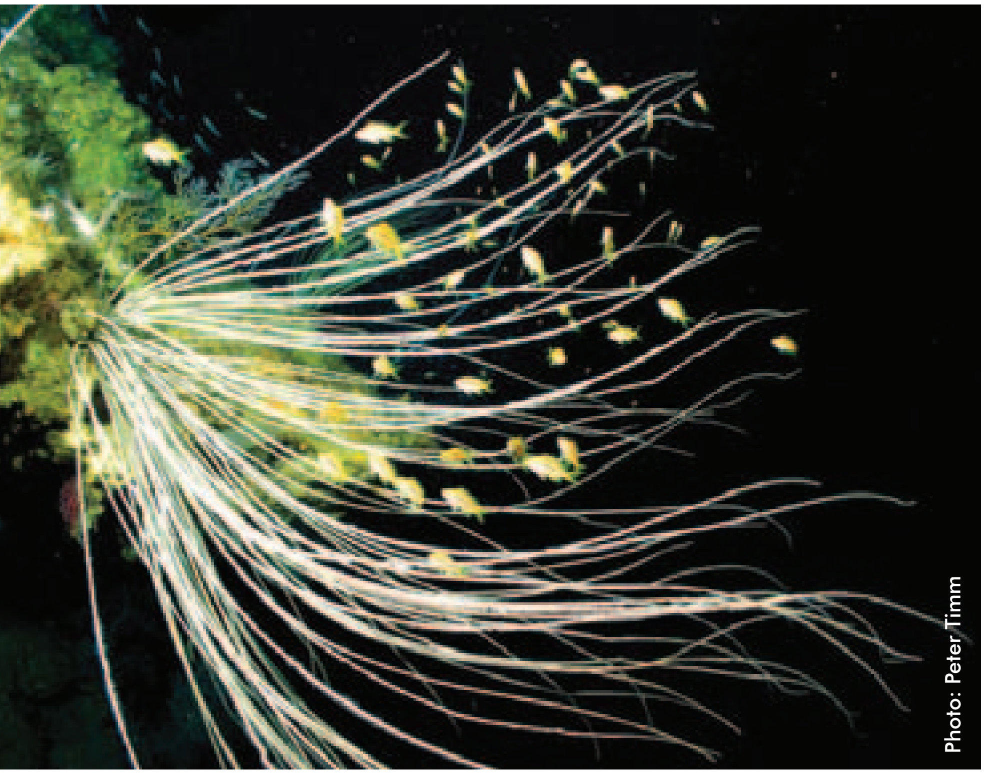


Figure 57.—Summary of ecosystem protection levels for marine and coastal ecosystems. The National Protected Area Expansion Strategy 2008 highlights the need to increase the number and size of strategically placed no-take zones within existing marine protected areas as a priority, and to establish offshore marine protected areas.

[45]The following Agulhas habitat types now receive additional protection in the Amathole MPA: Sandy Inshore, Sandy Inner Shelf, Inner Shelf Reef, Inshore Gravel and Gravel Inner Shelf.

Figure 58.—Map of ecosystem protection levels for coastal, inshore and offshore benthic habitat types, showing clearly that almost no offshore ecosystems are well protected.

The National Protected Area Expansion Strategy 2008 highlights the need to increase the number and size of strategically placed no-take zones within existing marine protected areas as a priority. In addition, there is an urgent need for a marine protected area along the Namaqua coast, which is currently completely unprotected (see Figure 58). As discussed earlier, a national coastal biodiversity plan is needed for South Africa. Such a coastal biodiversity plan would identify coastal ecosystem priority areas, including priorities for consolidation, zoning and expansion of coastal MPAs and areas within existing coastal MPAs that should become no-take zones.



Offshore ecosystems have very low levels of protection, and are the least protected of all South Africa's ecosystems.

Nearly 70% of offshore habitat types are not protected at all, as shown in Figure 59. Figure 60 shows that within the offshore environment two ecosystem groups, deepsea sediments and seamounts, are not represented in South Africa's marine protected area network, and that beyond the shelf edge no habitat types are well protected. This reinforces the urgency of declaring offshore marine protected areas, as emphasised in the National Protected Area Expansion Strategy 2008.

Substantial work has been done on identifying focus areas for offshore protection through the multi-partner Offshore Marine Protected Area project (OMPA) (see Figure 83 in Chapter 12), and the National Protected Area Expansion Strategy 2008 set ambitious targets for expanding offshore marine protected areas in particular. The challenge is now to implement these targets. Mechanisms for expanding the marine protected area network, especially offshore, are somewhat more complex than for land-based protected areas. In the offshore environment, no private property rights are involved; all rights of access to the sea are regulated by the state, which awards mining rights and fishing rights with or without annual quotas. Such rights may need to be restricted in particular areas in order to establish marine protected areas. Mechanisms for negotiating and implementing area restrictions vary among departments and activities.

Given that fishing is the biggest pressure on marine ecosystems, implementing the ecosystem approach to fisheries management is an urgent priority for South Africa, as discussed further in Chapter 10 in the section on harvested marine species. The ecosystem approach to fisheries management includes a focus on the important role of marine protected areas and other spatial management measures in supporting sustainable fisheries.

In the marine environment, there are 13 habitat types that

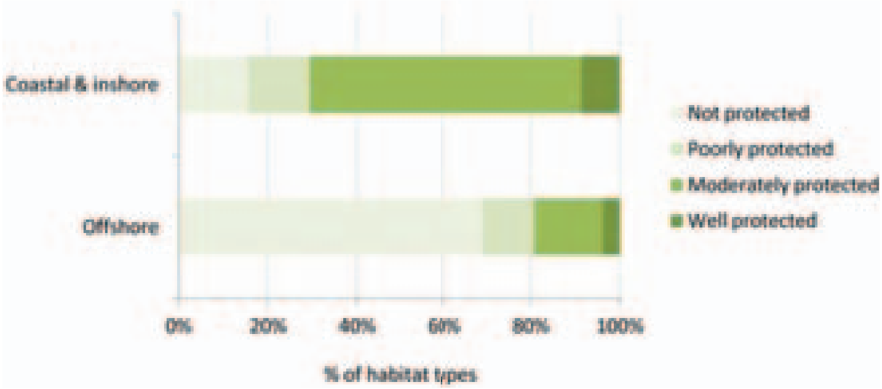


Figure 59.—Ecosystem protection levels by coastal and inshore vs. offshore habitat types. Offshore ecosystems are the least protected of all South Africa's ecosystems. Although 23% of South Africa's coastline falls within land-based or marine protected areas, only a small proportion of coastal and inshore ecosystems are well protected, reflecting the fact that less than a third of marine protected areas are no-take. No-take zones provide a higher degree of protection than extractive use zones in marine protected areas.

Table 6.—Critically endangered marine and coastal habitats that also have no protection

Coastal and inshore habitats	Offshore habitats
Namaqua Sheltered Rocky Coast	Namaqua Inner Shelf Reef
Namaqua Sandy Inshore	Agulhas Canyon
Namaqua Inshore Reef	Southern Benguela Canyon
Namaqua Inshore Hard Grounds	Southern Benguela Hard Shelf Edge
Namaqua Boulder Shore	Agulhas Muddy Inner Shelf
Natal Boulder Shore	Agulhas Mixed Sediment Outer Shelf
	Southern Benguela Gravel Outer Shelf
	Southern Benguela Gravel Shelf Edge
	Southern Benguela Muddy Shelf Edge

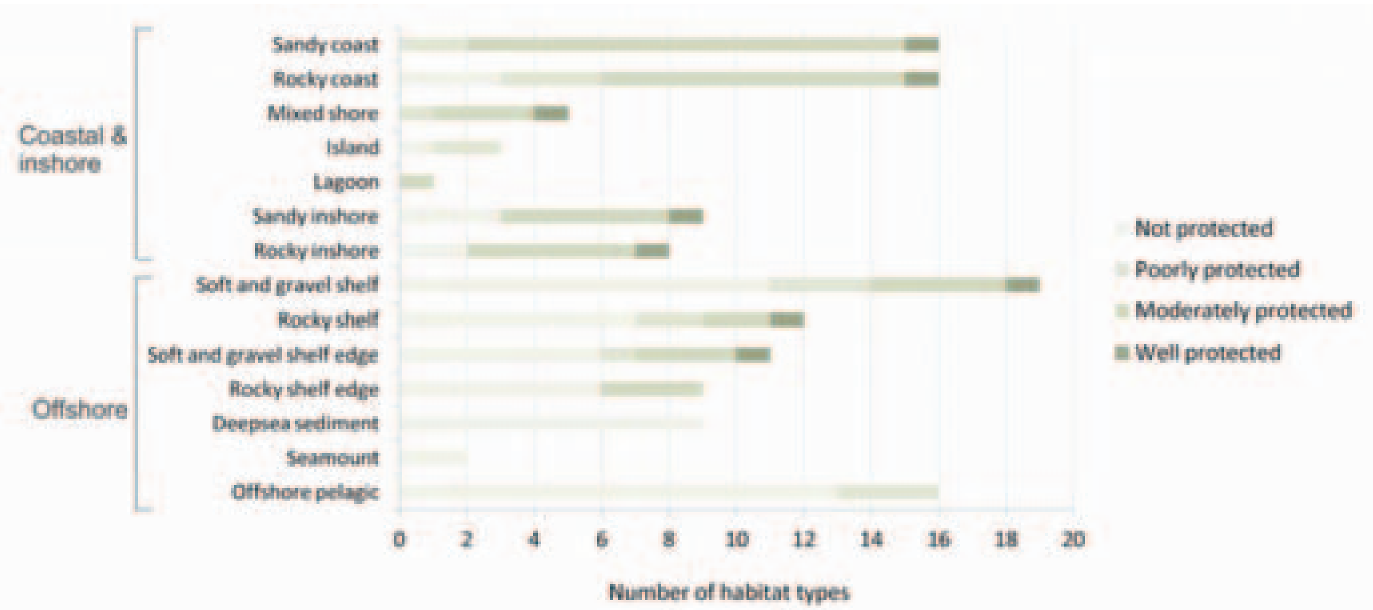


Figure 60.—Ecosystem protection levels by broad ecosystem group in the marine and coastal environment. Within the offshore environment, two ecosystem groups, deepsea sediments and seamounts, are not represented at all in South Africa's marine protected area network, and beyond the shelf edge no habitat types are well protected.

Namaqua Sheltered Rocky Coast is a critically endangered ecosystem that also has no protection. The Namaqua coastal and inshore environment is a priority for expansion of the protected area network.

are critically endangered **and** not protected at all. Inshore and along the coast, most of these are Namaqua habitat types whose poor ecosystem threat status reflects multiple pressures, particularly diamond mining and fisheries. The absence of a marine protected area in Namaqualand is the key driver of the poor protection levels of these habitats. Offshore, priority habitats include ecosystems such as submarine canyons and hard grounds on the shelf and shelf edge along the west and south coasts (Southern Benguela and Agulhas ecoregions). Priority soft and gravel habitats include those of small spatial extent that are exposed to pressures over much of their extent such as Agulhas Muddy Inner Shelf and Southern Benguela gravel habitats. These offshore habitats should be considered as priority habitats for inclusion in South Africa's network of marine protected areas.

Although the NBA 2011 focuses on South Africa's mainland EEZ and not the Prince Edward Islands EEZ, we note that proclamation of the Prince Edwards Island Marine Protected Area remains an urgent national priority.

9. Resilience of biodiversity to climate change

Chapter summary

It is well known that climate change will impact on biodiversity, and with this the ability of biodiversity and ecosystems to provide ecosystem services that support human society. With these impacts in mind, it is important to understand the potential resilience of biomes and ecosystems to climate change, as well as the role of ecosystems in helping humans cope with climate change. By resilience we mean the ability of a biome, landscape or ecosystem to absorb change and re-organise itself in order to retain its character and ecological functioning.

Spatial analysis undertaken for the NBA 2011 identified **areas where biomes are most likely to be at risk** as a result of climate change, as well as **areas of biome stability** where biomes are most likely to maintain a stable ecological composition and structure in the face of climate change, based on a range of possible future climate scenarios. Areas of biome stability present good opportunities for new or expanded protected areas aimed at improving representation of the biome concerned in the protected area network.

Within areas of biome stability as well as areas where biomes are most likely to be at risk, some features in the landscape are more likely to support resilience of biodiversity to climate change than others. Such features include: riparian corridors and buffers; coastal corridors; areas with temperature, rainfall and altitudinal gradients; areas of high diversity; areas of high plant endemism; refuge sites including south-facing slopes and kloofs; and priority large unfragmented landscapes. All of these features were mapped, and then combined to provide a single map of **areas important for resilience of biodiversity to climate change** at the landscape scale. Keeping these areas in a natural or near-natural state will help ecosystems and species to adapt naturally to climate change, thus supporting healthy landscapes and the ability of ecosystems to continue to provide ecosystem services. They should be considered vital elements of South Africa's ecological infrastructure in the face of climate change.

Areas important for climate change resilience need to be managed and conserved through a range of mechanisms including land-use planning, environmental impact assessments, protected area expansion, and working with industry sectors to minimise their spatial footprint and other impacts.

In addition to supporting well-functioning landscapes in the long term, some of the areas important for climate change resilience may also provide more specific, immediate benefits that assist directly with human adaptation to the impacts of climate change, known as **ecosystem-based adaptation**. For example, buffers of natural vegetation along river corridors and around wetlands mitigate floods, reduce erosion and improve water quality. Intact coastal ecosystems such as dunes, mangroves, kelp beds and saltwater marshes help to protect human settlements and infrastructure against sea storms. Ecosystem-based adaptation has the potential to be both more effective and less costly than engineered solutions. Further work is needed to determine which ecosystems are most important for ecosystem-based adaptation in South Africa, and to examine the extent to which they overlap with areas important for climate change resilience at the landscape scale.

Because a relatively large proportion of South Africa's ecosystems are still in a natural or near-natural state, there are far better opportunities here than in many developed parts of the world to capitalise on options for supporting climate change resilience at the landscape scale. With quick action, it is still possible to conserve the required areas, whereas in many more developed countries that opportunity no longer exists.

The recently published National Climate Change Response White Paper recognises the integral role of healthy ecosystems in responding effectively to climate change. The work presented here will support the ability to put this into practice.

It is well known that climate change will impact on biodiversity, and with this the ability of biodiversity and ecosystems to provide ecosystem services that support human society. Initial research and reporting on biodiversity and climate change in South Africa has attempted to quantify the risk to species and ecosystems due to climate change, including possible increased extinction rates of species. This sector-leading work has also addressed pressures such as loss and fragmentation of natural habitat, and incorporated additional issues such as direct effects of rising atmospheric CO_2 on ecosystems. These compound risks and pressures have been well documented in South Africa's recent Second National Communication to the United Nations Framework Convention on Climate Change, which sums up current knowledge on how climate change may impact on a range of sectors and points to possible adaptation responses.[46]

In this chapter, we build on this knowledge base to develop a complementary thrust for resilience and adaptation action, focusing on areas most important for supporting resilience of biodiversity and ecosystems to climate change. By resilience we mean the ability of a biome, landscape or ecosystem to absorb change and re-organise itself in order to retain its character and ecological functioning. In line with the emphasis in the NBA on spatial assessment, we take a spatial approach to the task. Identifying geographic areas that are most important for climate change resilience enables appropriate management and conservation of those areas to ensure continued integrity of ecological infrastructure, supporting the provision of ecosystem services. We also note the role of ecosystems in helping humans cope with climate change, known as ecosystem-based adaptation, and highlight the need for further work in identifying and mapping such ecosystems. The analysis focuses mainly on terrestrial ecosystems at this stage, with the hope of extending this work to aquatic environments in future.

The integral role of healthy ecosystems in South Africa's response to climate change is highlighted in the recently published National Climate Change Response White Paper.[47] The work presented here will support the ability to put this into practice.

Box 17: Key aspects of South Africa's climate risk

As summarised in the National Climate Change Response White Paper, climate change is already a measurable reality and, along with other developing countries, South Africa is especially vulnerable to its impacts. Even under emission scenarios that are optimistic given current international emission trends, it has been predicted that by 2050 the South African coast will warm by around 1 to 2°C and the interior by around 2 to 3°C. By 2100, warming is projected to reach around 3 to 4°C along the coast, and 6 to 7°C in the interior.

With such temperature increases, life as we know it will change completely: parts of the country will be much drier and increased evaporation will ensure an overall decrease in water availability. Increased occurrence and severity of veld and forest fires, storms, floods and droughts will also have significant impacts. Sea-level rise will negatively impact the coast and coastal infrastructure.

The National Climate Change Response White Paper highlights the integral role of healthy ecosystems in responding effectively to these risks, and the need to conserve, rehabilitate and restore natural ecosystems that improve resilience to climate change impacts or reduce impacts.

9.1 Climate change risk at the biome scale

As discussed in Chapter 4, South Africa has nine biomes, or broad groupings of vegetation types that share similar ecological characteristics (see Figure 15). Each biome has a characteristic 'climate envelope' or a range and pattern of temperature and rainfall values within which it occurs. As the climate changes, an area that is currently climatically suited to one biome might become climatically suited to another, putting the ecosystems and species that make up the biome under stress. If such changes were to occur over a long period of time (many thousands of years), and if natural habitat were predominantly intact, the ecosystems and species that make up the biome may be able to shift in response. With changes in climate happening over relatively short periods (decades) and with much natural habitat lost, degraded or fragmented, it is difficult to predict how ecosystems and species will respond.

The first research on how the distribution of South Africa's biomes might be impacted by climate change was done in the mid-1990s and reported in 2000, among the first such work worldwide.[48] The work presented here builds on this concept, using more recent climate data and analysis methods.

Over the last decade, the science of climate change has evolved rapidly. Nevertheless, scientists are still a long way from being able to predict with certainty what the climate will be like in 50 or 100 years, and while confidence in global circulation models is

[46]Department of Environmental Affairs. 2010. *South Africa's Second National Communication Under the United Nations Framework Convention on Climate Change*. Department of Environmental Affairs, Pretoria.

[47]Government of the Republic of South Africa. 2011. *National Climate Change Response White Paper.* Government of South Africa, Pretoria.

[48]Rutherford, M.C., Midgley, G.F., Bond, W.J., Powrie, L.W., Roberts, R. & Allsopp, J. 2000. *Plant biodiversity: vulnerability and adaptation assessment*. In G. Kiker, Climate change impacts in southern Africa. Report to the National Climate Change Committee, Department of Environment Affairs and Tourism, Pretoria. This report was part of the South African Country Study on Climate Change, which contributed to South Africa's Initial National Communication to the UNFCCC

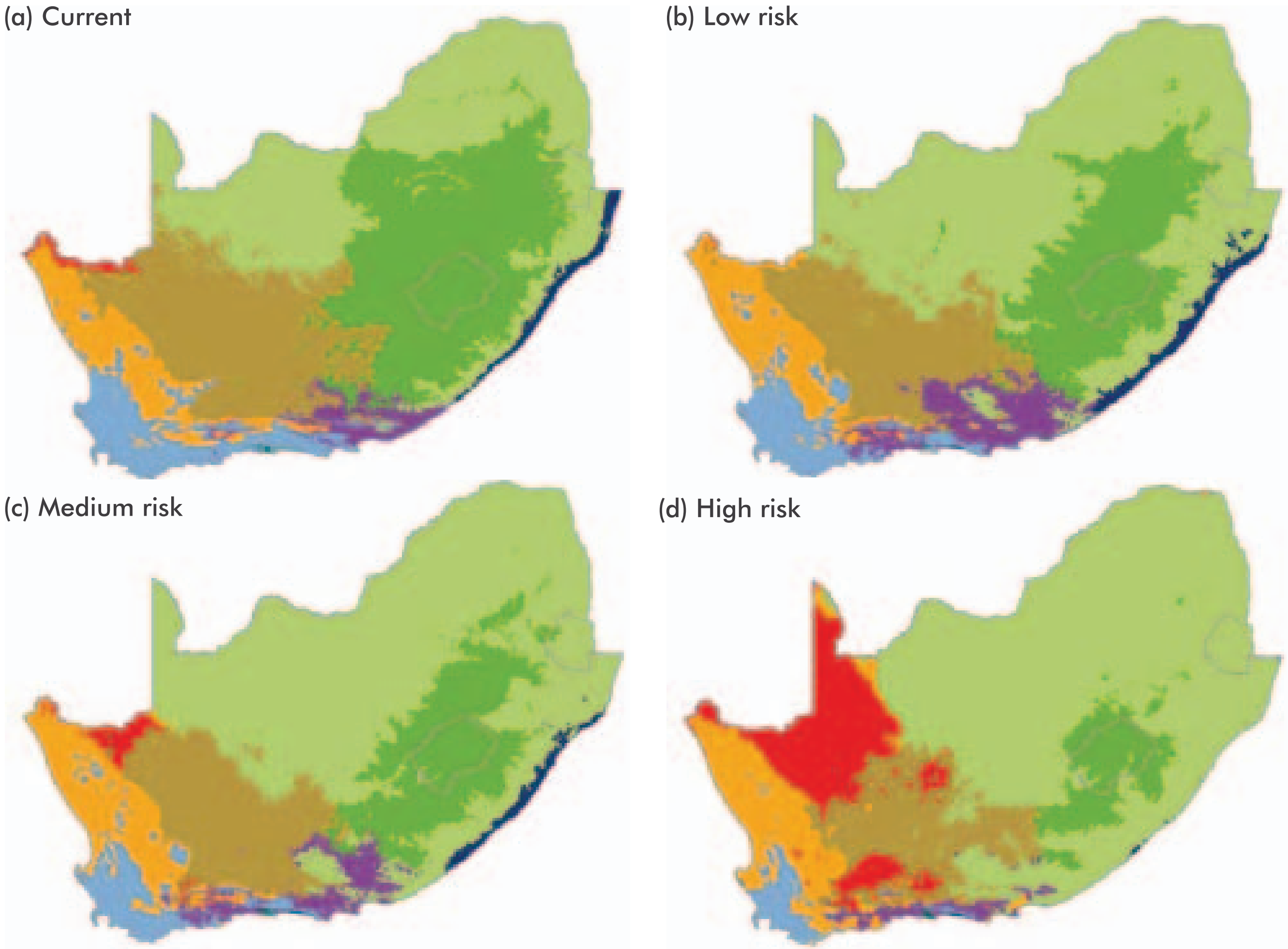


Figure 61.—Predictions of biome climate envelopes under different climate scenarios, looking ahead to approximately 2050. Each map shows that the future climate envelope in an area is likely to resemble the climate of a particular biome, often different from the current biome in that area. This does not necessarily mean the area will change to a different biome. A complex set of factors will influence how ecosystems and species respond in practice.

growing, there is greater appreciation of the uncertainties involved, especially in 'downscaling' the global models to produce climate projections at the regional and local scales.

Based on outputs from 15 global circulation models that were statistically downscaled, we developed three downscaled climate scenarios for South Africa, looking ahead to approximately 2050:[49]

- Best case scenario: smallest predicted increases in temperature and changes in rainfall.
- Intermediate scenario: middle of the range (median) predicted increases in temperature increases and changes in rainfall.
- Worst case scenario: greatest predicted increases in temperature and changes in rainfall.

This means that the results presented in this chapter are not dependent on any particular global circulation model but hold under a range of possible climate futures.

The next step was to develop a biome distribution model which predicts the distribution of biomes based on climate variables. The ability of the model to predict future distributions of biomes was tested by using it to 'predict' the current distribution of biomes. The model was very accurate at 'predicting' the current distribution of biomes, producing a map that matched the actual distribution of biomes very closely.

We then used this biome distribution model to show how the distribution of climate envelopes associated with different biomes is likely to change under each of the three climate scenarios. The results are shown in Figure 61. The maps show which biome's climate envelope the future climate in an area is likely to resemble most closely, often different from

[49]For more detail on the analysis and methods summarised here, see Holness *et al*. In prep. Where can protected areas contribute most to supporting resilience of biodiversity to climate change at the landscape scale in South Africa?

the current biome in that area. This does not necessarily mean the area will change to a different biome. It is not yet known how biomes, and the ecosystems and species that make them up, are likely to respond to these new climatic conditions in practice.

The maps in Figure 61 provide a picture of where biomes are most at risk as a result of climate change to mid-century, but based on statistically downscaled climate data only:

- The Grassland biome appears to be at most risk of significant change. Areas with a climate envelope suitable for Grassland are predicted to be greatly reduced under all scenarios, and in the worst case scenario to occur only in the highest altitude areas.
- The climate envelope found in large areas that are currently Nama-Karoo is likely to resemble an arid Savanna under the best case and intermediate scenarios, and a Desert climate envelope under the worst case scenario.
- The area with a climate envelope suitable for Indian Ocean Coastal Belt increases under the best case scenario with the warm moist conditions which favour this biome expanding southwest along the coast and extending inland. However, as soon as water becomes less available under the intermediate and worst case scenarios, the area with a climate suitable for Indian Ocean Coastal Belt shifts to a Savanna climate envelope.
- Areas with a climate envelope characteristic of Succulent Karoo largely persist under all the scenarios. This contrasts substantially with previous predictions from the mid-1990s as newer climate models with statistical downscaling indicate far smaller impacts on winter rainfall than previous generation models predicted. This does not preclude more significant impacts towards the end of the century.
- The eastern and northern sections of Fynbos are likely to be under climate stress with the climate envelopes in these areas becoming more like Succulent Karoo or Albany Thicket. The core southwestern portions of the Fynbos (especially the mountainous areas) remain within the current biome envelope, but probably with significant up-slope movement of suitable climate envelopes for particular species and habit types.
- Areas with an Albany Thicket climate envelope persist reasonably well under the best case and intermediate climate scenarios, but get replaced by Nama-Karoo and Savanna conditions under the worst case scenario.
- Areas with a climate similar to the current Desert biome are likely to expand in the future into areas which are now Nama-Karoo.
- It is extremely difficult to predict exact distributions of the climate envelope for the small Forest biome, but it is likely that many Forest areas, which are generally dependent of consistently available moisture and protection from fire, are likely to be under increasing pressure in the future.
- Although the climate envelope suitable for Savanna is likely to expand significantly in the future, and specific Savanna species are likely to benefit, this does not necessarily benefit existing habitats and species assemblages.

In addition to highlighting areas where biomes are at risk of structural change, the analysis shown in Figure 61 can also be used to highlight areas where biome climate envelopes are likely to be most stable under a range of statistically downscaled scenarios.[50] Figure 62 shows areas where the climate envelope for the current biome is expected

The climate envelope for the Albany Thicket biome is likely to persist reasonably well under the best case and intermediate scenarios, but under the worst case scenario may be replaced by climate conditions resembling Nama-Karoo and Savanna.

[50]A similar analysis was done in the NSBA 2004 based on the previous predictions of changes in biome climate envelopes published in 2000, which used older climate models.

to persist, shown as the darkest areas on the map. These are areas which are most likely to have a stable ecological composition and structure in the face of climate change as simulated using statistically downscaled scenarios. More sophisticated modelling of South African climate is currently underway that could potentially alter this view to some degree. It will be a priority to test if simulations using this greater national capacity in climate change modelling support the projections made here, and if these hold to the end of this century. It is also important to note that changes due to rising CO_2 effects on plant growth and productivity are not simulated by this modelling approach, and must also be considered urgently to provide a more comprehensive picture of change.

In areas where biomes are most at risk of change in composition and structure, it is particularly important to retain natural features in the landscape that will allow ecosystems and species to adapt as naturally as possible, for example corridors of natural habitat that enable species to move along an altitudinal gradient. These landscape features are discussed further in Section 9.2 below. Areas where biomes are most likely to be stable in the face of climate change present good opportunities for the location of new or expanded protected areas aimed at improving the representation of the biome concerned in the protected area network in the longer term, as they are more likely to retain their current composition and structure and thus to effectively represent the ecosystems concerned.

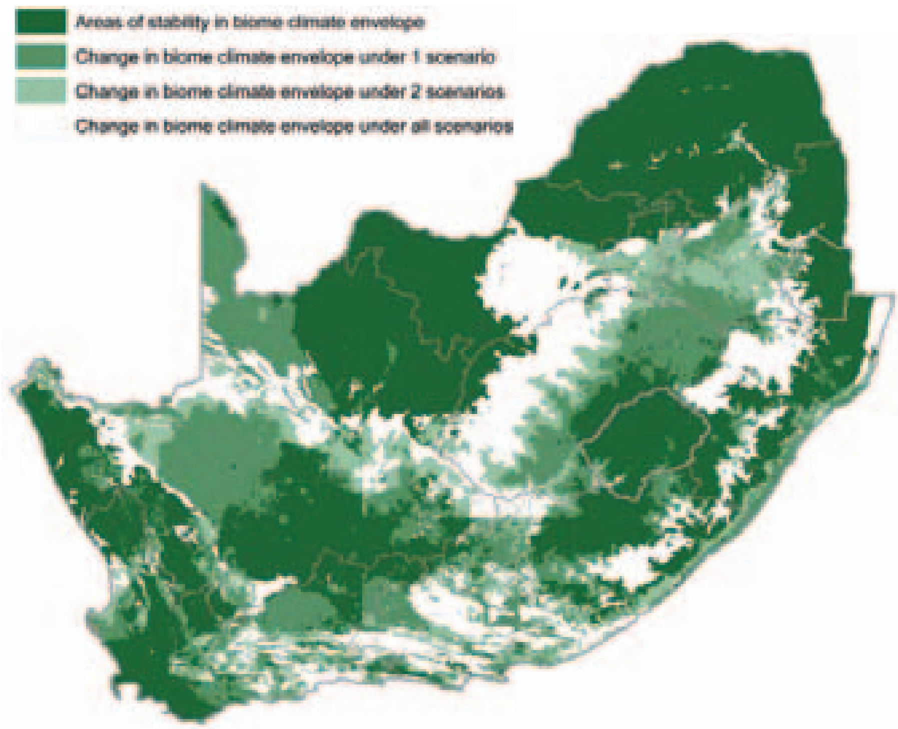


Figure 62.—Areas of biome stability in the face of climate change, under a range of climate scenarios, according to niche modelling results using statistically downscaled future climate scenarios only. The darkest areas are predicted to stay within their current climate envelopes under all three climate scenarios, and hence are most likely to maintain a stable ecological composition and structure. The white areas are areas where biomes are most at risk of change in composition and structure in the face of climate change.

9.2 Climate change resilience at the landscape scale

The analysis presented above for biomes is at a very broad spatial scale. Within any biome there are some areas and features in the landscape that are more important for enabling and supporting resilience to climate change than others. As noted earlier, by resilience we mean the ability of a biome, landscape or ecosystem to absorb change and re-organise itself in order to retain its character and ecological functioning. Keeping these areas that support resilience in a natural or near-natural state will allow ecosystems and species to adapt naturally to climate change, thus supporting ecologically healthy landscapes and the ability of ecosystems to continue to provide a range of ecosystem services.

While scientific understanding of species and ecosystem adaptation to climate change is still developing, there is some consensus that the areas or features where intact natural habitat is most likely to contribute to climate change resilience at the landscape scale include the following:

- **Riparian corridors and buffers.** River corridors and buffers of natural riparian vegetation provide important connectivity in the landscape, allowing ecosystems and species to respond to climate change.
- **Coastal corridor.** Intact coastal ecosystems provide important connectivity in the landscape to allow ecosystems and species to respond to climate change.
- **Areas with important temperature, rainfall and altitudinal gradients**. Maintaining these areas is important in order to allow species and ecosystems to rapidly adapt to changing climate, as they represent the areas where the shortest possible movements are required for a species or ecosystem to remain within its acceptable climate envelope. Importantly, these areas coincide largely with South Africa's high water yield subcatchments, which are responsible for delivering the bulk of South Africa's water supply.
- **Areas of high diversity.** These are areas where relatively high numbers of biomes, vegeta-

River corridors are features in the landscape that can contribute to climate change resilience. Intact buffers of natural vegetation along river corridors provides connectivity, allowing ecosystems and species to respond to climate change.

tion groups or vegetation types occur in close proximity. They contain an extremely diverse set of habitats, landscapes and microclimates, and represent areas that are likely to be very important for supporting biodiversity adaptation capacity.

- **Areas of high plant endemism.** Apart from containing an exceptionally high diversity of species, many endemic to the area concerned, these are areas where species have survived previous eras of climate change, and hence are likely to be very important for supporting biodiversity adaptation capacity.
- **Refuge sites including south-facing slopes and kloofs.** These sites tend to be wetter and cooler than the surrounding landscape, and represent key shorter term refugia which allow species to persist in regions, such as most of South Africa, that are predicted to become warmer and drier.
- **Priority large unfragmented landscapes.** These include existing protected areas as well as large areas identified in the National Protected Area Expansion Strategy as priorities for protected area expansion to meet biodiversity targets for terrestrial and freshwater ecosystems (see Chapter 12). The ecological processes which support climate change adaptation are more likely to remain functional in unfragmented landscapes than in fragmented ones.

All of these features were mapped, and then combined to identify areas that are most important for climate change resilience at the landscape scale, as shown in Figure 63 and Figure 64. Crucially, these areas can support resilience to climate change only if they remain in a natural or near-natural state, or at least retain their ecological functioning. For this reason, areas where natural habitat has already been irreversibly lost were removed from the analysis.

As we have noted, resilient ecosystems are good for people, helping to maintain the stock of natural capital from which all ecosystem services flow. All of the areas identified in Figure 64 should thus be considered vital elements of South Africa's ecological infrastructure. In addition to supporting well-functioning landscapes in the long term, some of the natural features identified in Figure 64 may also provide more specific, immediate benefits that assist directly with human adaptation to the impacts of climate change. This is known as ecosystem-based adaptation, discussed further below.

9.3 Ecosystem-based adaptation to climate change

In the 1990s, discussion and debate on climate change focused

Intact coastal corridors help ecosystems and species adapt to climate change, and also help to buffer humans from the impacts of climate change, as discussed in the text.

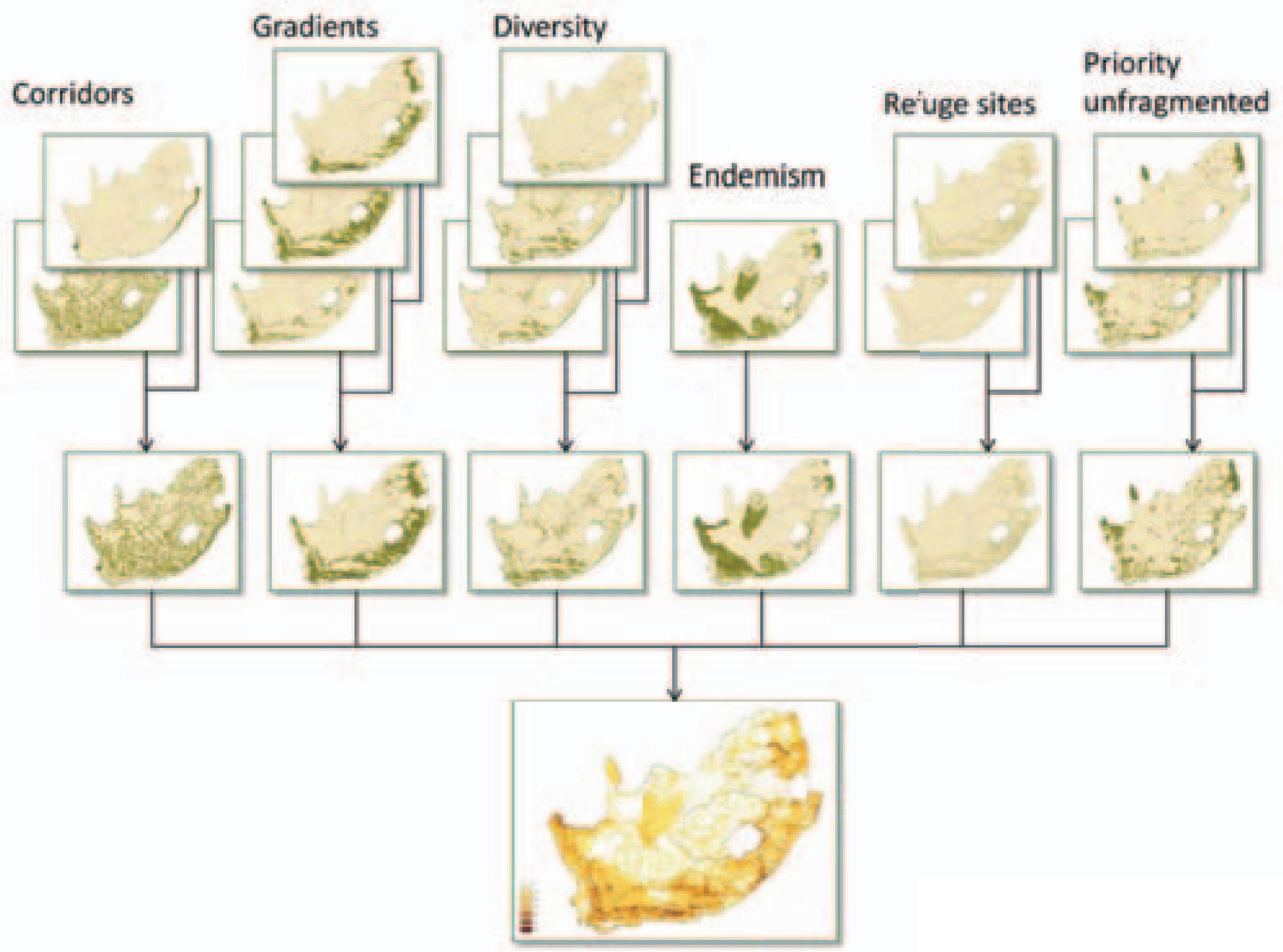


Figure 63.—Summary of features that were combined to identify areas important for climate change resilience at the landscape scale. By resilience we mean the ability of a biome, landscape or ecosystem to absorb change and re-organise itself in order to retain its character and ecological functioning.

mainly on mitigation, or how to limit climate change. Since the 2000s this has changed, with growing emphasis globally on the need for humans to adapt to the inevitable impacts of climate change.

Within the discussion on climate change adaptation, the majority of attention is often given to engineering and technology-based solutions to the impacts of climate change, such as building new and bigger dams to ensure security of water supply, developing new drought-resistant agricultural cultivars, or building concrete structures to shore up vulnerable parts of the coastline.

However, in the last few years a new concept has emerged: using healthy ecosystems as a convenient and cost-effective response to the impacts of climate change, known as ecosystem-based

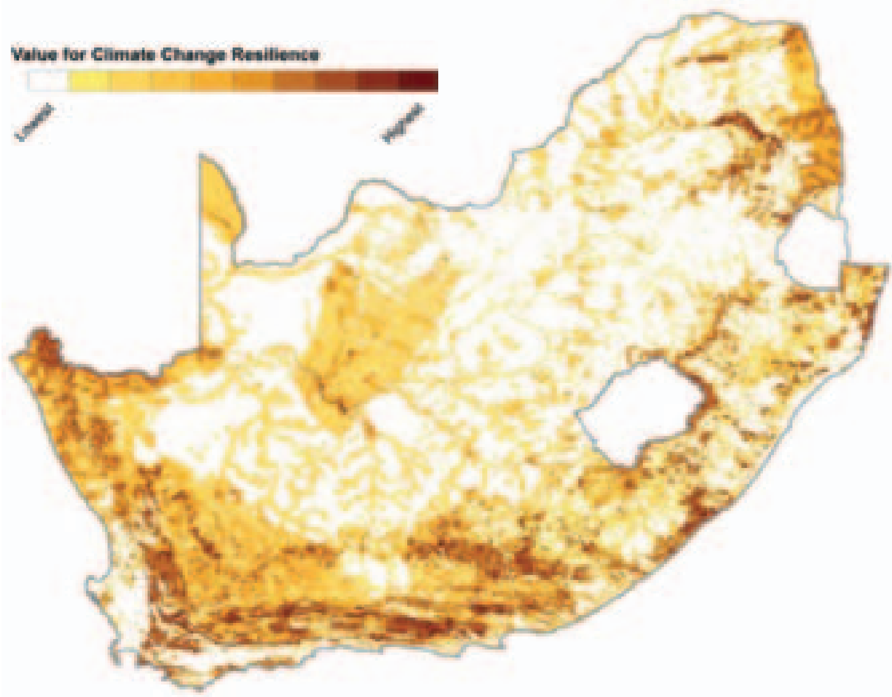


Figure 64.—Remaining natural or near-natural areas important for climate change resilience at the landscape scale, under a range of climate scenarios. Keeping these areas in a natural or near-natural state will help ecosystems and species to adapt naturally to climate change, thus supporting ecologically healthy landscapes and the ability of ecosystems to continue to provide a range of ecosystem services.

adaptation. The CBD defines ecosystem-based adaptation as "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change",[51] and the first major international report on ecosystem-based adaptation was published by the World Bank in 2009.[52] As noted earlier, South Africa's National Climate Change Response White Paper fully supports this approach.

Ecosystem-based adaptation focuses on managing, conserving and restoring ecosystems to buffer humans from the impacts of climate change, instead of relying only on engineered solutions. This approach is particularly effective in helping society cope with extreme climate events such as droughts, floods and storms. For example, buffers of natural vegetation along riparian corridors and around wetlands have been shown to mitigate floods, reduce erosion and improve water quality. Intact coastal ecosystems such as coastal dunes, mangroves, kelp beds and saltwater marshes provide direct benefits to humans by helping to protect settlements and infrastructure against sea storms. In many cases ecosystem-based adaptation can work hand in hand with engineered adaptation responses.

Ecosystem-based adaptation requires investing in maintaining and restoring ecological infrastructure, which frequently has the added benefit of creating jobs and contributing to livelihoods, especially in rural economies most at risk from adverse climate change impacts. In some cases, ecosystem-based adaptation requires simply that healthy natural ecosystems are left alone to do what they already do best, and ensuring that they are not converted to other land uses. In other cases, it requires rehabilitation of impacted ecosystems, for example clearing invasive alien plants in mountain catchments to increase water supply rather than building desalination plants or dams.

The concept of ecosystem-based adaptation is summarised in Figure 65, which shows how ecosystem-based adaptation contributes to three outcomes simultaneously: socio-economic benefits, climate

Buildings and other structures at the coast are vulnerable to the impacts of climate change, including sea-level rise and extreme storms. If coastal ecosystems are kept intact, they help to buffer humans from these impacts.

[51]Secretariat of the Convention on Biological Diversity. 2009. Connecting Biodiversity and Climate Change Mitigation and Adaptation: Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change. *CBD Technical Series* No. 41. Convention on Biological Diversity, Montreal.

[52]World Bank. 2009. *Convenient Solutions to an Inconvenient Truth: Ecosystem-based Approaches to Climate Change*. Environment Department, World Bank, Washington D.C.

change adaptation, and biodiversity and ecosystem conservation.

The spatial analysis presented in Figure 64 identifies areas that contribute both to climate change adaptation and to biodiversity and ecosystem conservation—two of the three outcomes in the diagram in Figure 65. Among these areas, we have not yet prioritised which deliver the most direct immediate value for human society, in other words, which of them are also important for ecosystem-based adaptation, contributing to all three outcomes in Figure 65.

Such spatial prioritisation for socio-economic benefits will vary depending on its purpose. For example, an economic analysis may focus on flood risk mitigation through protection of riparian buffers, securing important water supply for metropolitan areas and large cities, and avoiding damage to infrastructure through limiting development in low lying coastal and estuary areas. If the objective is supporting vulnerable rural communities that are directly dependent on ecosystem services, then a different set of areas would be prioritised. In addition, there are likely to be other areas and features, not included in the map of areas important for climate change resilience, which contribute to ecosystem-based adaptation, especially at the local scale.

However, even without spatial prioritisation among the areas identified as important for climate change resilience in Figure 64, all of them play at least an indirect role in ecosystem-based adaptation by giving ecosystems the best chance to adapt to climate change and retain their ecological functioning, thus supporting the ongoing provision of ecosystem services for humans.

Identifying priority natural ecosystems for ecosystem-based adaptation requires building on the landscape-scale analysis presented here, including mapping and analysis of features at the local scale. This is already being incorporated to some extent in the development of maps of Critical Biodiversity Areas and Ecological Support Areas in many parts of the country (see Chapter 12), but could be strengthened and made more explicit. This is a key emerging area of work for biodiversity planners in South Africa, in partnership with urban and regional planners.

We have identified areas important for climate change resilience in a way that ensures positive benefits under a wide range of climate scenarios. In other words, the areas identified in Figure 64 take into account the current high levels of uncertainty about South Africa's future climate, and are not tied to any one particular climate scenario. Almost regardless of how rainfall and temperature changes, conserving and managing these areas is a good investment in ecological infrastructure.

Areas important for climate change resilience need to be managed and conserved through a range of spatial mechanisms including land-use planning, environmental impact assessments, protected area expansion, and working with industry sectors such as agriculture, forestry and mining to minimise their spatial footprint and other impacts in areas where keeping natural habitat intact is critical for climate change resilience.

Because a relatively large proportion of South Africa's ecosystems

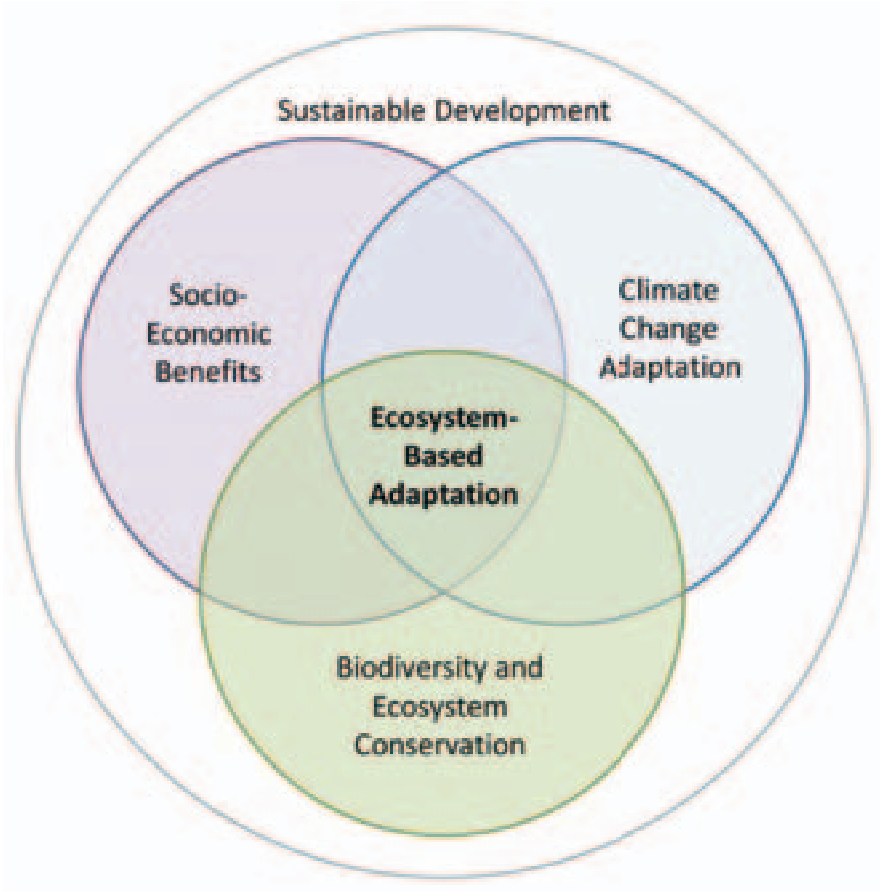


Figure 65.—Ecosystem-based adaptation focuses on managing, conserving and restoring ecosystems to buffer humans from the impacts of climate change. It combines socio-economic benefits, climate-change adaptation, and biodiversity and ecosystem conservation, contributing to all three of these outcomes simultaneously.[53]

[53]This diagram comes from: Midgley, G., Marais, S., Barnett, M. & Wagsaether, K. 2011. *Biodiversity, climate change and sustainable development: harnessing synergies and celebrating successes*. Final technical report, January 2012.

Because South Africa has many ecosystems that are still in good ecological condition, there are significant opportunities to use ecosystem-based adaptation as a strategy to help humans cope with the impacts of climate change.

are still in a natural or near-natural state, there are far better opportunities in South Africa than in many developed parts of the world to capitalise on the options presented by ecosystem-based adaptation. With quick action, it is still possible to conserve the required areas, whereas in many more developed countries that opportunity no longer exists.

In the longer term we need to refine and prioritise the identification of areas most important for supporting human adaptation, to incorporate more nuanced ecological modelling (carbon dioxide fertilisation, fire, drought periods and so on), to undertake integration of planning with other sectors (e.g. agriculture), and to properly value the costs and benefits of ecosystem-based adaptation.

In addition to providing direct socio-economic benefits, the recognition that intact ecosystems are a key requirement for human adaptation to climate change and have the potential to be both more effective and less costly than engineered solutions, is emerging as a powerful force for aligning biodiversity and developmental and social agendas.

10. Species of special concern

Chapter summary

Species of special concern

- South Africa has over 95 000 known species, with many more still to be discovered and described.
- SA Red Lists show that 1 in 5 inland mammal species, 1 in 5 freshwater fish species, 1 in 7 frog species, 1 in 7 bird species, 1 in 8 plant species, 1 in 12 reptile species, and 1 in 12 butterfly species are threatened. Key threats to indigenous species include loss of natural habitat and invasive alien species.
- SA has over 2 000 medicinal plant species, 656 of which are traded. Of these, 56 are threatened.
- More than 630 marine species are caught by fisheries in SA. The stock status of 41 of these was reported in 2010. Of the 41 species, 25 were considered overexploited, collapsed or threatened.

Species are the building blocks of ecosystems, playing a fundamental role in maintaining well-functioning ecosystems and thus in supporting the provision of ecosystem services. South Africa has over 95 000 known species, far more than our fair share based on the percentage of Earth's surface the country occupies, with more regularly discovered and described. Species of special concern are those that have particular ecological, economic or cultural significance, some of which are the focus of this chapter.

Medicinal plants

South Africa has over 2 000 plant species that are recorded as used for medicinal purposes, out of a total of over 20 000 plant species, with the highest numbers of medicinal plant species occurring in the Grassland, Forest and Savanna biomes. About a third of medicinal plant species (656 species) are traded in medicinal markets. Trade in traditional medicines was estimated at R2.9 billion per year in 2007, with at least 133 000 people employed in the trade, many of whom are rural women.

Harvesting of plants for medicinal use is often destructive to the plant, so one might expect to find that a large proportion of medical plant species are threatened with extinction. However, the Red List of South African Plants shows that of the 656 medicinal plant species that are traded, 9% (56 species) are threatened. Urgent action is required for these 56 threatened medicinal plant species if future generations are to continue to benefit from them, and research and monitoring of the remaining traded species is needed to ensure that harvesting patterns are sustainable. Possible actions include developing Biodiversity Management Plans in terms of the Biodiversity Act and exploring options for cultivation of medicinal plant species.

Harvested marine species

Fisheries make a significant contribution to the South African economy, but the resources on which fisheries depend—the species that are harvested—are in many cases in decline. This does not bode well for long-term food and job security. More than 630 marine species, most of them fish species, are caught by commercial, subsistence and recreational fisheries in South Africa. The country has a long history of fisheries management grounded in science, focused mainly on managing total catch and fishing effort for individual species. However, only a small proportion of these 630 species are managed in this way, and the stock status of only 41 of them was reported in 2010. Of those 41 species, 25 were considered overexploited, collapsed or threatened.

The good news is that fish stocks can recover with management interventions, with deep water hake and south coast rock lobster providing recent South African examples. More and better assessments of the stock status or trends for harvested marine resources are essential in order to know how to intervene. However, it will never be feasible to manage all harvested species using a traditional fisheries management approach that regulates catch or fishing effort for each individual species. Hence the importance of implementing the ecosystem approach to fisheries management to ensure the long-term integrity of marine resources and ecosystems, including using marine protected areas and other spatial management measures to protect important habitats such as spawning and nursery areas, foraging areas and other habitats that play a role in the recovery of fish stocks.

Threatened species

Conservation assessments, or Red Lists, use an internationally agreed set of criteria to assess how threatened different species are, based on the likelihood of extinction. South Africa is a world leader in Red Listing, having assessed a wider range of taxonomic groups than most countries, and being the only mega-diverse country to have assessed its entire flora, in the Red List of South African Plants. Red List assessments in South Africa to date show that: one in five inland mammal species is threatened; one in five freshwater fish species is threatened; one in seven frog species is threatened; one in seven bird species is threatened; one in eight plant species is threatened; one in twelve reptile species is threatened; and one in twelve butterfly species is threatened. Analysis based on Red Lists shows clearly that the primary threat to species comes from loss of natural habitat, particularly as a result of cultivation in the terrestrial environment. Invasive alien species are another severe threat in the terrestrial and freshwater environments.

Keeping track of the status of species and gathering the required data for assessing their status is a daunting task. Hundreds of volunteers, or citizen scientists, have played a crucial role in the process and continue to do so through a range of atlassing projects and virtual museums that make use of modern technology to enable amateurs to contribute data from around the country.

There are still many knowledge gaps with respect to the conservation status of species in South Africa. Priorities include assessments of marine species, especially linefish, and increasing the numbers of invertebrates assessed. Further challenges include developing a strategy for keeping assessments current, making a consolidated national Red List available online, and developing a national Red List Index to track trends in conservation status of species over time. See http://redlist.sanbi.org for more information.

So far, the focus of this report has been mainly on ecosystems, including their threat status and protection levels, and their contributions to climate change adaptation. We now turn our attention to species—the building blocks of ecosystems. It is well known that South Africa has vast numbers of species—more than our fair share based on the percentage of Earth's surface that the country occupies. For charismatic species, such as whales or birds, it is relatively easy to motivate for conservation action. However, all species in South Africa—95 000 and counting—play a fundamental role in maintaining well-functioning ecosystems and thus in supporting the provision of ecosystem services. Figure 66 shows the numbers of species currently known in South Africa for different groups of living organisms. Especially for groups such as insects, fungi and micro-organisms, knowledge is far from complete, with additional species regularly discovered and described. The extent to which the country's species diversity has been documented and described, and the capacity to do this in South Africa, is discussed further in Chapter 13.

This chapter deals with species of special concern, or species that are of particular ecological, economic or cultural significance. First we look at species that are harvested from the wild, including medicinal plants and harvested marine species, and then at threatened species across a range of taxonomic groups. There are many other species of special concern, for example food plants, keystone species and species that are an important part of cultural and religious practices, which are not a focus of the chapter. In future NBAs we will endeavour to focus on a wider range of species of special concern.

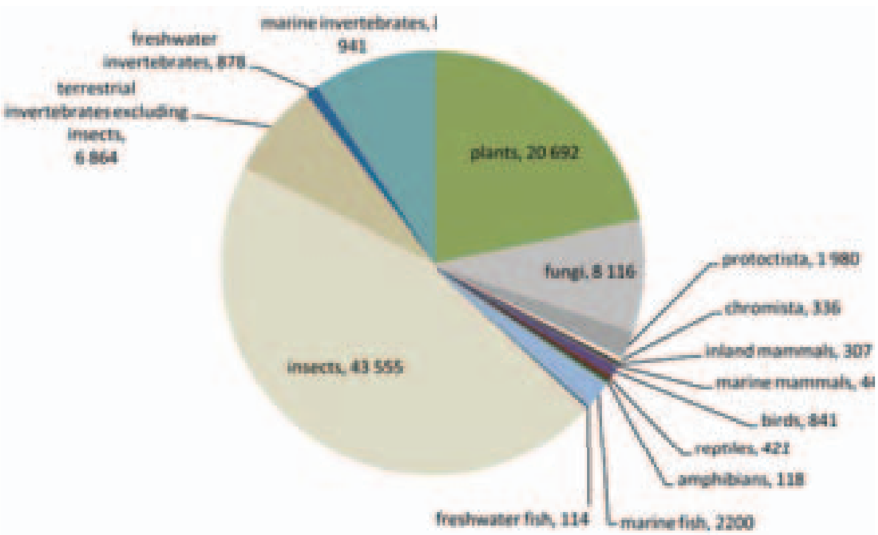
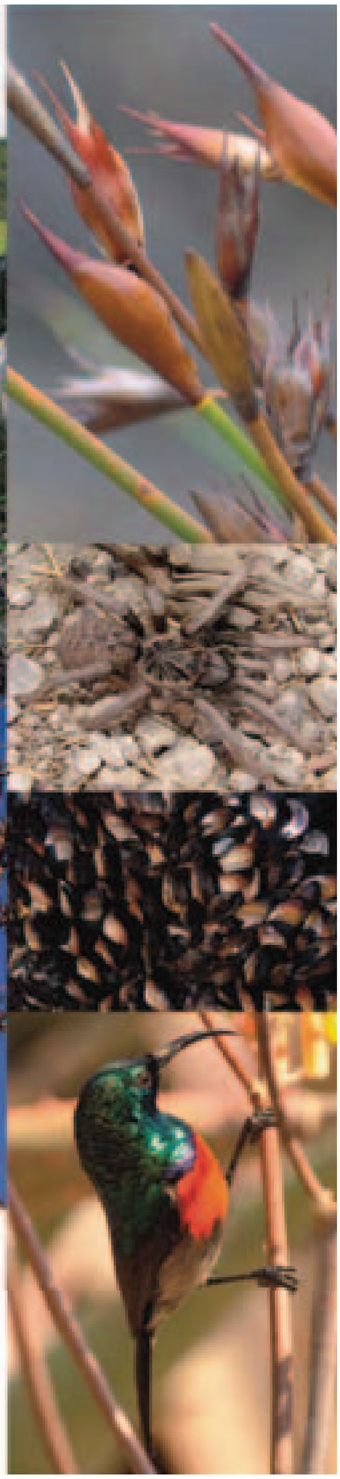


Figure 66.—Numbers of known species in South Africa for major groupings of living organisms. Many more species have yet to be discovered and described, especially among insects, fungi and micro-organisms.

Some species provide direct services to humans, also called provisioning services (see Chapter 1). These include wild species that are harvested for a range of reasons, such as wood for fuel, reeds for building material and weaving, indigenous flowers for the export market, plants for medicinal use, bait for fishing, and fish and shellfish for food. The social and economic significance of such species is easy to see. The challenge is to use them in a way that does not threaten their continued existence or the integrity of the ecosystems of which they are part. Below we focus on two categories of harvested species that are especially important in South Africa's society and economy: medicinal plants, on which many people rely for primary health care and income; and harvested marine species, which provide nutritious food and support a large industry and many jobs. As is shown in the discussion that follows, South Africa's wealth of medicinal plant species are mostly not threatened, with some important exceptions especially amongst heavily traded species. Harvested marine species, on the other hand, are in many cases in a poor state, raising concerns about the ongoing ability of this resource to provide ecosystem services.

10.1 Medicinal plants

South Africa has over 2 000 different plant species that are recorded as being used for traditional medicine, out of a total of over 20 000 plant species. Of these medicinal plant species, a third (656 species) are actively traded or recorded in the medicinal markets of KwaZulu-Natal,



Gauteng, Eastern Cape, Mpumalanga and Limpopo.[54] Figure 68 shows the distribution of medicinal plant species in South Africa, with the highest numbers occurring in the Grassland, Forest and Savanna biomes.

An estimated 27 million South Africans (more than half the population) are consumers of traditional medicine, with a significant supporting industry. Trade in traditional medicinal plants and products was estimated to be worth R2.9 billion per year in 2007, with at least 133 000 people employed in the trade, many of whom are rural women.[55] The potential to develop new medicinal products for commercial production, drawing on indigenous knowledge of medicinal plants, remains under-explored.[56]

In 2009 a comprehensive conservation assessment of all of South Africa's plant species was undertaken for the first time, producing the Red List of South African Plants, discussed further in Section 10.3. [57] One of the many advantages of having such a Red List is that it is possible to evaluate the conservation status of medicinal plants as a group based on evidence rather than guesswork. Harvesting of plants for medicinal use is often destructive to

[54]Williams, V.L., Victor, J.E. & Crouch, N.R. (in review). Threatened medicinal plants of South Africa. Submitted to *South African Journal of Botany*.

[55]Mander, M., Ntuli, L., Diederichs, N. & Mavundla, K. 2007. Economics of the Traditional Medicine Trade in South Africa. In S. Harrison, R. Bhana & A. Ntuli, *South African Health Review 2007*. Health Systems Trust, Durban.

[56]Van Wyk, B.E. 2011. The potential of South African plants in the development of new medicinal products. *South African Journal of Botany* 77(4): 830–843.

[57]Raimondo, D., Von Staden, L., Foden, W., Victor, J.E., Helme, N.A., Turner, R.C., Kamundi, D.A. & Manyama, P.A. (eds). Red List of South African plants. *Strelitzia* 25. South African National Biodiversity Institute, Pretoria.

Trade in traditional medicine is a significant industry in South Africa.

the plant, as the plant parts used typically include bulbs, roots and bark, so one might expect to find that a large proportion of medical plant species are threatened with extinction. However, the Red List shows that of the 656 medicinal plant species that are traded, 9% (56 species, or about one in 12) are currently threatened. A further 12% (78 species) are of conservation concern, for example classified as Near Threatened, Data Deficient, Rare or Critically Rare, or as Least Concern but with evidence of population decline[57] (see Panel 10 in Section 10.3 for more on these conservation status categories). Figure 67 provides a summary of these numbers.

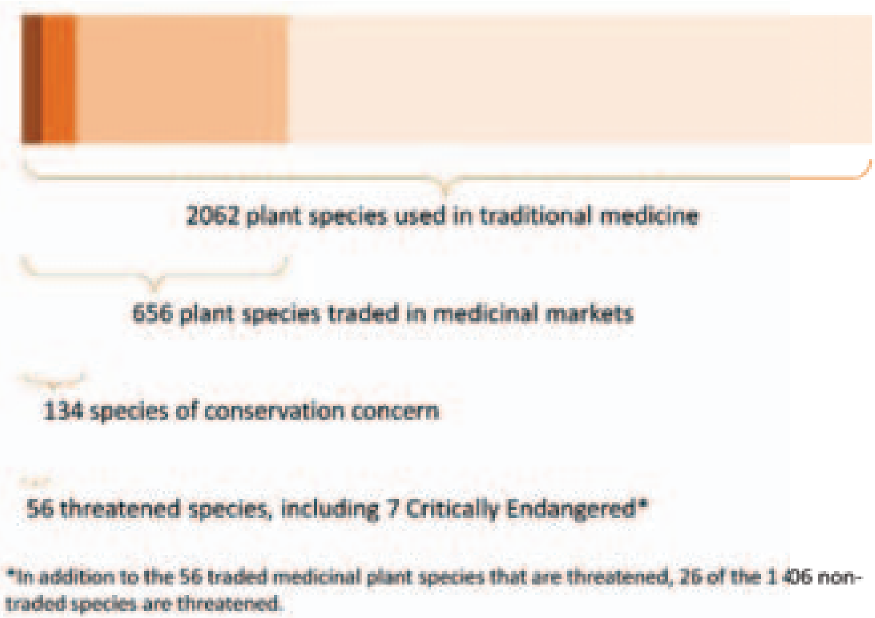


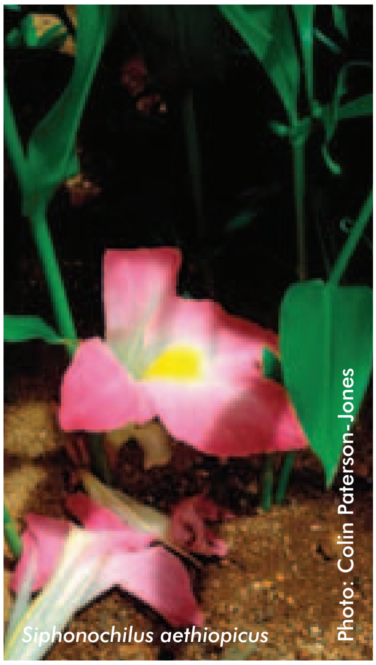
Figure 67.—Numbers of recorded, traded and threatened medicinal plant species in South Africa. Urgent attention is needed for the 56 traded medicinal plant species that are threatened, seven of which are Critically Endangered.
(Source: Based on data from Williams *et al*. (in review)[54])

Urgent attention needs to be paid to the 56 traded medicinal plant species that are threatened, seven of which are Critically Endangered and now extremely scarce. In addition, research and monitoring of the remaining traded species is important, especially those that are of conservation concern, to ensure that harvesting patterns are sustainable and that they do not become threatened. Box 18 gives three examples of well-known medicinal plant species, two of which are highly threatened.

Box 18: Examples of heavily traded medicinal plant species

Of South Africa's 2 062 plants species that are used in traditional medicine, 656 are traded in medicinal markets. Fifty-six, or about one in twelve, of these traded species is threatened. Below are three examples of heavily traded medicinal species, two of which are threatened and one of which has too little available data to assess its conservation status.

***Siphonochilus aethiopicus* (wild ginger)—Conservation status: Critically Endangered**



Siphonochilus aethiopicus

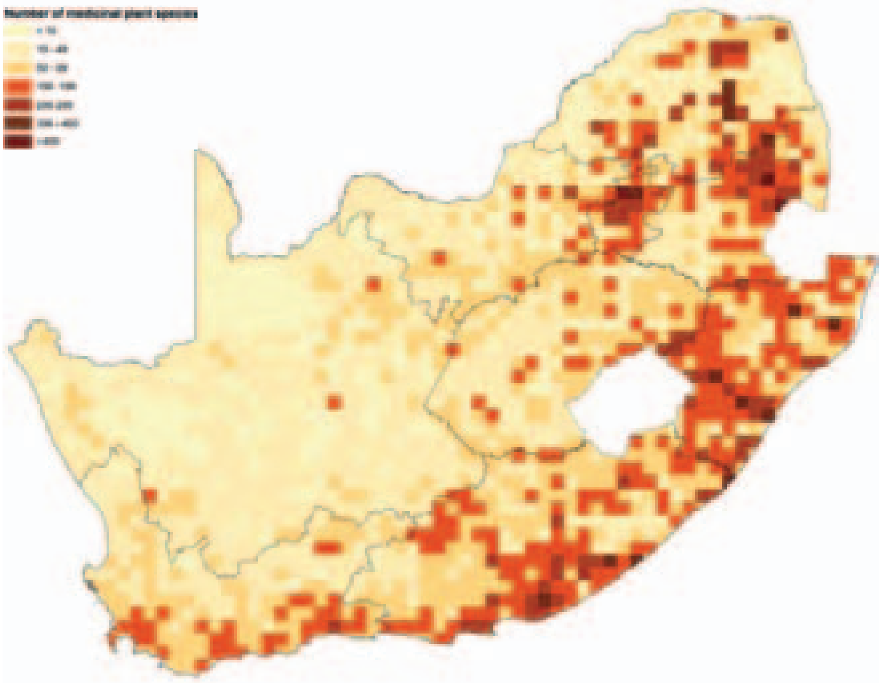


Figure 68.—Spatial distribution of medicinal plant species in South Africa (2 062 species). The highest numbers of medicinal plant species are found in the Grassland, Forest and Savanna biomes.

Sustainable harvesting of medicinal plants provides social and economic benefits and should be highlighted and promoted. At the same time, instances of unsustainable harvesting should be addressed. Urgent action is needed for those medicinal plant species that are threatened with extinction if future generations are to continue to benefit from them. Options for action include:

- Developing and implementing Biodiversity Management Plans in terms of the Biodiversity Act (see Box 18 for *Pelargonium sidoides* example). Biodiversity Management Plans are particularly appropriate for highly utilised species that are also exported, in which the private sector has a direct interest, such as devil's claw (*Harpagophytum procumbens*) and *Aloe ferox*.[58] Biodiversity Management Plans allow for coordination between multiple role players to ensure long-term survival of the species in nature. In addition to harvesters, traders and healers, provincial conservation authorities have a key role to play in developing and implementing these plans, as well as Department of Environmental Affairs officials who deal with bioprospecting, access and benefit sharing.
- Exploring options for cultivation of medicinal plant species through collaboration between traditional healer organisations and government, which

Siphonochilus aethiopicus is the most highly sought-after medicinal plant on South African muti markets. It is used to treat asthma, colds, coughs and flu. The underground rhizomes and roots are harvested and either chewed fresh or brewed as a tea.

This species is now extinct over most of its former range, with a 90% reduction in its extent of occurrence over the last 100 years. Numbers remaining in the wild are critically low. For example, recent monitoring of populations in Mpumalanga recorded an 84% decline in only four years. All indications are that harvesting of this species is unsustainable and that it is rapidly heading towards extinction. It is now considered among traders as the most scarce of all traded plants.

Siphonochilus aethiopicus is found in Limpopo and Mpumalanga, but has become extinct in KwaZulu-Natal. It is widespread elsewhere in Africa.

Warburgia salutaris

***Warburgia salutaris* (pepper-bark tree)—Conservation status: Endangered**

Warburgia salutaris is used as an expectorant for treating chest infections, as well as for treating a range of yeast, fungal and bacterial infections. The bark is harvested either directly from the tree or by felling branches so that bark can be stripped to the tips. The bark re-grows fairly rapidly, but if trees are debarked too often, when the bark has only partially re-grown, or if the roots are debarked, the tree is not able to recover and may die. In addition to being widely used by practitioners of traditional medicine, *Warburgia salutaris* is readily available in tablet form in health shops in urban centres.

[58] This applies not only to medicinal plant species but also to other economically and commercially valuable species such as *Cyclopia* species (honey bush) that are harvested only from wild plants and sold domestically and internationally as teas.

could benefit users of the plants directly and create new job opportunities.

- Research and development on sustainable harvesting practices, processing, storage, dosage and treatment, involving participants in the medicinal plant trade in the development of their own industry.[59]

Medicinal plants represent a significant resource that not only supports livelihoods through trade linked to traditional medicine, but could play a much larger role in enterprise development, job creation and the growing business of naturopathy in South Africa and globally. In making the most of the ecosystem services provided by medicinal plants, it is important to be absolutely sure that harvesting from the wild is undertaken sustainably, and that the holders of this valuable indigenous knowledge base benefit appropriately.

10.2 Harvested marine species

Fisheries make a significant contribution to the South African economy, with total annual production of 600 000 tonnes valued at approximately R6 billion, about 27 000 people employed in the commercial fishing industry, and an estimated 28 000 households engaged in subsistence fishing.[60] However, the resources on which fisheries ultimately depend—the

There has been at least a 50% decline in the South African population due to excessive harvesting of bark, especially in KwaZulu-Natal. While some healthy populations exist in Mpumalanga and Limpopo, most populations have been impacted by bark harvesting. The average thickness of the bark sold in markets has decreased, indicating that increasingly smaller trees are being debarked as the larger, more mature trees become unavailable. Both shop traders and street traders consider the bark to be popular and very scarce.

Warburgia salutaris occurs in KwaZulu-Natal, Limpopo and Mpumalanga, as well as in Swaziland, Mozambique, Zimbabwe and Malawi.


Pelargonium sidoides
Photo: David Newton

***Pelargonium sidoides* (umckaloabo)—Conservation status: Least Concern**

Pelargonium sidoides, a member of the Geranium family, is an aromatic perennial herb endemic to South Africa and Lesotho, where it is found widely in open grasslands. *Pelargonium* species have long been used in local traditional remedies for colic, dysentery, and other abdominal ailments. In recent years, *Pelargonium sidoides* has increasingly been harvested to supply a growing international market for root tubers, which are used in commercially produced remedies to treat bronchitis and other respiratory tract infections. The sale of wild harvested tubers provides income for rural collectors.

Reports of overexploitation of the species led SANBI and the Department of Environmental Affairs to develop a Biodiversity Management Plan for *Pelargonium sidoides* in terms of the Biodiversity Act. As part of this plan, a thorough resource assessment involving over 100 surveys was conducted in 2010 to better understand the size of the *Pelargonium sidoides* wild resource, to determine what proportion is currently harvested, and to identify areas where harvesting may impact on wild populations.

The results of the assessment showed that the harvesting of roots is not currently the main threat to *Pelargonium sidoides*. The greatest pressures on survival of the species are loss and degradation of its habitat, mainly due to heavy livestock grazing. *Pelargonium sidoides* can recover from harvesting and the majority of harvested plants were observed to be resprouting after being harvested; population declines were recorded in some local areas where repeat harvesting occurred frequently. Despite habitat degradation from overgrazing and localised declines from harvesting, the species is still widespread and abundant across the majority of its range.

This resource assessment was financed by the German company Schwabe Pharmaceuticals, which imports wild collected *Pelargonium sidoides* from South Africa. It is a good example of the application of the regulations on Bioprospecting, Access and Benefit Sharing, published in terms of the Biodiversity Act, which specify that permits for use of South Africa's biological resources will only be approved for companies that demonstrate investment in, amongst others, the enhancement of technical capacity of organs of state.

(Source: South African Red List of Plants http://redlist.sanbi.org)

[59]See Mander *et al*. 2007 (footnote 55) for more on research priorities and other recommendations for developing the informal and formal medicinal plant trade in a sustainable manner.

[60]Department of Agriculture, Forestry and Fisheries. 2010. *Draft integrated growth and development plan, 2011 – 2031*. Department of Agriculture, Forestry and Fisheries, Pretoria.

species that are harvested—are in many cases in decline. The current situation does not bode well for long-term food and job security.

More than 630 marine species, most of them fish species, are caught by commercial, subsistence and recreational fisheries in South Africa (although several of these are caught infrequently or in small numbers). The country has a long history of fisheries management grounded in excellent scientific research, focused mainly on managing total catch and fishing effort for individual species. However, only a small proportion of these 630 species are managed in this way, and the stock status of only 41 of them was reported in 2010. Of the 41 harvested species for which stock status was reported, over 60% (25 species) are considered overexploited, collapsed or threatened.[61] In 2000 a 'state of emergency' was declared in South Africa's linefishery, and since then data has not reflected an improvement in stock status, although many linefish assessments are outdated.

More than 630 marine species, mostly fish, are caught by commercial, subsistence and recreational fisheries in South Africa, making a large contribution to the economy but in some cases putting species and ecosystems at risk.

As we saw in Chapter 8, fishing is the main pressure on marine ecosystems. Key challenges linked to fishing include overexploited resources, substantial and unmanaged by-catch in some sectors, incidental seabird mortalities, competition between fishers and other predators, and damage to marine and coastal habitats such as reefs.

Mariculture (farming of marine organisms) can sometimes provide options for easing pressure on over-exploited marine resources. However, mariculture itself can impact heavily on ecosystems and often threatens indigenous fish stocks even further, for example through introduction of disease and parasites. Mariculture conducted in an open system, in other words in the ocean or in an estuary as opposed to on land in a closed system, is always risky, and the ecological costs tend to be borne by society rather than the mariculture enterprise. Closed land-based systems are usually more expensive to run, and require careful management to minimise ecological impacts, but are by far preferable to other forms of mariculture if the integrity of wild marine resources and ecosystems is to be maintained.

The good news is that fish stocks can recover with management interventions. For example, deep water hake is showing signs of recovery in response to a more conservative fishing strategy with lower quotas and more stringent effort limitation. Extended datasets to monitor trends and improved understanding of stock dynamics have played a key role in guiding management interventions. The decline of south coast rock lobster was arrested in the early 2000s, through coordinated catch and effort reductions, a 30% reduction in the number of active vessels and a reduction in the illegal catch.[60]

More and better assessments of the stock status or trends for harvested marine resources are urgently needed to guide how and where to intervene. This includes investing in critical datasets, dedicated data managers, and better data management systems to support science-based fisheries management. It also includes national conservation assessments for priority groups of marine species, such as linefish, as discussed in Section 10.3 on threatened species. However, it will never be realistic to gather comprehensive fisheries management data for all or even most of South Africa's 630 harvested marine species—it is not feasible to manage all harvested species using a traditional fisheries management approach that regulates catch or fishing effort for each individual species.

Hence the importance of implementing the ecosystem approach to fisheries management, including the use of marine protected areas and other spatial management measures, as a crucial strategy for ensuring the long-

[61]Department of Agriculture, Forestry and Fisheries. 2010. *Status of the South African marine fishery resources*. Status report compiled by Chief Directorate: Fisheries Research, Fisheries Branch, Department of Agriculture, Forestry and Fisheries.

term integrity of marine resources and the ecosystem services they provide.

The ecosystem approach to fisheries management focuses not only on regulating catch or fishing effort for individual species but also on:

- Protecting important habitats including spawning and nursery areas, foraging areas and other habitats that play a role in the recovery or maintenance of fish stocks.
- Improved by-catch management, which offers opportunities to reduce waste and derive benefits from non-target species, through adding value that supports job creation.
- Considering the interactions between competing species and the needs of other predators when modelling stock dynamics and providing management advice.
- Credible third party eco-certification that provides an incentive for responsible fisheries management and can deliver additional economic benefits through improved market access and security.

Marine protected areas and other spatial management measures form part of the ecosystem approach to fisheries management and are a relatively easy and cost effective way to contribute to healthy fisheries. By providing no-take zones where fishing is not allowed, marine protected areas allow for the recovery and maintenance of a range of species impacted by fisheries, both target and non-target species. To play this role effectively, the marine protected area network must represent a range of marine and coastal habitats, including productive offshore habitats that support commercial fisheries, as well as specific areas important for ecological processes such as spawning and nursery grounds. South Africa's current marine protected area network is inadequate, especially in the offshore environment, as discussed in some detail in Chapter 8. Work has been undertaken to identify the most strategic spatial areas for offshore marine protection (see Chapter 12), taking into account the need to contribute to the sustainability of fisheries. When implemented, expansion of the marine protected area network and other spatial management measures will support long-term food security as well as job security in South Africa's fisheries.

Fisheries by-catch refers to any part of the catch that is unmanaged or unused. Reduction of by-catch in South African fisheries, through management of more species that are caught, is an important focus of the ecosystem approach to fisheries management.

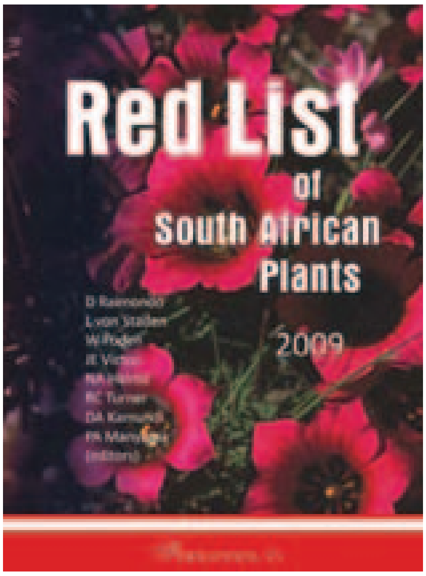
10.3 Threatened species

As noted in the introduction to this chapter, South Africa has a wealth of species, with over 95 000 known species and many more still to be described. In order to decide where to focus limited conservation resources, it is important to know which species are threatened or of particular concern for other reasons such as rarity.

How many South African species are threatened?

Conservation assessments, also known as Red Lists, tell us how threatened different species are, based on the likelihood of a species becoming extinct. The IUCN has developed a standard set of criteria and terminology for classifying species from highest to lowest risk of extinction, enabling comparison between different countries (see Panel 10). South Africa is a world leader in Red Listing, and one of the few countries with a dedicated Threatened Species Programme that promotes Red Listing of a range of taxonomic groups.[62] Many countries focus only on charismatic groups, such as mammals and birds, and assess only those species on which scientists are currently working. In contrast, South Africa has assessed a wider range of taxonomic groups, and promotes comprehensive assessments, meaning that for each group all species that occur in South Africa are assessed. Comprehensive conservation assessments enable a much more accurate understanding of the status of species.

[62]SANBI's Threatened Species Programme works in collaboration with a range of partners, as discussed further in the chapter.



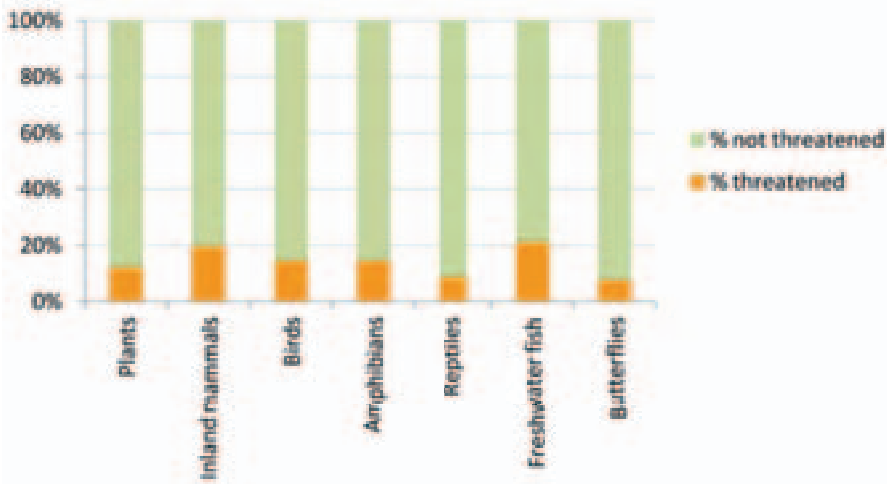


Figure 69.—Proportion of threatened species for those taxonomic groups that have been comprehensively assessed, based on the most recent available Red Lists. The proportion of threatened species is highest for freshwater fish and inland mammals. By far the highest numbers of threatened species (over 2 500) are found among the plant group (also see Table 7).

To date South Africa is the only mega-diverse country to have comprehensively assessed its entire flora.[57]

The results of Red List assessments for South Africa to date are summarised in Table 7 and in Figure 69. They show that:

- One in every five inland mammal species is threatened.
- One in every five freshwater fish species is threatened.
- One in every seven frog species is threatened.
- One in every seven bird species is threatened.
- One in every eight plant species is threatened.
- One in every twelve reptile species is threatened.
- One in every twelve butterfly species is threatened.

Red Lists give us more than just information about numbers of species that are threatened. They also enable analysis of the factors that contribute to threat status. The most recent conservation assessments completed in South Africa (for plants in 2011, reptiles in 2011 and amphibians in 2010) show clearly that the primary threat to species comes from loss of natural habitat or land cover change, particularly as a result of cultivation. The issue is not simply the loss of individual patches of natural vegetation but also the resulting fragmentation of the remaining natural vegetation, which is a problem especially for species that need large areas of natural habitat to survive and species that cannot move easily between remaining patches of habitat. Fragmentation also prevents landscape-scale ecological processes, such as fire, from functioning effectively.

Table 7.—Summary of species status in South Africa, for those groups that have been comprehensively assessed

Taxonomic group	# described taxa*	# threatened	% threatened	# extinct	# endemic to SA	% endemic to SA	% of Earth's taxa	Most recent Red List
Plants	20 692	2 505	12%	40	13 203	64%	6%	2011
Inland mammals	307	60	20%	3	57	19%	6%	2004**
Birds	841	122	14.5%	2	68	8%	8%	2000***
Amphibians	118	17	14%	0	51	43%	2%	2010
Reptiles	421	36	9%	2	196	47%	5%	2011
Freshwater fish	114	24	21%	0	58	51%	1%	2007
Butterflies	793	59	7%	3	415	52%	?	2011

* A taxon (plural taxa) is usually a species but in some cases may be a subspecies or variety.

** Inland mammals will be reassessed in 2012–2013.

*** Figures for birds in this table are based on BirdLife South Africa figures online (www.birdlife.org.za/conservation/threatened-species, accessed December 2011), which are being used in preparation of the new Red List for Birds, currently underway and due to be completed in 2012.

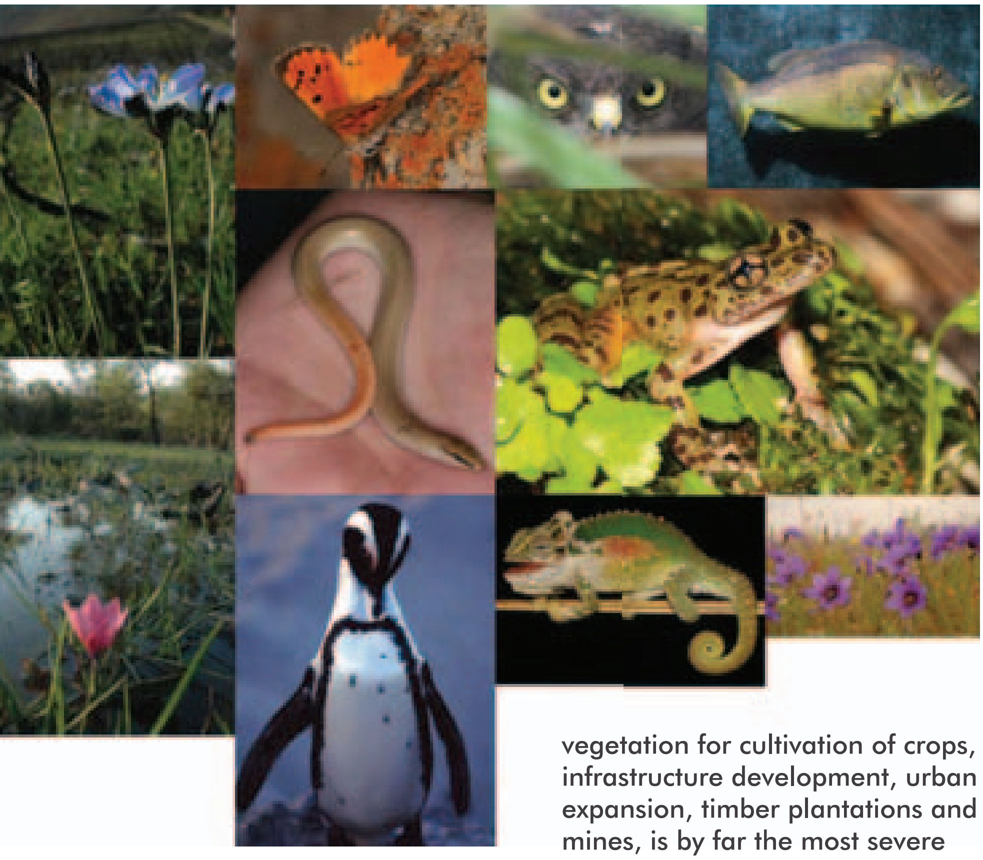


Figure 70 shows a breakdown of the number of plant species threatened by a range of factors. Habitat loss, which includes the irreversible conversion of natural vegetation for cultivation of crops, infrastructure development, urban expansion, timber plantations and mines, is by far the most severe threat to South African plants, affecting more than 1 600 taxa. Invasive alien plant species, which out-compete indigenous plant species and alter their habitat, is another severe threat. Habitat degradation includes overgrazing, inappropriate fire management (fires may be too frequent, not frequent enough or out-of-season) and clearing of woody shrubs and trees from forests and savannas. Such degradation may appear to leave natural vegetation intact, but causes disturbance and breakdown of essential ecosystem processes, resulting in the loss of sensitive species.

There are hundreds of species in South Africa that are threatened and that warrant more attention than is possible in a short chapter such as this one. Without wanting to favour some species above others, we have nevertheless chosen some species of special concern to focus on in more detail in order to bring to life some of the dry statistics reported above: white rhinoceros, much in the news recently because of unprecedented levels of poaching; cycads, the most threatened plant group in South Africa and globally; and threatened freshwater fish, one of the country's most threatened animal groups—see Box 19, Box 20 and Box 21.

Panel 10: Defining threatened species and species of conservation concern

Conservation assessments, or Red Lists, assess the likelihood of a species becoming extinct in the wild, based on a series of objective criteria set out by the IUCN. **Threatened species** are those that face a high risk of extinction in the near future, including the following categories:

- Critically Endangered (CR)
- Endangered (EN)
- Vulnerable (VU)

Conservation assessments also highlight other species of significant conservation importance. **Species of conservation concern** include threatened species as well as the following categories:

- Extinct (EX)
- Extinct in the Wild (EW)
- Near Threatened (NT)
- Data Deficient (due to insufficient data to make an assessment or uncertainty about the identity of the species) (DD)
- Rare or Critically Rare (these are South African categories, not used by the IUCN)

Further information about Red Listing is available from the following sources:

- SANBI. 2010. *Threatened Species: A guide to Red Lists and their use in conservation*. SANBI Threatened Species Programme, Pretoria, South Africa. Available at www.sanbi.org.za/programmes/threats/threatened-species-programme
- www.iucnredlist.org
- http://redlist.sanbi.org

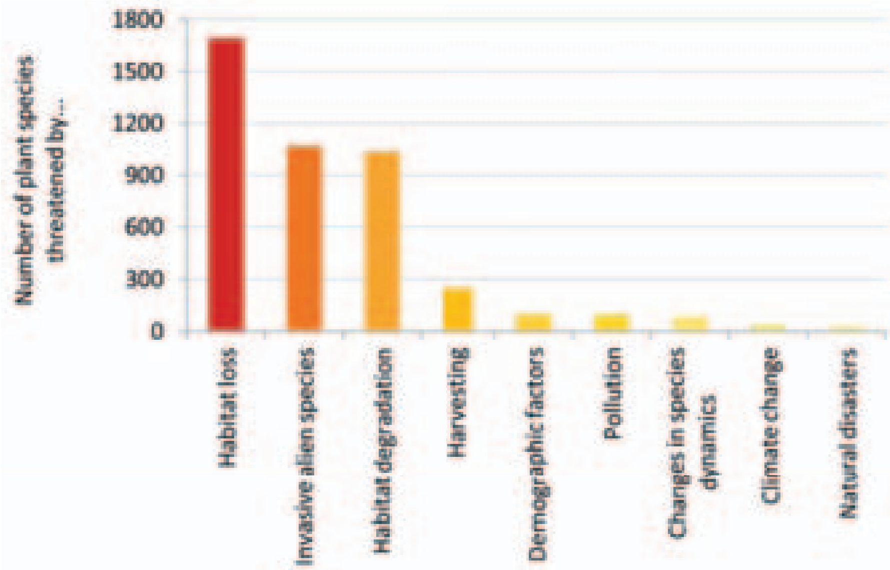


Figure 70.—Analysis of threats facing plant species in South Africa, based on the Red List of South African Plants. Loss of natural habitat, for example as a result of cultivation, mining, urban expansion or timber plantations, is the most severe threat.

Box 19: White rhinoceros—a South African conservation success story under threat

In 1895 the southern white rhinoceros (*Ceratotherium simum simum*) was on the verge of extinction. Only a small population of 20 to 50 animals survived in the iMfolozi area of what is now the Hluhluwe Imfolozi Park in KwaZulu-Natal. Concerted conservation efforts by the state and the private sector resulted in a steady increase in numbers to 150 in 1929, 550 in 1948, 1 800 in the 1960s and approximately 18 800 animals in 2010. Part of the success can be attributed to the development of translocation methods pioneered by the then Natal Parks Board in the early 1960s, which made it possible to distribute animals throughout the country to numerous state-owned protected areas and private reserves, with an additional 1 365 now occurring in the wild in eight other African countries. Careful management of South Africa's southern white rhino population has resulted in an annual growth rate of approximately 6%. This is a remarkable story of recovery of a species from critically low numbers to healthy population levels numbering over 20 000 animals worldwide, through collaborative action over the course of a century.*

The majority of southern white rhino (90%) occur in South Africa, with large populations in the Hluhluwe Imfolozi Park and the Kruger National Park, while a quarter of the national population occurs on private land. South Africa therefore bears most of the responsibility for the future of this species. In 2008, poaching started to increase dramatically to meet the growing demand for rhino horn in Southeast Asia. The number of rhino deaths due to poaching in South Africa has risen sharply from only 13 rhinos (white and black) in 2007, to 333 animals in 2010 and 448 (approximately 2.4% of the national population) in 2011.

The high level of poaching threatens the continued growth in numbers of southern white rhino and will result in overall declines if current trends continue. In addition to the direct loss of animals to poaching, the increased security risks may have other impacts. In keeping with best management practices, limited numbers of animals are removed annually from established populations to keep these populations productive and to provide founder rhinos for new populations. The sale of these animals to and within the private sector generates important revenue for conservation authorities and the wildlife industry. Legal hunting on privately owned game farms and reserves also contributes to the economic viability of these enterprises and provides an economic incentive for the conservation of this species and its habitat. However, an increasing number of owners perceive their rhinos as an expensive risk due to increased poaching and are seeking to sell, with the result that live white rhino prices have started to decline.

* Another subspecies, the northern white rhino (*Ceratotherium simum cottoni*), numbered 2 230 animals in 1960 in central and east Africa, but is now listed by the IUCN as possibly extinct in the wild and is thought to exist only in captivity.

Citizen science: involving the public in monitoring the conservation status of species

Keeping track of the status of species in a mega-diverse country such as South Africa, and gathering the required data for assessing their status, is a daunting task. SANBI is formally mandated to monitor and report on the conservation status of indigenous species in South Africa, but could not possibly undertake the task alone. SANBI's Threatened Species Programme coordinates the collection of information on species, particularly those that are less well known, through projects involving scientists, taxonomists and managers from partner institutions across the country, as well as volunteers from the public. Data collected through these projects feeds directly into Red Listing.

Hundreds of volunteers, or citizen scientists, play a crucial role in the process through atlassing projects and virtual museums. Atlassing projects, such as the South African Bird Atlas Project (SABAP1 and 2), the Southern African Butterfly Conservation Assessment (SABCA), the Southern African Reptile Conservation Assessment (SARCA), the South African National Survey of Arachnida (SANSA) and the Custodians of Rare and Endangered Wildflowers (CREW), involve the public in collecting information on the

Box 20: Cycads—South Africa's most threatened plant group

Cycads are the oldest living seed plants. They existed on Earth at least 280 million years ago and have survived three mass extinction events. Cycads flourished during the time of the dinosaurs, but declined at the same time that dinosaurs died out about 65 million years ago. Modern cycads evolved around 10 million years ago. Cycads grow slowly, taking ten to twenty years to reach maturity, and they reproduce infrequently. Each cycad plant is either male or female (or dioecious in botanical terms, unlike most plants which are hermaphroditic) and their pollination depends on insect pollinators, in some cases involving only one specialised insect species. Globally there are 308 cycad species. South Africa is one of the world centres of cycad diversity, with 38 species, 29 of which are endemic.

The last known wild specimen of the Venda cycad (*Encephalartos hirsutus*). When the species was described in 1996, the estimated population size was between 400 and 500 plants.

Having survived for so long, cycads are now threatened with extinction. Because of their unusual primeval beauty, many cycad species are highly sought after for horticulture and are considered collectors' items. Some cycad species are also harvested for traditional medicine markets. Collecting from the wild primarily for private collectors is the most important cause of decline, with theft of the plants even from inside protected areas taking place in some cases.

The IUCN's recent global assessment of cycads shows that 62% of the world's cycad species are threatened, up from just over half less than a decade ago, making cycads the most threatened plant group globally. The Red List of South African Plants shows that 68% of South Africa's cycad species are threatened, with nearly a third classified as Critically Endangered, making cycads the most threatened plant group in this country as well. South Africa also has three of the four cycad species classified as Extinct in the Wild, two of which have become Extinct in the Wild in the period between 2003 and 2010. South Africa currently has seven cycad species that have fewer than 100 individuals left in the wild. There is a high risk that these cycad species will become Extinct in the Wild within the next decade unless the illegal removal of cycads from the wild can be stopped.

Cycads are currently fully protected by national legislation. They are listed as threatened species in terms of the Biodiversity Act, and all activities with wild specimens (including possession and trade) are prohibited. However, it can be difficult to distinguish between a cycad plant that has been cultivated legitimately in a nursery and one that has been removed from the wild. Systems to implement and enforce legislation relating to cycads are weak, and the challenges are complex. Collaboration between conservation authorities, cycad traders and other stakeholders is urgently required if the decline of this ancient group of plants is to be turned around.

distribution of species.[63] Electronic data records in addition to actual specimens are gathered. Different projects collect different types of data, but all include the collector, date, locality, identity of the species and usually some population data as well. Citizen scientists contribute their time and resources on a voluntary basis, making the collection of data on a large scale feasible.

Virtual museums are now a central part of most of these atlassing projects. These are databases which store photographs of plants or animals submitted by the public. The ideal virtual museum is backed up by experts who identify the photographs; however, amateur identification also works well, with some schemes allowing participants to progress from 'novice' to 'expert' status as they develop their identification skills. Virtual museums are increasingly used in atlassing projects, especially for groups of species that are more difficult to identify. Photographs

Box 21: Threatened freshwater fish can be protected in just 15% of South Africa's river length

Freshwater fish are among the most threatened animal groups in South Africa, with one in five species threatened. Threatened indigenous fish include large angling species like yellowfish as well as small fish like redfins. Invasive alien fish, such as bass, trout and carp, present a grave threat to indigenous fish species, together with deterioration in the ecological condition of rivers. These species are often introduced to river systems for aquaculture and recreational fishing. Even when invasive alien fish are not directly introduced in rivers, they often escape from farm dams in which they are stocked (e.g. when the dam wall is breached in floods). Invasive alien fish now occur extensively in most large rivers in South Africa, and impact on indigenous freshwater plants and animals through altering habitats, competing for resources and eating indigenous plants and animals.

As part of the recent National Freshwater Ecosystem Priority Areas project (NFEPA), a national map of fish sanctuaries was developed, shown in Figure 71. Rivers in these sub-quaternary catchments are essential for protecting threatened and near-threatened freshwater fish that are indigenous to South Africa, and they make up just 15% of total river length in the country. In order to protect threatened fish, there should be no further deterioration in river condition in fish sanctuaries and no new permits should be issued for stocking invasive alien fish in farm dams in the associated sub-quaternary catchments. Fish management plans should be developed for all fish sanctuaries to protect the fish they contain, with priority given to those fish sanctuaries containing critically endangered or endangered fish species.

The Tradou River Gorge and upstream tributaries near Barrydale in the Western Cape represent the entire distribution range of the Critically Endangered Barrydale redfin (*Pseudobarbus burchelli*).

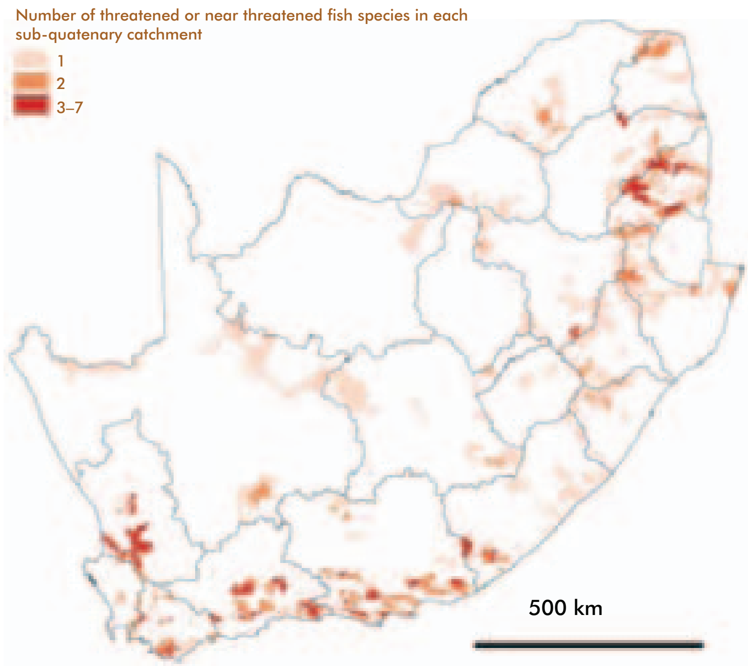


Figure 71.—Fish sanctuaries for threatened and near threatened freshwater fish species indigenous to South Africa. Rivers in these sub-quaternary catchments are essential for protecting threatened and near-threatened freshwater fish, and they make up just 15% of total river length in the country.

[63]These atlassing projects involve partnerships between various organisations, including SANBI, the Animal Demography Unit at the University of Cape Town, the Agricultural Research Council, the Lepidopterists' Association of South Africa, and conservation agencies.

are provided by amateurs along with data on locality, date and often anything else of interest.

SANBI is soon to launch iSpot in South Africa, a website that will allow anyone with a cell phone or computer to contribute to, exchange biodiversity data, or obtain an identification of animals, plants or fungi on the subcontinent. South Africa is the first mega-diverse country to use iSpot, which was initially developed in the United Kingdom. The hope is that iSpot will facilitate contributions from South Africa's network of keen amateur scientists to species monitoring efforts, and will encourage a new generation of tech-savvy naturalists—under the online guidance of experts and knowledgeable amateurs—to develop their skills and reputation in a group.

Filling the information gaps: what are the priorities?

This excellent work notwithstanding, there are still many knowledge gaps with respect to the conservation status of species in South Africa. In some cases filling these gaps requires improving taxonomic knowledge of the groups of species concerned—more about this in Chapter 13. Major Red Listing priorities include the following:

- Conducting Red List assessments of marine species, especially linefish.
- Increasing the number of invertebrate species assessed. Priority groups include economically important species such as pollinators, particularly all bees; dung beetles because of their important role in ecosystem functioning; and freshwater macro-invertebrates which are often important indicators of ecosystem health.
- Re-assessing groups for which Red Lists are out of date, including mammals and birds.
- Re-assessing freshwater fish based on updated taxonomy.

Custodians of Rare and Endangered Wildflowers (CREW) involves communities in monitoring threatened plant species that occur in their area. The information gathered by CREW volunteers helps to prioritise the species that need conservation attention.

In addition, a strategy for keeping conservation assessments current is needed. The international standard for Red Listing promoted by the IUCN suggests that assessments should be redone every five years. However, given the very high numbers of species in South Africa, comprehensive assessments (in which every species in a group is assessed) are time consuming, generally taking between two and five years. It may be more realistic to aim for comprehensive assessments every ten to 15 years, depending on the size of the group, and to take a sampling approach in intervening years. This would involve randomly selecting a sub-sample of South African species for both field monitoring and re-assessment, along the lines of the global Sampled Red List Index, which is based on a stratified sample from all major taxonomic groups, biogeographic realms and ecosystems.

A further challenge is to develop a consolidated national Red List that is easily available in one place. The first national Red List website was recently launched (http://redlist.sanbi.org) with exactly this intention—over time all national assessments will be included on this site. In addition to making all comprehensive assessments available, the site will also highlight particular species that are known to be threatened even if the whole group has not been assessed.

Lastly, a national Red List Index to track trends over time needs to be developed. A single Red List gives a snapshot in time, while a Red List Index tracks species' movement through the Red List categories. Only changes in Red List status that result from genuine deterioration or improvement in a species' status are used in the analysis; taxonomic changes or changes resulting from improvements in knowledge are excluded. A Red List Index would thus provide a reliable estimate of the success or failure of conservation actions in preventing species extinction.

11. Invasive alien species

Chapter summary

Invasive alien species

- Known invasive species in South Africa include 660 plants species and about 150 animal species. These are under-estimates as thorough surveys have not taken place in most environments.
- Extent of invasion by established invasive woody plants doubled between the mid-1990s and 2007.
- At least R6.5 billion worth of ecosystem services lost every year to invasive plants–this would be as much as R42 billion in the absence of intervention.
- Estimated cost to clear established invasive plants is R1.4 billion per year over the next 25 years.
- Return on investment is highest from early detection of potentially invasive species and rapid action to eradicate before they become established.

Invasive alien species are species that have become established in an area beyond their natural distribution range following introduction by humans, and whose spread threatens ecosystems, habitats or species with environmental or economic harm. They present a large and growing challenge in South Africa and globally. Not only do invasive species threaten indigenous biodiversity, they also have serious socio-economic impacts including threats to water security, reduced productivity of rangelands, increased fire risk, and impacts on crop agriculture. In South Africa, a conservatively estimated R6.5 billion worth of ecosystem services is lost each year as a result of invasive alien plants, a value that would be more than six times higher had no management of these plants been carried out.

Known invasive alien species in South Africa include 660 plant species, six mammal species, ten bird species, at least six reptile species, at least 22 freshwater fish species, at least 26 mollusc species, at least seven crustacean species, and more than 70 invertebrate species. These figures are almost certainly underestimates, as thorough surveys have yet to take place in most environments.

The pathways or routes by which alien species are introduced are varied. Common ones include transport of agricultural products and other freight; movement of travellers by air, sea and land; release of ballast water from ships; fouling (colonisation by species) of ships' hulls and other infrastructure in the sea; aquaculture and mariculture; inter-basin transfers of water; plants introduced for forestry or biofuels; horticultural trade; and trade in pets. Efforts to prevent the introduction of potentially invasive species need to address all of these diverse pathways.

Invasive species are not evenly distributed across the South African landscape and seascape. More is known about the distribution of invasive woody plant species than other groups of invasive species. In the mid-1990s an estimated ten million hectares of South Africa's land area had been invaded by invasive woody plants. In 2010 the first National Invasive Alien Plant Survey showed that this had doubled to 20 million hectares (16% of South Africa's land area). Widespread species or groups include wattle (*Acacia* spp.), gum (*Eucalyptus* spp.), prickly pear (*Opuntia* spp.), pine (*Pinus* spp.), poplar (*Populus* spp.), weeping willow (*Salix babylonica*) and mesquite (*Prosopis* spp.).

Addressing the challenge of invasive alien species can create opportunities linked to restoring ecosystem functioning, securing the provision of ecosystem services and creating employment. One of the best known examples of this, in South Africa and globally, is the Working for Water programme, which uses labour-intensive methods to clear invasive woody plants, supporting job creation and relieving poverty as well as protecting scarce water resources and restoring productive land and biodiversity. From its inception in the mid-1990s to 2010/11, the programme created a total of over 130 000 person-years of employment.

In 2010/11 Working for Water had a budget of just more than R700 million. The projected cost of controlling the species included in the National Invasive Alien Plant survey over the next 25 years is R36 billion (an average of R1.4 billion a year). These costs may seem high until one considers the value of the ecosystem services currently being lost as a result of invasive alien plants. There is enormous scope to scale up the operations of Working for Water and other natural resource management programmes, with potential for further job creation combined with the benefits of restoring ecosystem functioning and securing ecosystem services.

The bulk of Working for Water's activities focus on physical removal of invasive plants, through mechanical or chemical means. However, South Africa is also a leader in biological control of invasive plants, which involves using a completely host-specific natural enemy of a species, such as a plant-feeding insect or a fungus, to reduce population or seed production. Biological control can be highly cost effective, especially for invasive plant species that are so widespread that other methods of containment and management are difficult.

Recognising that prevention is better and cheaper than cure when it comes to invasive alien species, Working for Water established an Early Detection and Rapid Response programme in 2008, which aims to identify potentially invasive plants already present in the country and act quickly to eradicate them before they become widely established. Provincial coordinators work with taxonomists and networks of 'informers' including professionals and members of the public.

Although South Africa has responded significantly to the challenge of invasive alien species, most effort has tended to be invested in managing invasive species that have already become a problem. Increasingly, countries around the world are recognising the value of a hierarchical approach to dealing with invasive species, with a strong focus on preventing the entry of new high risk alien species and eradicating those that are at an early stage of establishment. The return on investment of public funds is much higher for prevention and early eradication than for containment and management of established invasive species. For invasive species that are so widespread they cannot be contained, it is important to take an asset-based approach to management, restoring and protecting specific highly valued ecological assets. Working for Water does exactly this, with sophisticated planning tools for prioritising quaternary catchments for clearing of invasive plants based on a range of factors.

The Biodiversity Act provides the legal framework for prevention, management and control of invasive species, and regulations for alien and invasive species and accompanying lists of species were in the process of being finalised at the time of writing. In addition to the regulations, South Africa would benefit from a national strategy for invasive alien species to support the effective implementation of legislation. Such a strategy was in the process of being initiated at the time of writing. Cooperative governance and involvement of a wide range of stakeholders are critical foundations for success.

The focus of Chapter 10 was on species indigenous to South Africa, including those harvested from the wild and those that are threatened. In this chapter, we focus on invasive alien species—species introduced to South Africa through human action, whose spread causes not only ecological damage but also in many cases economic damage. See Panel 11 for definitions of invasive alien species and other key terms.

As globalisation leads to increased trade and travel between countries and continents, more and more species are introduced to new environments either deliberately or by accident. A range of factors interact to determine whether an introduced species becomes invasive, including biological traits of the species as well as features of the environment. The fact that South Africa has such a wide range of biomes and habitats increases the chances that an introduced species will find a home here and become established. As a rule of thumb, about ten percent of introduced species establish populations in new host countries, and about ten percent of those become invasive.

Invasive alien species present a large and growing challenge in South Africa. Not only do they threaten indigenous biodiversity, they also have serious socio-economic impacts. The South African government recognises this, and sets out the legal framework for addressing alien and invasive species in the Biodiversity Act together with accompanying regulations. Addressing the challenge of invasive alien species can also create opportunities for employment creation and enterprise development, linked to restoring and maintaining ecological infrastructure and securing the provision of ecosystem services, as discussed further below.

In this chapter, we outline some of the problems caused by invasive alien species, summarise known numbers of alien species and invasive species in South Africa, discuss some of South Africa's responses to date, and encourage the ongoing development of a hierarchical approach with a strong

Panel 11: Defining invasive species

The definitions below draw on the Convention on Biodiversity as well as the Biodiversity Act.

An **alien species**, also sometimes called an introduced species or a non-native species, is a species that has been introduced to an area beyond its natural distribution range by humans.

An **established or naturalised species** is an alien species that has established itself in the wild and is able to reproduce and maintain a durable population without human intervention.

An **invasive alien species** or **invasive species** is an alien species whose establishment and spread threatens ecosystems, habitats or species with environmental and/or economic harm.

Introduction means the movement of a species outside its natural range through human action, either intentional or accidental.

Pathways, also called vectors, are the ways in which invasive alien species are introduced or spread, either intentionally or accidentally.

focus on return on investment to deal with the challenge.

11.1 Why are invasive species a problem?

Invasive alien species transform the ecology of the area they inhabit, often eroding ecological infrastructure, decreasing agricultural productivity, compromising water supplies, interfering with rural livelihoods, reducing rural land asset values, and threatening indigenous species with extinction.

Estimates put the cost of the damage caused by invasive species worldwide at 5% of the global economy.[64] In South Africa, it is conservatively estimated that at least R6.5 billion worth of ecosystem services are lost each year to invading plants, and that this value would have been a much higher R42 billion had there been no management of invasive plants.[65]

Some of the specific social and economic problems caused by invasive alien species in South Africa are:

- **Threat to water security**: Invasive alien plants reduce surface water runoff, which in turn reduces the amount of water that reaches rivers and the yield from water supply schemes. It is estimated that the reduction amounts to more than 3 billion cubic meters of surface water runoff annually, or approximately 7% of the runoff of the country—equivalent to 18 large dams.[66] If invasive plants were left to spread to their full potential, reductions could be more than eight times greater (25 billion cubic metres or 58% of runoff). Much of the impact would be felt in the Grassland biome, in which the economic heartland of the country is situated.[67]
- **Reduced productivity of rangelands**: When unpalatable plants invade rangelands and out-compete fodder plants, they reduce the available feed for cattle and the carrying capacity of the land, interfering with subsistence and commercial livelihoods. Some invasive species are poisonous and kill livestock, and some cactus species can kill stock indirectly through sharp barbs piercing mouths of animals. Livestock farmers are forced to remove herds from paddocks where poisonous or thorny species dominate. If invasive alien plants are left to spread to their full potential, the carrying capacity for large stock units could be reduced by 71%.[66]
- **Increased risk, frequency and severity of fire**: Invasive alien plants, both trees and grasses, increase fuel loads, which results in fires that burn at higher temperatures, spread faster and are more difficult to bring under control than fires burning in indigenous vegetation. At higher temperatures damage to the soil is also greater, which can result in erosion. Fires that are more difficult to control pose a greater threat to human life and property. The threat of fire in certain heavily invaded environments may result in an increase in insurance premiums.
- **Agricultural pests**: Many agricultural pests, such as certain plant-feeding insects, are invasive species. They reduce agricultural productivity, for example by feeding on crops, and often lead to increased spraying of pesticides. They can also impact on exports and limit market access as countries around the world become more concerned about preventing the introduction of pests from an infected country.
- **Crime hotspots**: Invasive alien plants can even provide havens for criminals, for example in the City of Cape Town where a council-owned site in Delft on the Cape Flats was covered with Port Jackson trees, which provided a screen for numerous rapes and murders. In 2005 the area was cleared by the City with the help of residents, who referred to the trees as 'the bush of evil'.

The costs of preventing, eradicating and managing invasive species can be substantial, but are often much lower than the costs of the damage caused by these species. See Section 11.5 for more on this, including a discussion on the returns on investing in different approaches for dealing with invasive alien species.

11.2 How many known invasive alien species occur in South Africa?

The state of invasive species in South Africa has been synthesised in a chapter of the recently published *Encyclopedia of Biological Invasions*[68] which provides the main source of information for the brief summary presented here, together with additional information from the technical reports for the marine, estuarine and freshwater components of the NBA.

[64]Department for Environment, Food and Rural Affairs (DEFRA). 2008. *The Invasive Non-Native Species Framework Strategy for Great Britain*. DEFRA, London.

[65]De Lange, W.J. & Van Wilgen, B.W. 2010. An economic assessment of the contribution of biological control to the management of invasive alien plants and to the protection of ecosystem services in South Africa. *Biological Invasions* 12: 4113–4124. Figures are in 2008 Rands, and are based on estimates of the impacts on invasive alien plants on water, grazing and biodiversity, at levels of invasive alien plant cover estimated in the late 1990s.

[66]Based on the average size of South Africa's 174 largest dams (Andrew Wannenburgh, pers. comm.).

[67]Van Wilgen, B.W., Reyers, B., Le Maitre, D.C., Richardson, D.M. & Schonegevel, L. 2008. A biome-scale assessment of the impact of invasive alien plants on ecosystem services in South Africa. *Journal of Environmental Management* 89: 336–349.

[68]Richardson, D.M., Wilson, J.R., Weyl, O.L.F. & Griffiths, C.L. 2011. South Africa: Invasions. In D. Simberloff & M. Rejmanek (eds), *Encyclopedia of Biological Invasions*. University of California Press, Berkeley and Los Angeles.

Increased risk, frequency and severity of fire is one of among several serious socio-economic problems caused by invasive alien species in South Africa.

Table 8 summarises the numbers of known alien species present in South Africa as well as those that are known to have become invasive, compiled from a range of sources. The figures are almost certainly underestimates, as thorough surveys for alien species have yet to take place in most environments, and where surveys have been done many previously unidentified alien species have often been found. For example, in the marine environment the number of alien species recorded increased dramatically from 22 in 2009 to at least 86 in 2011,[69] most likely reflecting increasing research in this field rather than an actual increase in the number of alien species.

Water hyacinth is an invasive aquatic plant that damages freshwater ecosystems as well as infrastructure such as bridges and dams.

Table 8 shows that invasive plant species far outnumber invasive animal species. South Africa is unusual in having so many invasive trees and woody plants; in other parts of the world invasive plants tend to be mainly herbaceous species including grasses. The Southern Africa Plant Invader Atlas (SAPIA), managed by the Agricultural Research Council, is based on data from roadside surveys beginning in 1979 with concentrated efforts between 1993 and 1999 (SAPIA Phase 1) and again from 2005 to 2010 (SAPIA Phase 2). SAPIA shows that new invasive alien plants are emerging at a steady rate, with 106 new species added to the database in the five years prior to 2010. Many of the newly recorded species are horticultural ornamental species located close to urban areas, along roads, rivers and in disturbed sites.[70] In Section 11.3 we discuss the types and distribution of invasive woody plants in South Africa in more detail.

In the freshwater environment, in addition to the destructive impacts of invasive woody plants on water flows, several invasive aquatic plants clog up waterways and can damage infrastructure such as bridges and dams. The five most widespread invasive aquatic plants are: red water fern (*Azolla filiculoides*), water hyacinth (*Eichhornia crassipes*), water lettuce (*Pistia stratiodes*), parrot's feather (*Myriophyllum aquaticum*) and salvinia (*Salvinia molesta*).

Invasive alien fish, such as bass, carp and trout are also a problem in South Africa's rivers. Not only

[69]Mead, A., Carlton, J.T., Griffiths, C.L. & Rius, M. 2011. Revealing the scale of marine bioinvasions in developing regions: a South African re-assessment. *Biological Invasions* 13(9): 1991–2008.

[70]Henderson, L. 2010. *Final Report: Surveys of alien weeds and invasive plants in South Africa - Southern African Plant Invaders Atlas (SAPIA) Phase II*. Agricultural Research Council – Plant Protection Research Institute, Pretoria.

do they alter habitats and interfere with ecological functioning, they prey on indigenous fish and are the primary reason for the high numbers of indigenous fish species that are threatened with extinction (see Box 21 in Chapter 10).

In the marine environment, research on invasive species has come to the fore in South Africa only in the last decade, and, as noted, the rate of discovery of alien species in South African waters is increasing. The most well-known and to date the most ecologically disruptive marine invasive is the Mediterranean mussel (*Mytilus galloprovincialis*), which occupies two thirds (over 2 000 km) of South Africa's coastline, outcompeting indigenous mussels and limpets. Some harmful algal blooms are

Table 8.—Number of alien species and invasive species recorded in South Africa

Group	Typical pathways of introduction	# known alien species in South Africa	# invasive alien species
Algae: marine, estuarine	Shipping (e.g. hull fouling, ballast water), aquaria	At least 4	1 (Red algae *Schimmelmannia elegans*)
Plants: terrestrial, freshwater, estuarine	Introductions for forestry, agriculture and horticulture. Inadvertent introductions in animal feed and contaminated seed imports	750 tree species; 8 000 herbaceous species	660 naturalised 13 in estuaries (8 tree or shrub, 3 aquatic plants, 2 grasses)
Molluscs: terrestrial	Inadvertent introductions, e.g. shipping containers, horticultural imports	34	At least 15 are widespread (including Marsh slug *Deroceras leave*; Brown field slug *Deroceras panormitanum*; Reticulate field slug *Deroceras reticulatum*; Hedgehog slug *Arion intermedius*; Small conical snail *Cochlicella barbara*; Slippery moss snail *Cochlicopa cf. lubrica*; Orchid snail *Zonitoides arboreus*; European brown garden snail *Cornu aspersum*; Vermiculate snail *Eobania vermiculata*; Three-banded garden slug *Lehmannia valentiana*; Yellow garden slug *Limacus flavus*; Cellar glass snail *Ocychilus cellarius*; Garlic glass snail *Oxychilus alliarius*; Draparnaud's glass snail *Oxychilus draparnaudi*; Smooth grass snail *Vallonia pulchella*)
Molluscs: freshwater	Aquarium trade, aquaculture	At least 10 gastropods	At least 8 (including Apple snail *Pomacea diffusa*; Reticulate pond snail *Lymnaea columella*; Rust-coloured pond snail *Radix rubiginosa*; Slender bladder snail *Aplexa marmorata*; Sharp-spired bladder snail *Physa acuta*; Chinese ram's-horn snail *Gyraulus chinensis*; Dury's ram's-horn snail *Helisoma duryi*; Quilted melania *Tarebia granifera*)
Molluscs: marine	Mariculture, shipping (e.g. hull fouling, ballast water)	12	3 (Mediterranean mussel *Mytilus galloprovincialis*; Bisexual mussel *Senimylitus algosus*; Pacific oyster *Crassastrea gigas*)
Crustaceans: freshwater	Aquaculture, aquarium trade	1 fish louse species and 4 freshwater crayfish species are known to have escaped recently	5 (Fish louse *Argulus japonicus*; Yabby *Cherax desctructor*; Australian redclaw *Cherax quadricarinatus*; Marron or freshwater crayfish *Cherax tenuimanus*; North American red swamp crayfish *Procambarus clarkii*)
Crustaceans: marine	Shipping (e.g. hull fouling, ballast water)	22	2 (European shore or green crab *Carcinus maenas*; Pacific barnacle *Balanus glandula*)
Other invertebrates: terrestrial	Trade in agricultural products, contaminated packaging, and shipping containers	Over 300 (includes insects, earthworms, flatworms, roundworms, spiders, mites, springtails, millipedes, and crustaceans)	At least 70 (including Mediterranean fruit fly *Ceratitus capitata*; Codling moth *Cydia pomonella*; Argentine ant *Linepithema humile*; Wood wasp *Sirex noctilio*; Varroa mite *Varroa destructor* associated with bees; at least one European springtail)
Other invertebrates: marine	Shipping (e.g. hull fouling, ballast water)	Approximately 41	3 (Sea vase Ascidian *Ciona intestinalis*; Feather duster anemone *Metridium senile*; Rooted anemone *Sagartia ornate*)

Table 8.—Number of alien species and invasive species recorded in South Africa (continued)

Group	Typical pathways of introduction	# known alien species in South Africa	# invasive alien species
Fish: freshwater	Aquaculture, recreational angling, aquarium trade, inter-basin water transfer	At least 58	At least 22 (including Bluegill sunfish *Lepomis macrochirus*; Smallmouth bass *Micropterus dolomieu*; Spotted bass *Micropterus punctulatus*; Largemouth bass *Micropterus salmoides*; Nile tilapia *Oreochromis niloticus*; Goldfish *Carassius auratus*; Grass carp *Ctenopharyngodon idella*; Common carp *Cyprinus carpio*; Silver carp *Hypophthalmichthys molitrix*; Tench *Tinca tinca*; Vermiculated sailfin *Pterygoplichthys disjunctivus*; Perch *Perca fluviatilis*; Mosquito-fish *Gambusia affinis*; Guppy *Poecilia reticulata*; Swordtail *Xiphophorus helleri*; Rain-bow trout *Onchorhynchus mykiss*; Brown trout *Salmo trutta*)
Amphibians	Pet trade	At least 14	0
Reptiles	Pet trade, transport of garden soil	275	At least 6 (Common snapper turtle *Chelydra serpentine*; Slider or red-eared turtle *Trachemys* spp; Painted reed frog *Hyperolius marmoratus*; Tokay gecko *Gekko gecko*; Green iguana *Iguana iguana*; Brahminy blind snake *Ramphotyphlops braminus*)
Birds	Pet trade, intentional introductions, shipping lanes	48	10 (Mallard *Anas platyrhynchos*; Rock dove or feral pigeon *Columba livia*; House crow *Corvus splendens*; Common chaffinch *Fringilla coelebs*; House sparrow *Passer domesticus*; Chukar partridge *Alectoris chukar*; Common peacock *Pavo cristatus*; Rose-ringed parakeet *Psittacula krameri*; Common myna *Acridotheres tristis*; Common starling *Sturnus vulgaris*)
Mammals: ter-restrial	Zoo escapes, pet trade, historic intentional intro-ductions	At least 50 (not includ-ing those species held only in captivity)	6, mainly in urban environments (Gray squir-rel *Sciurus carolensis*; House mouse *Mus musculus*; Norway rat *Rattus norvegicus*; Black rat *Rattus rattus*; Fallow deer *Dama dama*; Red lechwe *Kobus leche*)

(Sources: Giliomee 2011,[71] Henderson 2010,[72] Mead *et al*. 2011,[69] Picker & Griffiths 2011,[73] Richardson *et al*. 2011,[68] Van Wilgen *et al*. 2010[74])

(Note that the numbers and species in this table do not correspond exactly with the species listed in South Africa's draft Alien and Invasive Species Regulations. At the time of writing, the regulations and accompanying lists were in the process of being finalised, and the lists will be subject to regular review once the regulations have been published. Invasive species listed in terms of legislation may include species not yet recorded in South Africa but known to be invasive elsewhere.)

[71]Giliomee, J.H. 2011. Recent establishment of many alien insects in South Africa – a cause for concern. *African Entomology* 19(1): 151–155.

[72]Henderson, L. 2010. *Final Report: Surveys of alien weeds and invasive plants in South Africa - Southern African Plant Invaders Atlas (SAPIA) Phase II*. Agricultural Research Council – Plant Protection Research Institute, Pretoria.

[73]Picker, M. & Griffiths, C.L. 2011. *Alien & invasive animals: a South African perspective*. Struik, Cape Town.

[74]Van Wilgen, N.J., Wilson, J.R.U., Elith, J., Wintle, B.A. & Richardson, D.M. 2010. Alien invaders and reptile traders: what drives the live animal trade in South Africa? *Animal Conservation* 13, Suppl.1: 24–32.

caused by alien species introduced through poor management of ballast water, with potentially severe consequences for human health, fisheries resources and the mariculture industry.

Invasive mammals in the terrestrial environment include the grey squirrel (*Sciurus carolensis*), the house mouse (*Mus musculus*), the Norway rat (*Rattus norvegicus*) and the black rat (*Rattus rattus*), all mostly associated with urban environments, as well as the fallow deer (*Dama dama*) and the red lechwe (*Kobus leche*). Another concern with mammals is the increase in range of species such as warthog (*Phacochoerus africanus*), impala (*Aepyceros melampus melampus*) and nyala (*Tragelaphus angasii*) due to human translocation of these species for game ranching.

Ten of the 48 alien bird species introduced to South Africa have established feral populations. The four most widespread are the rock dove or feral pigeon (*Columbia livia*), common myna (*Acridotheres tristis*), common starling (*Sturnus vulgaris*) and house sparrow (*Passer domesticus*), all deliberately introduced by humans. The house crow (*Corvus splendens*) was not deliberately introduced but arrived inadvertently though movement of cargo ships up and down Africa's east coast and trade with the Asian continent, and is now well established in Cape Town, Durban and Richard's Bay. All three cities have begun eradication attempts.

Although there are currently only a few known established invasive reptile species, the trade in exotic pet reptiles is relatively young and growing fast, and tends to be poorly regulated. Together with the wide range of potentially suitable habitats in South Africa, this creates a significant threat of invasive reptiles becoming a problem.

The house crow (*Corvus splendens*) is one of several invasive bird species in South Africa. Among other impacts it is a potential health hazard, for example as a potential vector for cholera and other diseases.

Research on invasive terrestrial invertebrates has focused mainly on agricultural pests, many of which are alien species, for example the Mediterranean fruit fly (*Ceratitus capitata*) and the codling moth (*Cydia pomonella*), both of which cause significant crop losses in South Africa's fruit industry and are international quarantine pests. Their presence in South Africa threatens existing export markets and jeopardises the exploitation of new markets, including for emerging small-scale fruit farmers trying to enter the export market. For example, consignments of fruit have been rejected on reaching their export destination in Europe or the United States because of the presence of live fruit fly larvae or even a single live fruit fly. The European and United States markets are major export destinations for South Africa's deciduous fruit industry which is estimated to earn gross income of R8 billion per year and to employ 100 000 people.

Other invasive insects include the Argentine ant (*Linepithema humile*), the wood wasp (*Sirex noctilio*), and the harlequin ladybird (*Harmonia axyridis*). Argentine ants disrupt safe storage of indigenous seeds from fire as, unlike indigenous ants, they do not move seeds to underground storage. The harlequin ladybird can out-compete indigenous ladybirds and impact on food webs, and can harm grape crops. A recent review of alien insects in South Africa found that the rate of new introductions is increasing, with at least 13 new alien pests having become established in the last 12 years, compared with about 60 in the 350 years prior to 2000.[75]

The pathways or routes by which alien species are introduced are varied. Common ones include transport of agricultural products and other freight; movement of travellers by air, sea and land; release of ballast water from ships; fouling (colonisation by species) of ships' hulls and other infrastructure in the sea; aquaculture and mariculture; inter-basin transfers of water; plants introduced for forestry or biofuels; horticultural trade; and trade in pets. Efforts to prevent the introduction of potentially invasive species need to focus on all of these diverse pathways—not a simple task, but, as discussed below, much more cost effective than acting only once invasive species have become established and need to be eradicated or managed.

[75]Giliomee, J.H. 2011. Recent establishment of many alien insects in South Africa – a cause for concern. *African Entomology* 19(1): 151–155.

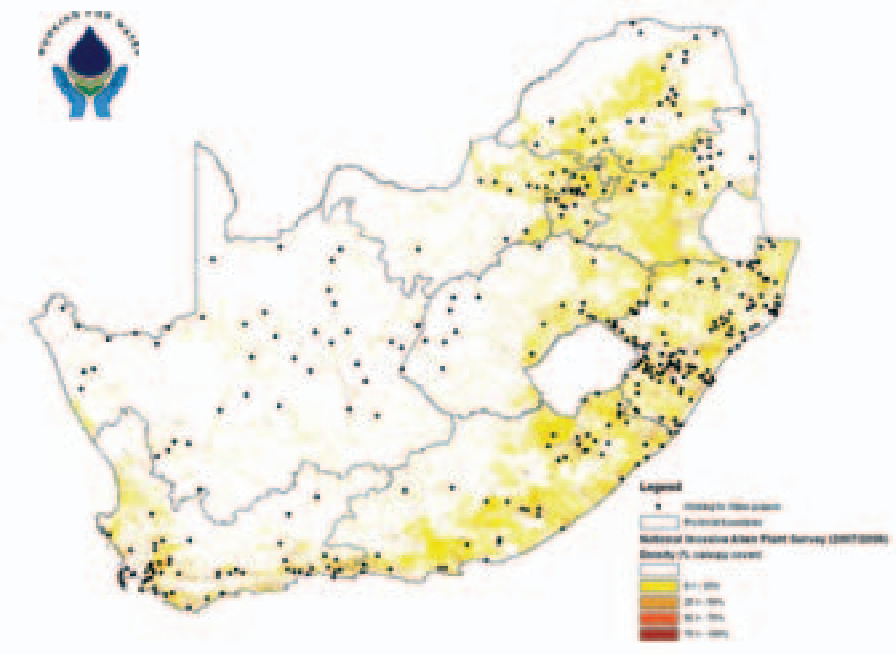


Figure 72.—Density of 27 established invasive plant species or groups of species in South Africa, as surveyed by the National Invasive Alien Plant Survey 2010. The total area of land infested increased from an estimated 10 million hectares in the mid-1990s to approximately 20 million hectares in 2007 when the survey was conducted.

Eucalyptus species are amongst the most widespread invasive alien plants in South Africa, and are used for timber, firewood and the production of honey. However, they use large amounts of water, especially if they occur along watercourses, and contain volatile and flammable oils that can result in intense fires.

11.3 How are invasive species distributed in South Africa?

Invasive species, like indigenous species and ecosystems, are not evenly distributed across the South African landscape and seascape. Most is known about the distribution of invasive woody plant species. Because these species have been targeted by the Working for Water programme (see Section 11.4), considerable effort has gone into mapping their location to aid planning, implementation and monitoring.

In the mid-1990s, an estimated ten million hectares of South Africa's land area had been invaded by invasive woody plants.[76] In 2010, the first National Invasive Alien Plant Survey showed that this had doubled to 20 million hectares (16% of South Africa's land area).[77] Figure 72 shows the density of 27 well-established invasive alien plant species or groups of species in South Africa, based on a combination of remote sensing and field surveys correlated with soil and climatic data. Invasive woody plants are especially widespread in the wetter eastern parts of the country and the Fynbos biome. In the Fynbos biome *Acacia* (wattle) and *Pinus* (pine) species are especially widespread; in the Grassland biome *Acacia*, *Eucalyptus*, *Salix babylonica* (weeping willow) and *Populus* (poplar) species are prominent invaders; while *Prosopis* (mesquite) and *Opuntia* (cactus) species are a major problem in the more arid Nama-Karoo and Succulent Karoo. Table 9 gives the number of hectares occupied by selected established species or groups of species, with *Acacia* and *Eucalyptus* species covering the largest areas.

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[76]Versfeld, D.B., Le Maitre, D.C. & Chapman, R.A. 1998. *Alien invading plants and water resources in South Africa: a preliminary assessment*. Report no. TT 99/98, Water Research Commission, Pretoria.

[77]Kotzé, I., Beukes, H., Van den Berg, E. & Newby, T. 2010. *National Invasive Alien Plant Survey*. Report number GW/A/2010/2. Agricultural Research Council – Institute for Soil, Climate and Water, Pretoria.

Table 9.—Well-established invasive alien plant species surveyed in the National Invasive Alien Plant Survey 2010, including the number of hectares occupied by each species or group of species

Species or group of species	Common name	Area occupied (hectares)	Area occupied (condensed hectares*)
Acacia mearnsii/dealbata/baileyana	Wattle	7 475 944	470 588
Eucalyptus spp.	Gum	6 103 288	271 605
Opuntia spp.	Prickly pear	3 422 575	94 498
Pinus spp.	Pine	3 362 606	130 822
Populus spp.	Poplar	2 381 438	57 722
Salix babylonica	Weeping willow	2 337 200	37 296
Prosopis spp.	Mesquite	1 832 150	364 540
Melia azedarach	Syringa	1 664 750	14 157
Chromolaena odorata	Triffid weed	1 489 919	101 168
Solanum mauritianum	Bugweed	1 091 238	40 011
Agave spp.	Agave	875 813	11 277
Cereus jamacaru	Queen of the night	839 175	10 899
Acacia cyclops	Rooikrans	763 963	54 415
Lantana camara	Lantana	571 919	31 959
Rosa rubiginosa	Eglantine	408 956	11 674
Senna didymobotrya	Peanut butter cassia	454 581	11 451
Acacia saligna	Port Jackson	444 169	49 790
Caesalpinia decapetala	Mauritius thorn	332 000	8 774
Hakea spp.	Hakea	327 706	35 865
Psidium guajava	Guava	303 031	6 205
Jacaranda mimosifolia	Jacaranda	277 738	4 186
Atriplex nummularia	Old man saltbush	235 063	5 824
Cestrum spp.	Inkberry	127 613	7 138
Arundo donax	Spanish reed	156 731	3 185
Acacia melanoxylon	Blackwood	97 606	2 728
Tamarix chinensis	Chinese tamarisk	88 006	2 116
Sesbania punicea	Red sesbania	48 756	1 663
Total			**1 841 556**

* Equivalent to 100% canopy cover. Invasive plant species occur at varying densities, and different species occur at different average densities. Condensed hectares take the density of infestation into account, giving a value that can be compared across different species that occur at different densities.

In the marine environment, invasive alien species seem to follow a clear spatial pattern, with higher numbers occurring on the west coast, although this might reflect uneven sampling effort. Harbours are hotspots for invasive species, with few species being able to withstand the wave-exposed open coast. Temperate invasive species that come from the northern hemisphere are generally found on South Africa's west and south coast, and species from the southern hemisphere tend to occur on the east coast.

11.4 Turning the challenge into an opportunity

As discussed in Section 11.1, the impacts of invasive alien species are often costly in economic terms and require intervention. The allocation of government and private resources to addressing the challenge of invasive alien species can create opportunities linked to restoring ecological infrastructure and securing the provision of ecosystem services.

Working for Water

One of the best known examples of such a response, in South Africa and globally, is the Working for Water programme which uses labour-intensive methods to clear invasive woody plants, supporting job creation and relieving poverty

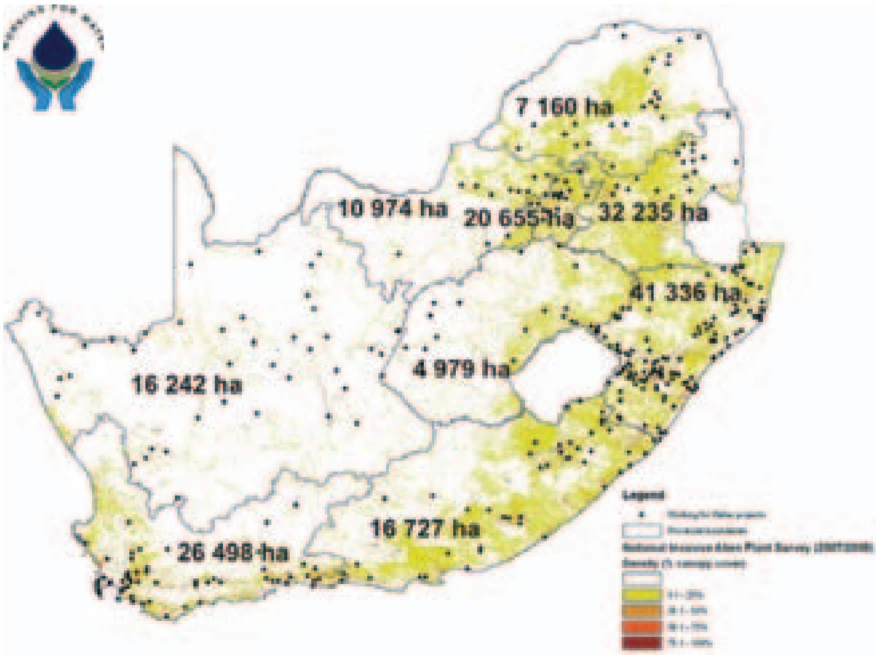


Figure 73.—Invasive alien plants cleared by Working for Water over the period 2000 to 2007. Areas are expressed as condensed areas, or the area equivalent to 100% canopy cover. Initial clearing should be followed up and maintained to ensure that species do not re-invade.

as well as protecting scarce water supplies and restoring productive land. Established in 1995 as a small pilot project in the Department of Water Affairs, Working for Water grew rapidly and spawned a series of related natural resource management programmes such as Working for Wetlands and Working on Fire, most of which are now housed in the Department of Environmental Affairs.

By the end of 2007, Working for Water had cleared almost 2 million hectares of invasive alien plants. Figure 73 shows the initial cleared area per province in the period 2000 to 2007, in condensed hectares. Initial clearing is followed up several times, and areas then need to be maintained to ensure that species do not reinvade.

In the process of clearing invasive alien plants, Working for Water has created thousands of jobs for people who may otherwise have had little or no chance of employment. South Africa has a stubbornly high unemployment rate of around 25% (not counting those too discouraged to seek work) and a skewed labour market with a large supply of unskilled labour. It is in this context that the work opportunities created through Working for Water and other natural resource management programmes are so important from a socio-economic point of view.

In its first year of operation in 1995/96, the Working for Water programme created the equivalent of just over 2 000 person-years of employment. During subsequent years this grew substantially, with an average of about 9 000 person-years of employment created each year over the period 1996/97 to 2010/11, adding up to a total of nearly 140 000 person-years of employment to date.[78] The number of people involved is far greater, as most of the work opportunities created are short term. In 2010/11 work opportunities were created for over 28 000 people.

Working for Water provides employment opportunities and contributes to poverty alleviation as well as protecting scarce water supplies and restoring productive land.

[78]Annual Reports of the Working for Water Programme.

In addition to creating jobs directly, use of the timber from invasive trees has resulted in secondary industries which produce, among other products: school desks, walking sticks for pensioners and 'eco-coffins'.

Another possible opportunity linked to clearing invasive woody plants lies in the resulting biomass, which could be used as a source of energy. Although so-called second generation biofuels, produced from lingo-cellulosic feedstocks using biochemical or thermochemical technology, have yet to succeed on a large scale, further research and development may change this. Biofuels from invasive plant biomass would be by far preferable to biofuels produced from crops, which use scarce water and often result in destruction of natural habitat.

There is enormous scope to scale up the operations of Working for Water and other natural resource management programmes, with potential for further job creation combined with the benefits of restoring ecosystem functioning and securing the provision of ecosystem services. The potential for expanding the Working for Water programme is highlighted by Figure 74, which shows the initial area cleared over the period 2000 to 2007 relative to the total invaded area. A recent study has shown that the bulk of potential new jobs linked to the green economy in South Africa lie in natural resource management rather than in the renewable energy and resource efficiency sectors.[79]

The projected cost of controlling the species included in the National Invasive Alien Plant Survey over the next 25 years is R36 billion (an average of R1.4 billion a year), based on annual reduction rate of 22% to overcome an annual expansion rate of 5%. Table 10 gives a provincial breakdown.[80] These costs seem high, until one considers the value of the ecosystem services currently being lost as a result of invasive alien plants—at least R6.5 billion every year, which would increase substantially in the absence of management efforts (see Section 11.1).

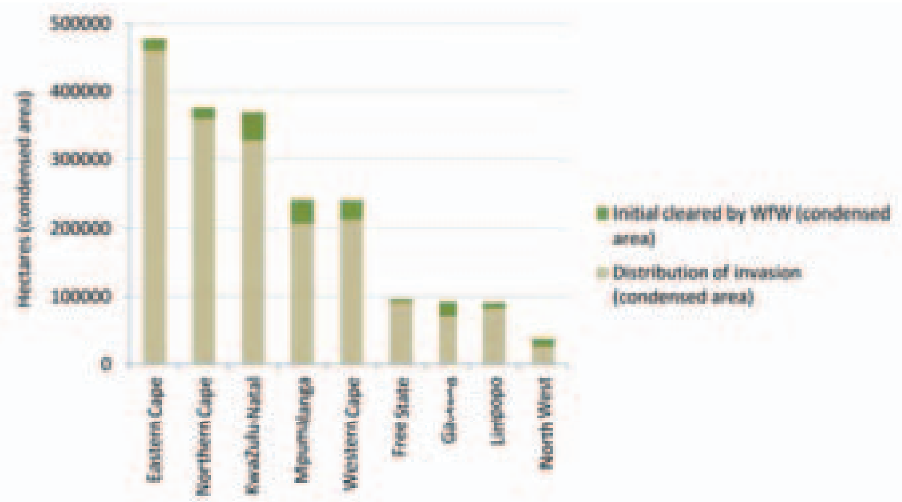


Figure 74.—Initial area cleared by Working for Water (2000–2007) relative to area infested by established invasive alien plants (2007), in condensed hectares. This graph illustrates the enormous potential to scale up the Working for Water programme, with multiple benefits for job creation, restoring ecological infrastructure and securing ecosystem services.

The Working for Water programme had a budget of approximately R710 million in 2010/11, provided by government. The highest cost lies in the initial clearing of infested areas; however, repeated follow-up to keep land clear is required, followed by a maintenance phase. Maintenance activities provide opportunities to mobilise private resources to complement the state's resources dedicated to initial clearing. For example, South Africa is currently exploring the establishment of Payments for Ecosystem Services (PES) in which landowners or land users are paid for an ecosystem service (such as water provision) or a land use likely to secure the ecosystem service (such as keeping land in critical catchments free of invasive alien plants).

Table 10.—Projected cost to control invasive alien plants per province over the next 25 years, using mechanical and chemical means

Province	Estimated cost over 25 years (R billion)
Eastern Cape	8.0
Northern Cape	6.9
KwaZulu-Natal	6.4
Western Cape	3.9
Mpumalanga	3.6
Limpopo	2.8
Free State	1.9
Gauteng	1.2
North West	0.9
Total	35.6

[79]Maia, J., Giordano, T., Kelder, N., Bardien, G., Bodibe, M., Du Plooy, P., Jafta, X., Jarvis, D., Kruger-Cloete, E., Kuhn, G., Lepelle, R., Makaulule, L., Mosoma, K., Neoh, S., Netshitomboni, N., Ngozo, T. & Swanepoel, J. 2011. *Green jobs: an estimate of the direct employment potential of a greening South African economy*. Industrial Development Corporation, Development Bank of Southern Africa, Trade and Industrial Policy Strategies.

[80]At the time of writing further work was underway to refine these cost estimates (Giordano, T., Blignaut, J.N. & Marais, C. In prep. *Natural resource management – an employment catalyst: the case of South Africa*.)

Biological control

The bulk of Working for Water's activities focus on physical removal of invasive plants, through mechanical or chemical means or a combination. However, South Africa is also a leader in biological control of invasive plants, with a long history of research and practice dating back as far as 1913. A recent centenary publication on biocontrol in South Africa provided the basis for the summary given here.[81]

Biological control of invasive species or pests involves using a completely host-specific natural enemy of the species to reduce the population or seed production, rather than intervening directly. In the case of invasive plants in South Africa, the biocontrol agent is usually a phytophagous (plant-feeding) organism such as an insect or mite, or a plant-pathogen such as a fungus. The biocontrol agent in some cases simply eats the plant and in other stops the plant from reproducing by targeting the flowers or seed.

In 1913, the cochineal insect (*Dactylopius ceylonicus*) was imported into South Africa and achieved significant success in limiting invasion by prickly pears (*Opuntia monacantha*). Since then, other notable successes have been achieved with certain *Hakea* and *Acacia* species, especially in the Fynbos biome, and with several more cactus species. Overall, 106 biological control agents have been released in South Africa, mainly since the 1970s. Of these 106, 75 have become established on 48 invasive alien plants. Of these 48 invasive plants, 10 have been completely controlled and 18 are substantially controlled.

Potential biological control agents go through strict screening procedures and are thoroughly tested in quarantine before an application can be made to release them. Many are rejected, either because testing shows they are unlikely to be effective or because they may cause damage to non-target species and ecosystems.

The Early Detection and Rapid Response programme uses networks of 'informers' in the field who gather information about the spread of emerging invasive species, which helps to determine the appropriate response.

Biological control can be highly cost effective if correctly managed, especially for invasive plants that are already so widespread that other methods of containment and management are difficult. Estimates of the benefit:cost ratio for biological control in South Africa to date range from 50:1 for invasive sub-tropical shrubs to over 3 700:1 for invasive Australian trees.[82] Biological control agents, once they are established, have the advantage of being largely self-sustaining, with relatively low ongoing input costs, unlike mechanical and chemical methods of control which require ongoing investment. Continued research and investment in biocontrol, building on experience to date, is clearly an important part of South Africa's response to invasive plant species.

Early Detection and Rapid Response

As we will discuss further in Section 11.5, prevention is much better and cheaper than cure when it comes to invasive alien species. A small investment in early detection of potentially invasive species, and rapid action to eradicate them before they become widely established, can save vast sums down the line. There is usually a brief window period in which an invasive species can be stopped. In recognition of this, Working for Water established an Early Detection and Rapid Response (EDRR) programme in 2008.

The EDRR programme, hosted in SANBI, focuses on identifying potentially invasive plants already present in the country, in the ter-

[81]Klein, H. 2011. A catalogue of the insects, mites and pathogens that have been used or rejected, or are under consideration, for the biological control of invasive alien plants in South Africa. *African Entomology* 19(2): 515–549.

[82]De Lange, W.J. & Van Wilgen, B.W. 2010. An economic assessment of the contribution of biological control to the management of invasive alien plants and to the protection of ecosystem services in South Africa. *Biological Invasions* 12: 4113–4124.

restrial, freshwater or estuarine environment, and acting quickly to eradicate them before they become widely established. Provincial coordinators work with taxonomists to detect invasive plants, to gather information to evaluate and improve the management decisions for these plants, and to direct eradication attempts on target species. Taxonomic skills, which are scarce in South Africa and globally (see Chapter 13), are an essential foundation for the work of the programme. In order to manage a species it needs to be accurately identified so that it can be listed in terms of legislation and so that the correct herbicide or other management options can be used to target the species. Unfortunately, interest in taxonomy as a discipline among young scientists has been on the wane for many years. The EDRR programme has created work opportunities for several aspiring taxonomists and assistants for these taxonomists, making a contribution to reviving interest in taxonomy as a career option that is directly relevant to addressing urgent socio-economic challenges.

EDRR creates work for young scientists and scientific project managers at a higher skill level than the mass job creation which has been the previous focus of Working for Water and other natural resource management programmes. Many members of the EDRR team are young black scientists, for whom the programme has provided not simply a job but a career opportunity and work that they are passionate about.

Much of Working for Water's efforts concentrate on ten of the most widely established woody shrubs and trees which have the greatest impact on South Africa's limited water resources. The Southern African Plant Invader Atlas (SAPIA) identifies some 660 alien plant species which have become naturalised in South Africa with self-sustaining populations in natural environments. With so many potentially invasive plant species already in the country and so few being the target of management efforts, the EDRR programme has a wide scope of species on which to work. In order to focus efforts the programme has taken a decision to target species proposed to be listed as Category 1a in the draft Alien and Invasive Species Regulations (see Secton 11.5). There are just fewer than 40 such species, which are required by law to be removed and hence are potential eradication targets. In addition, the programme will focus attention on 80 or so species which are not listed but are under surveillance because of their possible invasive nature. The aim is to gather sufficient information to either list these species or to allay fears about their potential spread and no longer keep them under surveillance.

At the start of the programme in early 2009, the team hosted workshops for stakeholders in KwaZulu-Natal and Western Cape to identify priorities and to guide the work of the team. Many of the new sightings and much of the information about new invasive species is given to the team by professionals in the fields of agriculture or biodiversity and from keen members of the public. The provincial coordinators have established networks of 'informers' who feed information regarding the spread of particular species to the coordinators. In addition to this network, landowners are asked to report on particular target species through telephone and e-mail contacts.

Although the EDRR programme is relatively new, it already has some success stories to tell. For example, two species of Australian paperbark (*Melaleuca* species) were reported to the programme by CapeNature, who found these in sites that were previously *Eucalyptus* planta-

The EDRR programme has contracted teams in the Northern and Eastern Cape Provinces to clear several invasive *Cylindropuntia* species, which currently occupy less than 1 000 ha in the two provinces, but have the potential to invade large areas of productive grazing land.

Table 11.—A hierarchical approach to managing invasive alien species, showing estimated returns on investment[83]

Action	Description	Estimated return on investment
Prevention	Prevent the entry of new high risk alien plants and animals	1:100
Eradication	Eradicate those high risk species that are at an early stage of establishment—requires early detection and rapid response	1:25
Containment	For invasive species that are beyond eradication, contain further spread of the core infestation	1:5–10
Asset-based protection	For invasive species that are so widespread they cannot be contained, take an asset-based approach to management, restoring and protecting specific highly valued ecological assets	1:1–5 (with the exception of biocontrol, which can generate significantly higher returns)

[83]This example, including the estimated returns on investment, comes from the State of Victoria in Australia (State of Victoria. 2010. *Invasive Plants and Animals Policy Framework*. Victorian Government, Melbourne). Other countries and regions that have taken a similar approach include Canada, Great Britain, Europe and the South Atlantic islands.

tions but which had been handed over to become nature reserves. *Melaleuca quinquenervia* is listed as one of the world's 100 worst invasive alien species, and is a major problem in Florida and Hawaii in the United States, causing estimated annual losses in revenue from ecotourism of over US$160 million per year. Management efforts have limited this species in its current known locality in the Tulbagh region but efforts to discover and eradicate other populations are ongoing. *Acacia paradoxa* is an Australian species that is currently confined to a small area on Table Mountain in Cape Town. It has the potential to be highly invasive in South Africa, but focused efforts towards early eradication are on track to prevent this.

Early detection of potentially invasive species requires a concerted monitoring effort, coordinated by EDRR staff who work with a network of volunteers and stakeholders, and manage the process from detection, evaluation and eradication planning through to management of the eradication effort. The programme monitors particular sites as well as coordinating species-specific monitoring. The benefit of potentially removing an invasive alien species before it becomes fully established far outweighs the limited investment in staff and infrastructure needed to manage a programme of this nature.

11.5 The return on investment hierarchy

Although South Africa has responded significantly and in some cases successfully to the challenge of invasive alien species, most effort has tended to be invested in managing invasive species that have already become a problem. Increasingly, countries around the world are recognising the value of a hierarchical approach to dealing with invasive species, along the lines shown in Table 11.

The rationale for this tiered approach is that it is cheaper and more effective to focus on prevention and early eradication of high risk species, providing a much better return on public investment than simply focusing on management of established invasive species. The highest return on investment comes from preventing the introduction of new high risk alien plants and animals, which requires coordinated effort to address the diverse range of pathways by which alien species can enter the country (see Section 11.2). Returns from identifying and eradicating invasive species that are at early stages of establishment are next highest, as has been recognised in South Africa by the establishment of the EDRR programme discussed in Section 11.4. The strengths of this programme should be built on, expanding its focus to include both plants and animals as well as the marine environment, and ensuring that mechanisms are in place to mobilise resources for quick action when and where they are needed.

Eradication is generally only possible in the early stages of establishment. If an invasive species can no longer be eradicated it may be able to be contained, which involves preventing further spread of the core infestation by targeting small satellite infestations for eradication. For invasive species that are so widespread they cannot be contained, returns are generally highest if management efforts focus on specific highly valued ecological assets.

South Africa's Working for Water programme already takes an 'asset-based protection' approach to managing invasive alien plants. Rather than attempting to operate in all areas and to manage all species, a more focused approach has been developed. Spatial prioritisation of quaternary catchments for clearing of invasive plants is based on a range of factors, including high water yield, high water demand, high proportions of conservation land, high potential for further invasion, and high potential grazing lands or other uses. The map of priorities shown in Figure 75 was developed through provincial workshops involving managers from the land and water resource sectors, including conservation agencies and experts on invasive alien plants, using quantitative and qualitative data and a transparent multi-criteria approach.[84]

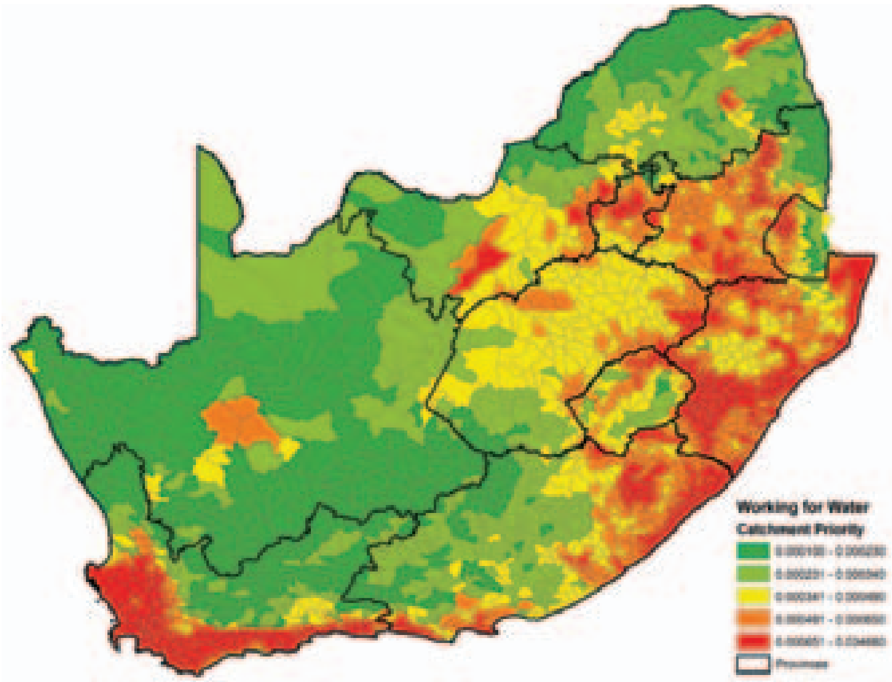


Figure 75.—Spatial priorities for clearing invasive alien plants at quaternary catchment scale, based on a range of factors including high water yield, high water demand, high proportions of conservation land, high potential for further invasion, and high potential grazing lands or other uses.

Many aspects of South Africa's response to invasive species are consistent with a hierarchical approach that focuses on maximising return on investment. However, this has not yet been brought together in an explicit national strategy.

The Biodiversity Act provides for listing alien and invasive species with a view to preventing the introduction of new invasive species and managing and controlling those already established. The process of developing regulations and lists of species has proven challenging. Two draft sets of regulations have been published for public comment, in 2007 and 2009. At the time of writing, the regulations and accompanying lists were in the process of being finalised.[85]

Finalising and implementing the Alien and Invasive Species Regulations is clearly a priority. In addition, the development of a national strategy for dealing with alien and invasive species was in the process of being initiated by DEA at the time of writing. The development of such a strategy will necessarily involve a wide range of stakeholders including government departments and agencies, NGOs, scientists, and trade and industry interests in the private sector.

Tackling the challenge of invasive alien species requires a partnership approach. Cooperative governance is a critical foundation, particularly for the prevention of new introductions, requiring collaborative action between several government departments, including but not limited to DEA, DAFF, Department of Transport, and the Department of Health. Collaboration between the public and private sectors is essential, as is building greater public awareness and understanding of the issues.

[84]Forsyth, G.G., Le Maitre, D.C. & Van Wilgen, B.W. 2009. *Prioritising quaternary catchments for invasive alien plant control within the Fynbos and Karoo biomes of the Western Cape province*. CSIR report number CSIR/NRE/ECO/ER/2009/0094/B, prepared for Working for Water.

[85]Other existing legal instruments include the Conservation of Agricultural Resources Act (Act 43 of 1983) in terms of which declared weeds, plant invaders and plants associated with bush encroachment are listed, and the Agricultural Pests Act (Act 36 of 1983).

12. Spatial biodiversity priority areas and priority actions

Chapter summary

South Africa has well-established capacity for producing spatial biodiversity plans that are based on best available science **and** relate directly to policy and legislative tools. These maps and accompanying data are a valuable information resource to assist with planning and decision-making in the biodiversity sector and beyond. They help to focus the limited resources available for conserving and managing biodiversity on geographic areas that will make the most difference, and can inform planning and decision-making in a range of sectors, especially those that impact directly on biodiversity.

Spatial biodiversity plans identify biodiversity priority areas that are important for conserving a representative sample of ecosystems and species, for maintaining ecological processes, or for the provision of ecosystem services. Biodiversity priority areas include the following categories, which are not mutually exclusive:

- Protected areas
- Critically endangered and endangered ecosystems
- Critical Biodiversity Areas and Ecological Support Areas
- Freshwater Ecosystem Priority Areas (including rivers and wetlands)
- High water yield areas
- Flagship free-flowing rivers
- Priority estuaries
- Focus areas for land-based protected area expansion
- Focus areas for offshore protection

A brief explanation of each of these is provided in the chapter. Maps, spatial data and reports on most of them are freely available on SANBI's Biodiversity GIS website (http://bgis.sanbi.org.za), and represent an excellent biodiversity information resource to assist with development planning and decision-making.

Coastal ecosystem priority areas and marine ecosystem priority areas have yet to be identified across the country, and are the missing elements in this set of biodiversity priority areas. Development of a national coastal biodiversity plan is an urgent priority.

Strategic objectives and priority actions for managing and conserving South Africa's biodiversity are set out in the National Biodiversity Strategy and Action Plan (NBSAP) and the National Biodiversity Framework (NBF), both of which are due to be reviewed shortly. Priority actions suggested by the results of the NBA 2011, which should feed into the review process, can be grouped into three major categories that apply across terrestrial and aquatic environments:

- **Reduce loss and degradation of natural habitat in priority areas**. These actions focus on preventing loss and degradation of natural habitat in those biodiversity priority areas that are still in good ecological condition.
- **Protect critical ecosystems**. These actions focus on consolidating and expanding the protected area network as well as strengthening the effectiveness of existing protected areas. It deals with formal protection by law, recognised in terms of the Protected Areas Act, including contract protected areas on private or communal land.
- **Restore and enhance ecological infrastructure**. These actions focus on active interventions required to restore those biodiversity priority areas that are currently not in good ecological condition, in order to enhance ecological infrastructure and support delivery of ecosystem services.

Key actions suggested by the NBA 2011 in each of these categories are highlighted in the chapter, underpinned by the maps of biodiversity priority areas that are summarised in the first part of the chapter.

In order to implement these priorities and unlock the opportunities presented by South Africa's wealth of biodiversity resources, a concerted investment in human capital is essential. Lack of sufficient skilled and experienced people has been identified as a key constraint in the biodiversity sector, along with many other sectors in South Africa. In response, the biodiversity sector has initiated a Human Capital Development Strategy, with great potential to contribute to national job creation and development objectives.

In the preceding chapters, we have reviewed the state of ecosystems, the state of indigenous species, and the state of invasive alien species. In the course of the assessment we have looked at pressures on ecosystems and species as well as some of society's responses. In this chapter, we draw together priority actions for managing and conserving biodiversity that emerge from the assessment, and summarise available information about spatial priority areas for these interventions. Some of the spatial biodiversity priority areas come from the NBA, and some from other national and provincial biodiversity planning initiatives. All of them provide a valuable biodiversity information resource to assist with planning and decision-making in a range of sectors, and underpin the priority actions highlighted in the chapter. The chapter concludes by looking at the importance of investing in human capital development to enable the implementation of these priorities.

12.1 Biodiversity priority areas

South Africa has well-established capacity for producing spatial biodiversity plans that are based on best available science **and** relate directly to policy and legislative tools. The maps and accompanying data produced by such plans can be enormously valuable in focusing the limited resources available for conserving and managing biodiversity on geographic areas that make the most difference, as well as for informing planning and decision-making in a range of sectors, especially those that impact directly on biodiversity. Spatial biodiversity plans identify biodiversity priority areas that are important for conserving a representative sample of ecosystems and species, for maintaining ecological processes, or for the provision of ecosystem services.

Assessments of ecosystem threat status, as presented in Chapters 4 to 8, go some way towards determining spatial priorities for conservation action. For example, one can say for sure that all critically endangered and endangered ecosystem types are priorities for prevention of further loss or degradation of habitat. However, there are many least threatened ecosystems that play a vital role in maintaining biodiversity and ecosystem services—it would not make sense to wait until they become threatened before taking action to manage and conserve them. In fact, it makes sense to identify priority areas within least threatened ecosystems as soon as possible, and to act to secure these, to ensure a network of intact ecosystems that effectively conserves biodiversity and delivers ecosystem services. Once ecosystems have become threatened, the opportunities for securing sensibly configured nodes and corridors of natural habitat are much reduced. Spatial biodiversity planning is needed to identify these configurations of natural ecosystems that conserve biodiversity and deliver ecosystem services most efficiently and effectively.

Similarly, assessments of ecosystem protection levels point to under-protected ecosystems, but do not tell us where the best opportunities lie for expanding the protected area network, or how best to ensure that protected area expansion also meets objectives for climate change resilience. Spatial biodiversity planning is needed to identify geographic priorities for expanding protected areas.

Spatial biodiversity plans have evolved considerably in South Africa since the 1990s, while remaining grounded in the principles of the systematic approach to biodiversity planning discussed in Chapter 1. The biodiversity priority areas identified take a range of forms, each with a different purpose and different implementation mechanisms. Biodiversity priority areas currently include the following categories, all shown in Figure 76:

- Protected areas
- Critically endangered and endangered ecosystems
- Critical Biodiversity Areas and Ecological Support Areas (these include priority areas identified within vulnerable and least threatened ecosystems)
- Freshwater Ecosystem Priority Areas and their associated sub-quaternary catchments
- High water yield areas
- Flagship free-flowing rivers
- Priority estuaries
- Focus areas for land-based protected area expansion
- Focus areas for offshore protection

Below we explain each of the categories in more detail, and Panel 12 provides a summary with brief definitions. The different categories are not mutually exclusive and in many cases overlap, often because a particular area or site is important for more than one reason. For example, a site might form part of a high water yield area and a focus area for land-based protected area expansion, or be identified as a Freshwater Ecosystem Priority Area and a Critical Biodiversity Area. The different sets of biodiversity priority areas should be seen as complementary rather than contradictory, with overlaps reinforcing the significance of an area from a biodiversity point of view. Spatial data and reports on most biodiversity priority areas are available on SANBI's Biodiversity GIS website (http://bgis.sanbi.org).

Coastal ecosystem priority areas and marine ecosystem priority areas have yet to be identified across the country, and are the missing elements in this set of biodiversity priority areas. In some provinces and regions, coastal and marine planning has taken place, but as discussed in Section 12.2, a national coastal biodiversity plan is an urgent priority. A national marine biodiversity plan is also recommended, building on the work that has been done to identify focus areas for offshore protection to identify a comprehensive set of marine ecosystem priority areas.

12.1.1 Protected areas

As explained in Chapter 3, protected areas are areas of land or sea that are formally protected by law and managed mainly for biodiversity conservation. The Protected Areas Act defines several categories of protected areas, and recognises a range of protected areas declared in terms of other legislation. Protected areas need not be owned and managed by the state, but can be declared on private or communal land with the landowner recognised as the management authority.

Protected areas are the most secure nodes in the network of biodiversity priority areas. When spatial biodiversity plans are undertaken, protected areas are assumed to contribute towards meeting biodiversity targets for the ecosystems, species and ecological processes that occur within their boundaries. Biodiversity priority areas outside the protected area network are identified only for those features that are not already adequately secured inside the protected area network. The configuration of spatial biodiversity priority areas outside the protected area network thus depends on those areas within the protected area network maintaining their protected status and being effectively managed. As highlighted in Chapter 3, in some cases management effectiveness of existing protected areas requires strengthening.

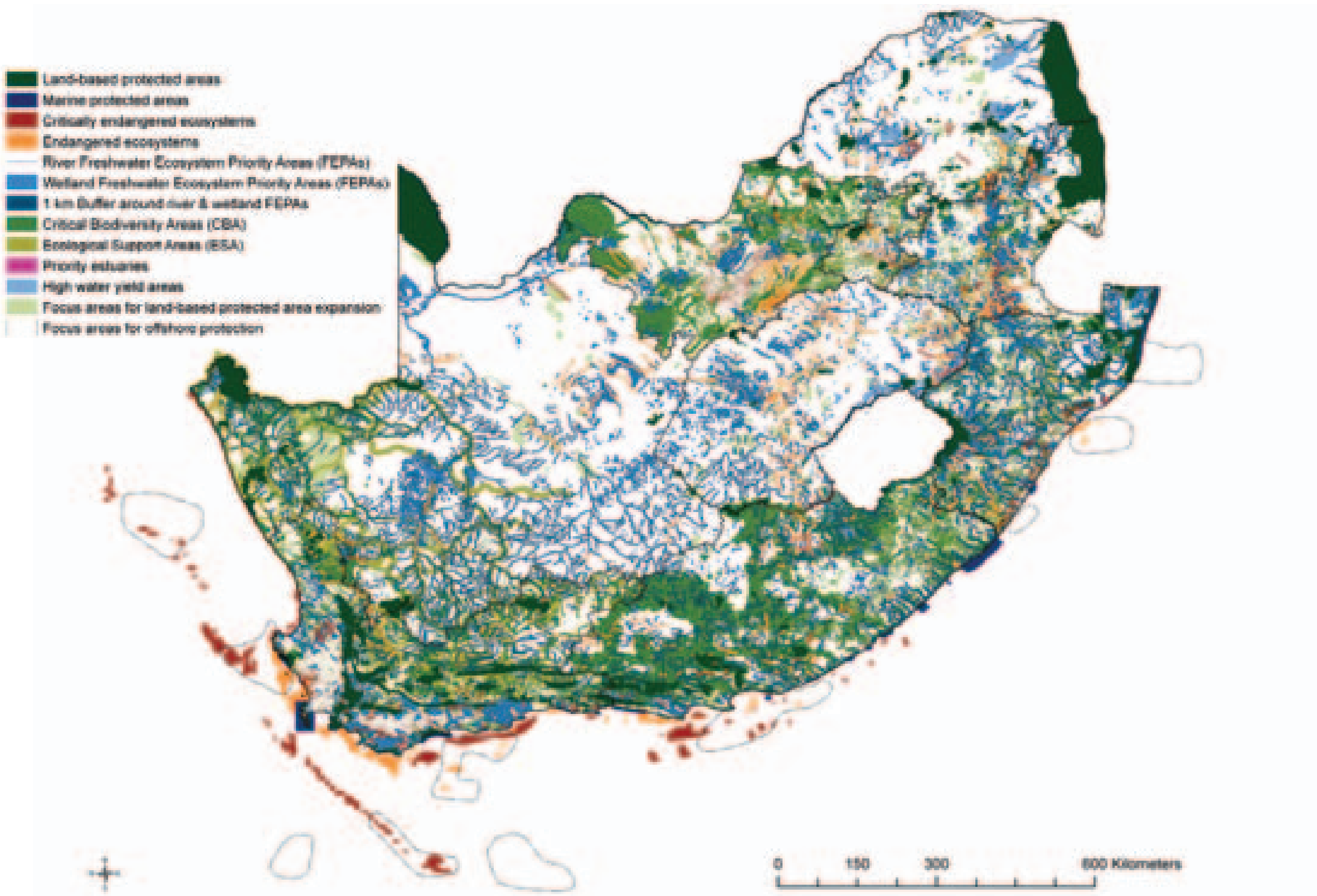


Figure 76.—Biodiversity priority areas in South Africa. The different categories are not mutually exclusive and in many cases overlap, often because a particular area or site is important for more than one reason. The categories are complementary, with overlaps reinforcing the significance of an area from a biodiversity point of view.

12.1.2 Critically endangered and endangered ecosystems

Critically endangered and endangered ecosystems are two of three categories of threatened ecosystems. As explained in Chapter 3, **critically endangered ecosystems** are ecosystem types that have very little of their original extent left in natural or near-natural condition. Most of the ecosystem type has been severely or moderately modified from its natural state. The ecosystem type is likely to have lost much of its natural structure and functioning, and species associated with the ecosystem may have been lost. Few natural or near-natural examples of these ecosystem types remain.

Endangered ecosystems are ecosystem types that are close to becoming critically endangered. See Chapter 3 for more.

Action required:

Any further loss of natural habitat or deterioration in condition of the remaining healthy examples of these ecosystem types must be avoided, and the remaining

Panel 12: Defining spatial biodiversity priority areas

Biodiversity priority areas are features in the landscape or seascape that are important for conserving a representative sample of ecosystems and species, for maintaining ecological processes, or for the provision of ecosystem services. They include the following categories:

- **Protected areas** are areas of land or sea that are formally protected by law and managed mainly for biodiversity conservation. See Panel 4 in Chapter 3 for more detail.
- **Critically endangered ecosystems** are ecosystem types that have very little of their original extent left in natural or near-natural condition. See Panel 3 in Chapter 3 for more detail.
- **Endangered ecosystems** are ecosystem types are that are close to becoming critically endangered. See Panel 3 in Chapter 3 for more detail.
- **Critical Biodiversity Areas** are areas required to meet biodiversity targets for ecosystems, species or ecological processes, as identified in a systematic biodiversity plan. They may be terrestrial or aquatic.
- **Ecological Support Areas** are not essential for meeting biodiversity targets but play an important role in supporting the ecological functioning of Critical Biodiversity Areas or in delivering ecosystem services. They may be terrestrial or aquatic.
- **Freshwater Ecosystem Priority Areas** (FEPAs) are rivers and wetlands required to meet biodiversity targets for freshwater ecosystems.
- **High water yield areas** are sub-quaternary catchments where mean annual runoff is at least three times more than the average for the related primary catchment.
- **Flagship free-flowing rivers** are the 19 free-flowing rivers that have been identified as representative of the last remaining 63 free-flowing rivers in South Africa. A free-flowing river is a long stretch of river that has not been dammed, flowing undisturbed from its source to the confluence with another large river or to the sea.
- **Priority estuaries** are estuaries that are required to meet targets for representing estuarine ecosystems, habitats and estuarine-dependent species.
- **Focus areas for land-based protected area expansion** are large, intact and unfragmented areas of high biodiversity importance, suitable for the creation and expansion of large protected areas.
- **Focus areas for offshore protection** are areas identified as priorities for representing offshore marine biodiversity, protecting vulnerable marine ecosystems, contributing to fisheries sustainability, and supporting the management of by-catch.

These categories are not mutually exclusive, and in some cases they overlap, often because a particular area or site is important for more than one reason. The different sets of biodiversity priority areas should be seen as complementary rather than contradictory, with overlaps reinforcing the significance of an area from a biodiversity or ecological infrastructure point of view.

Coastal ecosystem priority areas and **marine ecosystem priority areas** have yet to be identified across the country. In future, these categories of biodiversity priority areas will be added to this national list.

A map of currently identified biodiversity priority areas is shown in Figure 76. Spatial data and reports on most biodiversity priority areas are available on SANBI's Biodiversity GIS website (http://bgis.sanbi.org.za).

healthy examples should be the focus of urgent conservation action. This means that:

- Critically endangered and endangered ecosystems should be taken into account in land-use planning (for example, Spatial Development Frameworks) and environmental assessment (for example, EIAs).
- Remaining healthy examples or portions of critically endangered or endangered ecosystems are always priorities for protected area expansion, even if they do not fall within a mapped focus area for protected area expansion (see Section 12.1.8).

12.1.3 Critical Biodiversity Areas and Ecological Support Areas

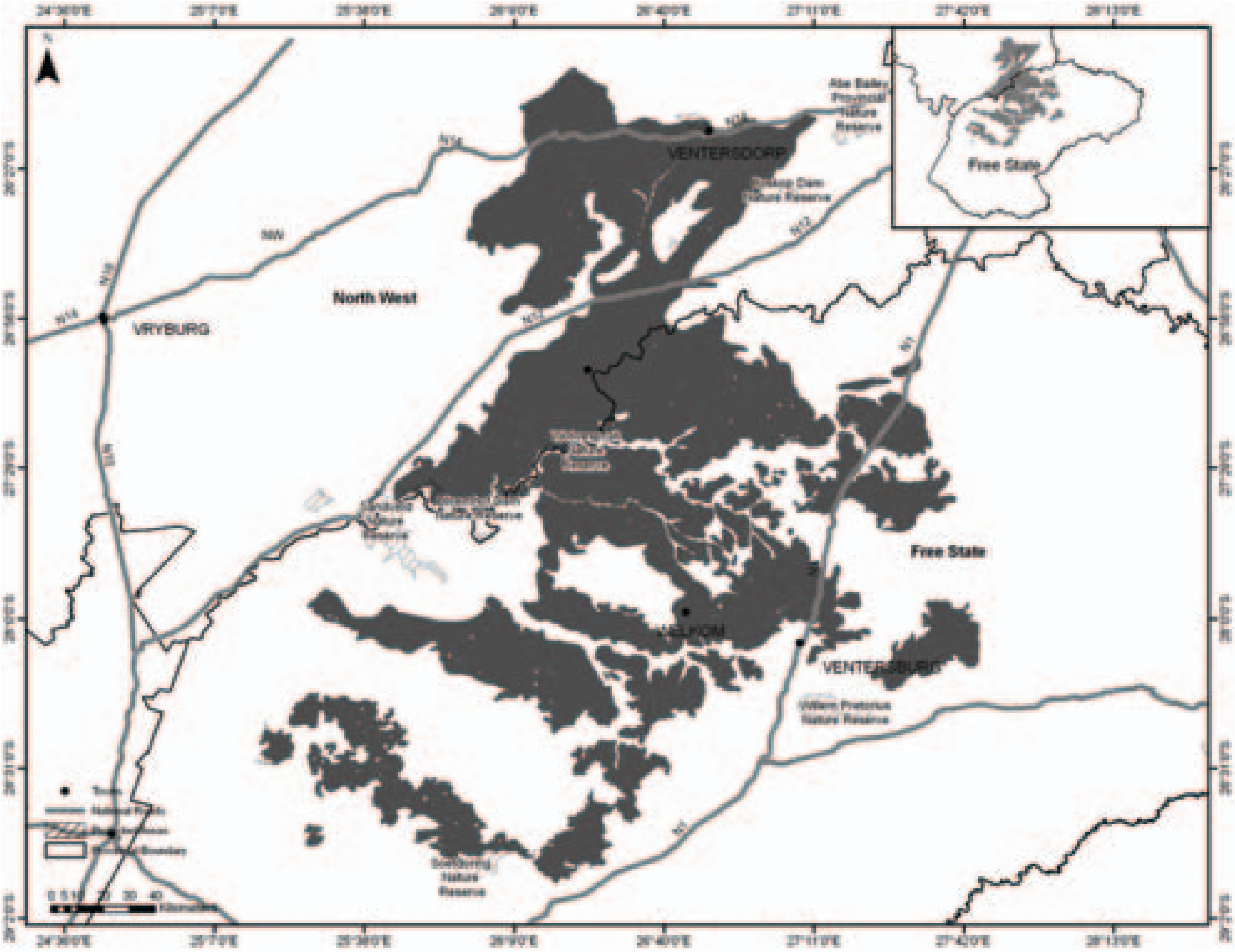
Critical Biodiversity Areas are areas required to meet biodiversity targets for ecosystems, species and ecological processes, as identified in a systematic biodiversity plan. **Ecological Support Areas** are not essential for meeting biodiversity targets but play an important role in supporting the ecological functioning of Critical Biodiversity Areas and/or in delivering ecosystem services. Critical Biodiversity Areas and Ecological Support Areas may be terrestrial or aquatic.

The primary purpose of a map of Critical Biodiversity Areas and Ecological Support Areas is to guide decision-making about where best to locate development. It should inform land-use planning, environmental assessment and authorisations, and natural resource management, by a range of sectors whose policies and decisions impact on biodiversity. It is the biodiversity sector's input into multi-sectoral planning and decision-making processes.

Most provinces have developed, or are in the process of developing, maps of Critical Biodiversity Areas and Ecological Support Areas in the form of provincial spatial biodiversity plans, usually led by the provincial conservation authority.[86] Table 12 summarises current progress on the development of provincial spatial biodiversity plans, and an example is shown in Figure 77. Some metropolitan municipalities have developed their own maps of Critical Biodiversity Areas and Ecological Support Areas at a finer spatial scale than the provincial map. Metros that have developed their own spatial biodiversity plans are Nelson Mandela Bay Municipality, as shown in Figure 78, and the City of Cape Town. Those in

Protected areas are the most secure nodes in the network of biodiversity priority areas.

[86]Some provinces use different terms for Critical Biodiversity Areas and Ecological Support Areas, such as 'irreplaceable areas' and 'highly significant areas'.



An example of an endangered terrestrial ecosystem, Vaal-Vet Sandy Grassland, that has been listed in terms of the Biodiversity Act. The map shows the original extent of the ecosystem, of which about a third remains. In cases where no list of threatened ecosystems has yet been published by the Minister, such as for all aquatic ecosystems, the ecosystem threat status assessment in the NBA can be used to identify critically endangered and endangered ecosystems.

the process of developing spatial biodiversity plans are the City of Johannesburg, the City of Tshwane, Ekurhuleni Metropolitan Municipality and eThekwini Municipality.

A map of Critical Biodiversity Areas and Ecological Support Areas should be accompanied by land-use guidelines linked to the categories on the map, and may be referred to as a biodiversity sector plan. It may also be formally published as a bioregional plan in terms of the Biodiversity Act, but need not be.

Action required:

Critical Biodiversity Areas should remain in a natural or near-natural state. Ecological Support Areas should remain in at least a functional state, in other words their ecological functioning should be maintained even if their structure and composition is disturbed. This means that:

- Critical Biodiversity Areas and Ecological Support Areas should be taken into account in land-use planning (for example, Spatial Development Frameworks) and environmental assessment (for example, EIAs). These areas form an interconnected network that enables proactive landscape-level planning by a range of actors in the landscape, rather than piecemeal decision-making.
- Critical Biodiversity Areas and Ecological Support Areas that highlight aquatic features should be taken into account in water resource planning and decision-making.
- Critical Biodiversity Areas and Ecological Support Areas that highlight estuaries or the near-shore environment should be taken into account in fisheries resource management and planning.
- Critical Biodiversity Areas and Ecological Support Areas provide opportunities for local economic development and rural development, for example linked to maintaining and restoring ecological infrastructure.
- Where possible Critical Biodiversity Areas should be included within priority areas for expanding the protected area network, including through biodiversity stewardship programmes. Critical Biodiversity Areas are identified at the finer spatial than the

Table 12.—Summary of provincial spatial biodiversity plans, which produce maps of Critical Biodiversity Areas and Ecological Support Areas

Province	Name of provincial spatial biodiversity plan	Lead agency	First available	Most recent update
Eastern Cape	Eastern Cape Biodiversity Conservation Plan	Department of Economic Development and Environmental Affairs (DEDEA)	2007	—
Gauteng	Gauteng C-Plan (current version 3.3)	Department of Agriculture & Rural Development (GDARD)	2003	2011
KwaZulu-Natal	KZN Biodiversity Conservation Plan	Ezemvelo KZN Wildlife	2004	2010
Free State	Free State Biodiversity Conservation Plan	Department of Economic Development, Tourism & Environmental Affairs (DEDTEA)	Under development	—
Limpopo	Preliminary Biodiversity Conservation Plan for Limpopo	Department of Economic Development, Environment & Tourism (LEDET)	2011	—
Mpumalanga	Mpumalanga Biodiversity Conservation Plan	Mpumalanga Tourism & Parks Authority (MTPA)	2007	Update underway
North West	North West Biodiversity Conservation Assessment	Department of Economic Development, Environment, Conservation & Tourism (DEDECT)	2008	—
Northern Cape	Namakwa District Biodiversity Sector Plan (covers only 1 of 3 districts in the province)	Department of Environment & Nature Conservation (DENC)	2011	—
Western Cape	Western Cape Biodiversity Framework	CapeNature	2010	—

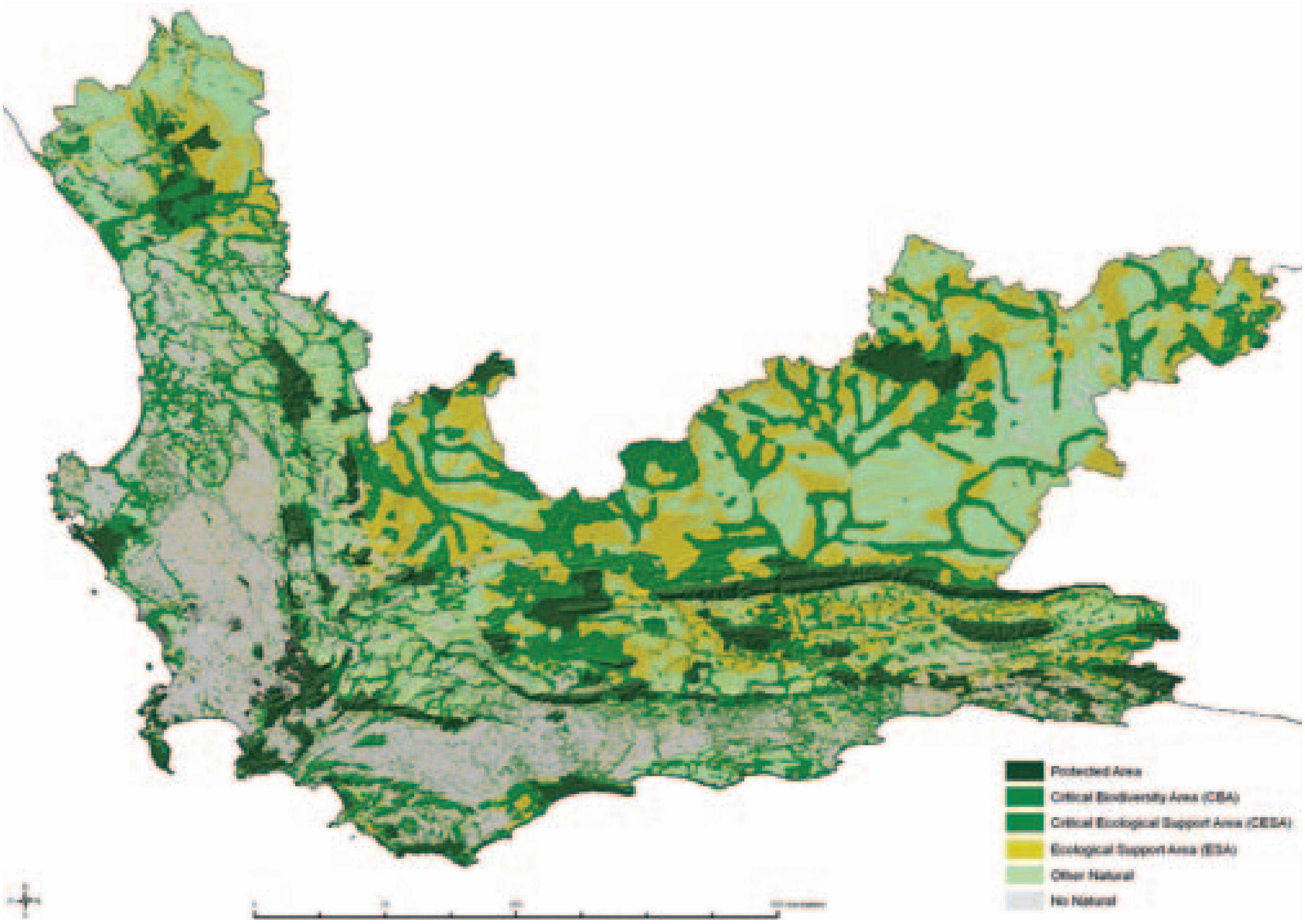


Figure 77.—An example of a map of Critical Biodiversity Areas and Ecological Support Areas, from the Western Cape province. Most provinces have developed or are in the process of developing such maps, which should be used to guide decision-making about where best to locate development.

national focus areas for land-based protected area expansion (see Section 12.1.8), and are thus useful for site-scale selection of priorities for protected area expansion.

12.1.4 Freshwater Ecosystem Priority Areas

Freshwater Ecosystem Priority Areas (FEPAs) are rivers and wetlands required to meet biodiversity targets for freshwater ecosystems. River FEPAs are usually shown with their associated sub-quaternary catchments.

River FEPAs are often tributaries that support hard-working larger rivers, and are an essential part of a sustainable water resource strategy. FEPAs need to stay in a good ecological condition to manage and conserve freshwater ecosystems, and to protect water resources for human use. This does not mean that FEPAs need to be fenced off from human use, but rather that they should be supported by good planning, decision-making and management to ensure that human use does not impact on the condition of the ecosystem.

River and wetland FEPAs were identified by the National Freshwater Ecosystem Priority Areas project (NFEPA), a three-year multi-partner project that concluded in mid-2011. A FEPA map was developed for each Water Management Area in South Africa. An example is shown in Figure 79. River FEPAs make up 22% of the country's river length, and wetland FEPAs make up 38% of the remaining wetland area in South Africa. As highlighted in Chapter 6, a large proportion of South Africa's wetland area has already been irreversibly lost, and remaining wetlands make up just 2.4% of the country's surface area. This means that wetland FEPAs make up less than 1% of South Africa's surface area.

Action required:

River FEPAs should be maintained in natural or near-natural condition (A or B ecological category).

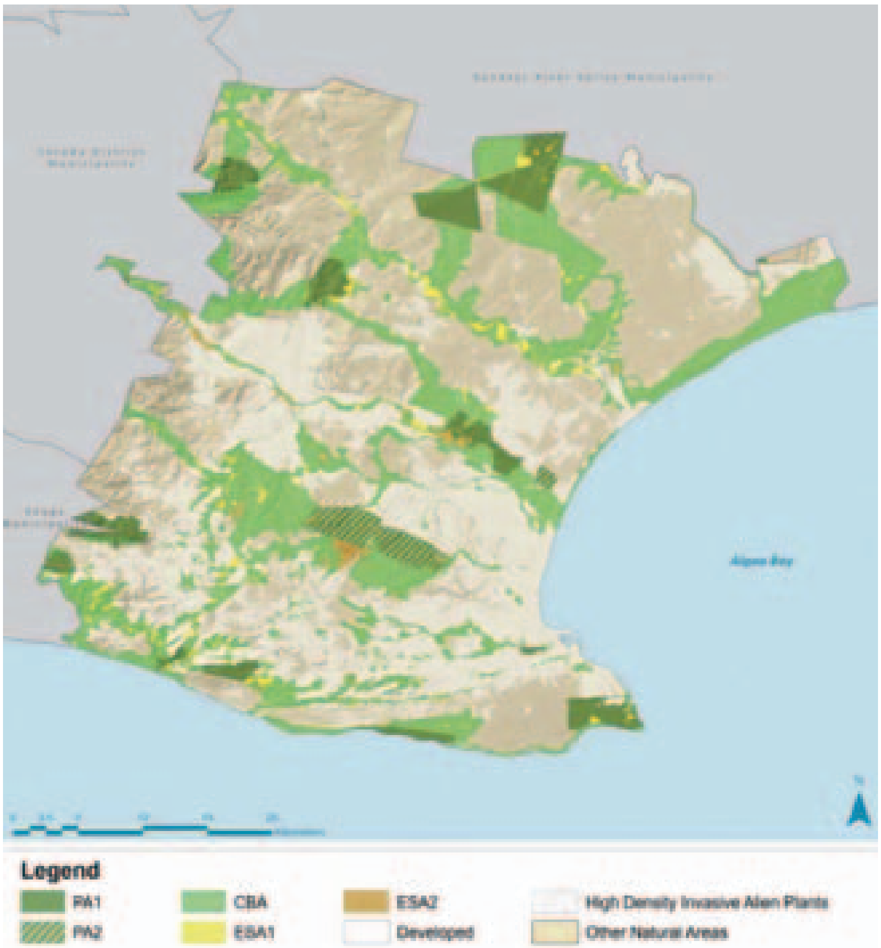


Figure 78.—An example of a map of Critical Biodiversity Areas and Ecological Support Areas, from the Nelson Mandela Bay Municipality. Some metropolitan municipalities have developed their own maps of Critical Biodiversity Areas and Ecological Support Areas at a finer spatial scale than the relevant provincial map.

Freshwater Ecosystem Priority Areas (FEPAs) have been identified for all Water Management Areas in South Africa. Many river FEPAs are healthy tributaries that help to sustain hard working main rivers.

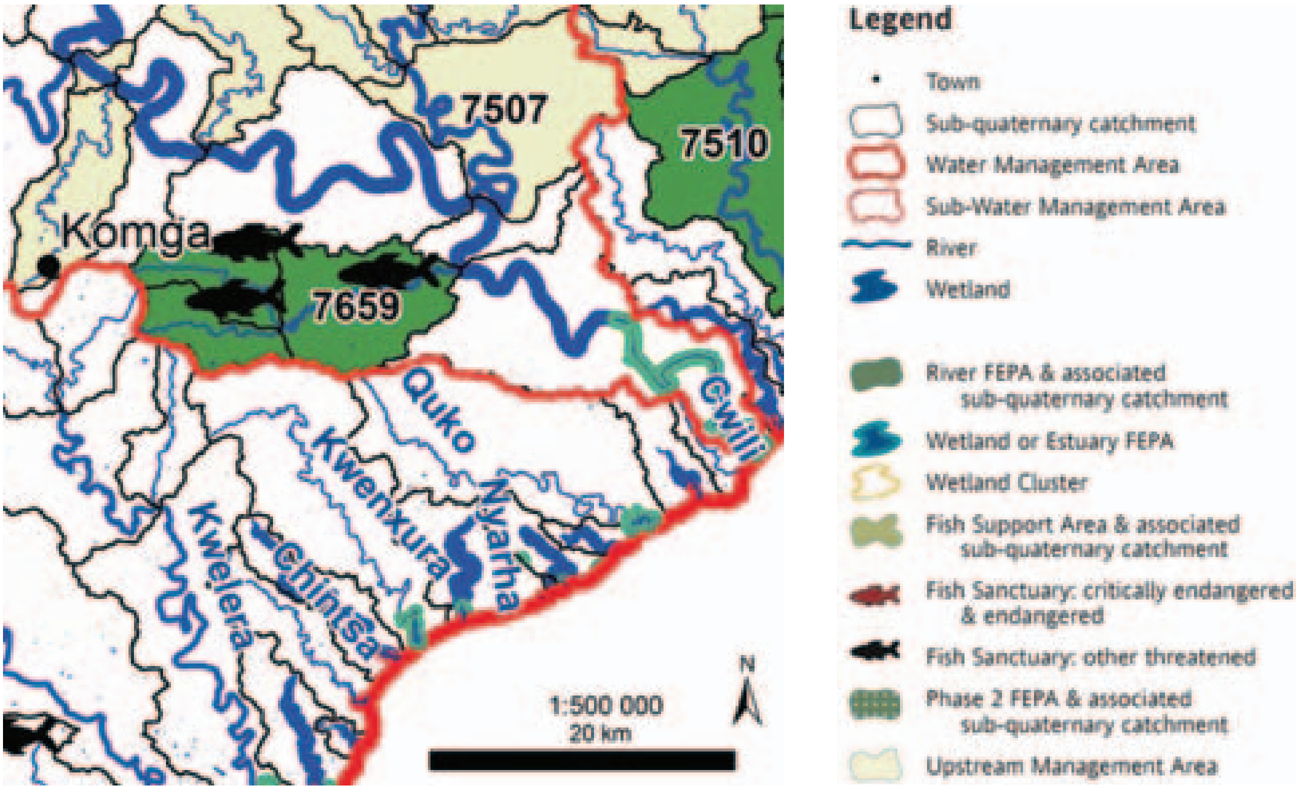


Figure 79.—An example of a Freshwater Ecosystem Priority Area (FEPA) map, showing a portion of the Mzimvubu Water Management Area. FEPA maps should be used to inform planning and decision-making that impacts on freshwater ecosystems, including the classification of water resources, land-use planning and EIAs.

Wetland FEPAs that are currently in natural or near-natural condition should remain so; those that are not should be rehabilitated to the best attainable ecological condition. This means that:

- River and wetland FEPAs should be taken into account in land-use planning (for example, Spatial Development Frameworks) and environmental assessment (for example, EIAs).
- River and wetland FEPAs should be taken into account in water resource planning (for example, Catchment Management Strategies), in the classification of water resources, in determining the ecological reserve for water resources, in water use authorisations, and in setting resource quality objectives for water resources.
- River and wetland FEPAs should be taken into account in determining priorities for clearing invasive alien plants.
- Buffers of healthy natural vegetation should always be maintained around river and wetland FEPAs.

For more information on river and wetland FEPAs, as well as other categories shown on FEPA maps, see the Atlas of Freshwater Ecosystem Priority Areas in South Africa[87] and the Implementation Manual for Freshwater Ecosystem Priority Areas.[88]

[87]Nel, J.L., Driver, A., Strydom, W.F., Maherry, A., Petersen, C., Hill, L., Roux, D.J., Nienaber, S., Van Deventer, H., Swartz, S. & Smith-Adao, L.B. 2011. *Atlas of Freshwater Ecosystem Priority Areas in South Africa*. WRC Report No. TT 500/11. Water Research Commission, Pretoria.

[88]Driver, A., Nel, J.L., Snaddon, K., Murray, K., Roux, D.J., Hill, L., Swartz, E.R., Manuel, J. & Funke, N. 2011. *Implementation Manual for Freshwater Ecosystem Priority Areas*. WRC Report No. 1801/1/11, Water Research Commission, Pretoria.

12.1.5 High water yield areas

High water yield areas are sub-quaternary catchments where mean annual runoff is at least three times more than the average for the related primary catchment. Mean annual runoff is the amount of water on the surface of the land that can be utilised in a year, which is calculated as an average (or mean) over several years. High water yield areas generally occur in mountain catchment areas, and are the 'water factories' of the catchment, generating a large proportion of the water for human and ecological use. Maintaining these areas in a healthy state plays a vital role in water security, supporting growth and development needs that are often far away.

High water yield areas generally occur in mountain catchments and are the water factories of the country.

High water yield areas were identified by the NFEPA project. They make up just 3.9% of the country, as shown in Figure 80. Currently only 18% of high water yield areas are formally protected. For more information, see the Atlas of Freshwater Ecosystem Priority Areas in South Africa and the Implementation Manual for Freshwater Ecosystem Priority Areas.

Action required:

High water yield areas that are currently in natural or near-natural condition should remain so; those that are not should be rehabilitated to the best attainable ecological condition. This means that:

- Land uses that reduce stream flow (for example, plantation forestry) should be minimised in these areas, as well as any activity that would affect water quality (for example, timber mills, mining, over-grazing).
- Wetlands in high water yield areas should be maintained in good ecological condition, as they regulate stream flow and prevent erosion.
- High water yield areas should inform the identification of priority sub-quaternary catchments for the control of invasive alien plants. Clearing of invasive alien plants in these areas would deliver large water yield benefits relative to clearing in other parts of the catchment.
- Options for extending and strengthening the protection of high water yield areas should be explored, for example declaring them as Protected Environments in terms of the Protected Areas Act, to ensure that

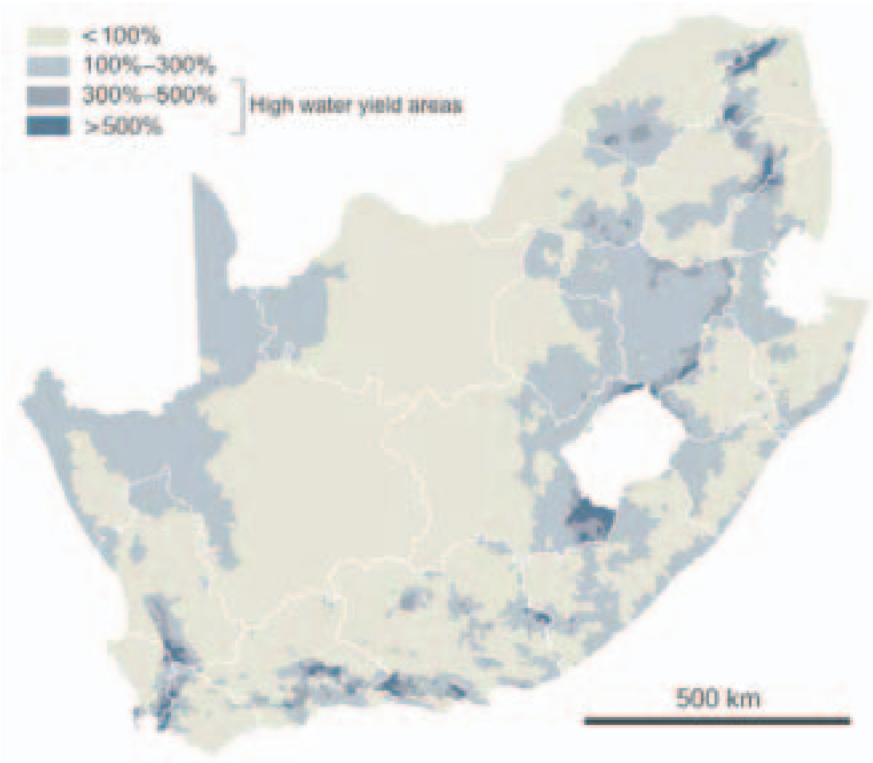


Figure 80.—High water yield areas are sub-quaternary catchments where mean annual runoff is at least three times greater than the related primary catchment. They are the water factories of the country, of strategic importance for South Africa's water security.

Table 13.—Flagship free-flowing rivers (listed anti-clockwise from Northern Cape to North West, from west to east within each province)

Northern Cape	**KwaZulu-Natal**
Upper Sak, Klein-Sak and tributaries*	Mzimkhulu*
Western Cape	Nsuze* (tributary of Thukela)
Doring and tributaries*	Black Mfolozi and tributaries*
Rooiels	Mkuze and tributaries*
Groot	**Mpumalanga**
Eastern Cape	Ntombe (tributary of Phongolo)
Kobonqaba	Elands*
Nqabarha*	Limpopo
Mtakatye*	Mutale-Luvuvhu*
Mtentu*	Mohlapitse
Mtamvuna and tributaries*	**North West**
Kraai and tributaries*	Upper Groot-Marico

* Flagship free-flowing rivers longer than 100 km. Of the 63 free-flowing rivers nationally, only 25 are longer than 100 km.

they are managed effectively with appropriate restrictions on land use. In many cases, only part of the sub-quaternary catchment concerned would require formal protection.

12.1.6 Flagship free-flowing rivers

A free-flowing river is a long stretch of river that has not been dammed, flowing undisturbed from its source to the confluence with another large river or to the sea. Dams prevent water from flowing down a river and disrupt ecological functioning, with serious knock-on effects for downstream river reaches and users. As discussed in Chapters 7 and 8, water flowing out to sea is not wasted but plays an important role in securing a range of estuarine and marine ecosystem services.

The Mtamvuna River in the Eastern Cape is one of only 25 rivers in South Africa that are longer than 100 km that have no dams, and has been identified as a flagship free-flowing river.

Free-flowing rivers are a rare feature in the South African landscape, with only 63 free-flowing rivers left. Of these 63, 19 were identified by the NFEPA project as flagship free-flowing rivers, based on their representativeness of free-flowing rivers across the country as well as their importance for ecological processes and biodiversity value. They are listed in Table 13. For more information, see the Atlas of Freshwater Ecosystem Priority Areas in South Africa and the Implementation Manual for Freshwater Ecosystem Priority Areas.[87, 88]

Action required:

Flagship free-flowing rivers should receive top priority for retaining their free-flowing character. This means that:

- Dams should not be constructed on flagship free-flowing rivers.
- Flagship free-flowing rivers should be maintained in a natural or near-natural ecological condition.
- Flagship free-flowing rivers should be considered priorities for protected area expansion. These rivers may lend themselves to a biodiversity stewardship approach.

12.1.7 Priority estuaries

Priority estuaries are estuaries that are required to meet targets for representing estuarine ecosystems, habitats and estuarine-dependent species. Of South Africa's 291 estuaries, 58 (20%) have been identified as priority estuaries that require full protection, and an additional 62 (21%) as priority estuaries that require partial protection. They are shown in Figure 81.

Priority estuaries were identified in the National Estuary Biodiversity Plan undertaken as part of the National Biodiversity Assessment 2011. They fed into the NFEPA project, and wherever possible river and estuary priorities were aligned. For more information see the National Estuary Biodiversity Plan[89] and the technical report for the estuary component of the NBA, as well as the Implementation Manual for Freshwater Ecosystem Priority Areas.[88]

Action required:

Priority estuaries that are currently in natural or near-natural condition should remain so; those that are not should be rehabilitated to the best attainable ecological condition. This means that:

- Specific recommendations which are provided for each priority estuary in the National Estuary Biodiversity Plan should be implemented, including:
  - The recommended ecological category for each priority estuary (usually A or B, but in some cases C or even D), with

The Heuningnes estuary, a temperate estuary on South Africa's south coast, is one of 120 priority estuaries that have been identified through the National Estuary Biodiversity Plan.

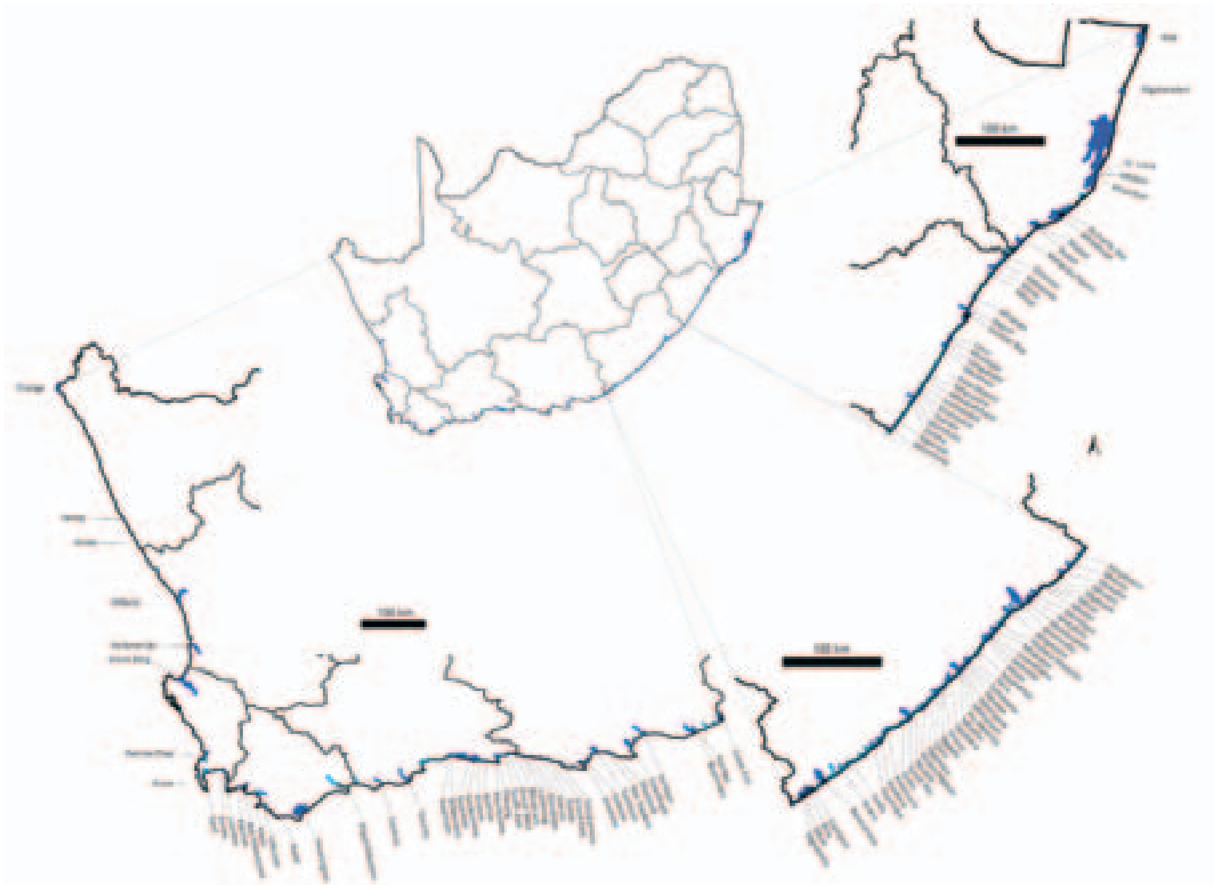


Figure 81.—Priority estuaries from the National Estuary Biodiversity Plan, shown in dark blue. The estuarine functional zone is shown for all estuaries, but only the priority estuaries are labelled. The development of estuary management plans in terms of the Integrated Coastal Management Act should be prioritised for these estuaries.

[89]Turpie, J.K., Wilson, G. & Van Niekerk, L. 2012. *National Biodiversity Assessment 2011: National Estuary Biodiversity Plan for South Africa*. Anchor Environmental Consulting, Cape Town. Report produced for the Council for Scientific and Industrial Research and the South African National Biodiversity Institute.

[90]CSIR. 2009. C.A.P.E. Estuaries Programme. *Proposed generic framework for estuary management plans. Version 1.1*. Report submitted to the C.A.P.E. Estuaries Programme. CSIR Report No. CSIR/NRE/CO/ER/2009/0128/A. CSIR, Natural Resources and the Environment, Stellenbosch.

implications for its freshwater flow requirements.

- ° The proportion of the estuary margin (ranging from 25% to 100%) that should remain free from development to an appropriate setback line.

- Priority estuaries that require full protection should become no-take areas, and estuaries that require partial protection may need one or more no-take zones.
- The development of estuary management plans in terms of the Integrated Coastal Management Act should be prioritised for priority estuaries. A generic framework for estuarine management plans is available.[90]

12.1.8 Focus areas for land-based protected area expansion

Focus areas for land-based protected area expansion are large, intact and unfragmented areas of high biodiversity importance, suitable for the creation and expansion of large protected areas. They also represent the best remaining large 'chunks' of natural capital that still have low levels of fragmentation and form a key part of the country's ecological infrastructure network.

The National Protected Area Expansion Strategy 2008 identified 42 focus areas for land-based protected area expansion, shown in Figure 82. They incorporate both terrestrial and freshwater features and are designed for resilience to climate change. The purpose of these focus areas is to guide the efforts of conservation agencies, both government and non-government, to achieve a cost-effective protected area network that represents all ecosystem types, includes key ecological processes and is resilient to climate change.

In addition to the focus areas, threatened ecosystems listed in term of the Biodiversity Act or identified in the National Biodiversity Assessment are priorities for protected area expansion. Threatened ecosystems are often highly fragmented and not suitable for the creation or expansion of large protected areas. They usually fall outside these identified focus areas.

Action required:

Focus areas for protected area expansion represent strategic priorities for meeting biodiversity targets for terrestrial and river ecosystems, through either the expansion of existing protected areas or the creation of new large protected areas. This means that:

- They should be a priority for national and provincial investment in protected area expansion, either through land acquisition or through contract agreements with private or communal landowners.
- They provide a national context in which provincial conservation authorities are able to develop more detailed provincial protected area expansion strategies and implementation plans.
- They provide a context for identification of site-scale priorities for protected area expansion. In most cases, the focus area represents an area within which protected area targets can be met, rather than an area which needs to be incorporated in its entirety into the protected area network.

Avoiding fragmentation of these focus areas should be a priority in land-use planning and decision-making, to avoid precluding future options for protected area expansion in areas that provide the most efficient and effective opportunities for such expansion.

12.1.9 Focus areas for offshore protection

Focus areas for offshore protection are areas identified as priorities for representing offshore marine biodiversity, protecting vulnerable marine ecosystems, contributing to fisheries sustainability, and supporting the management of by-catch. The offshore environment stretches from a depth of 30 m to 200 nautical miles offshore, which is the edge of South Africa's Exclusive Economic Zone.

The Offshore Marine Protected Area (OMPA) project, a four-year collaborative project that concluded in 2010, identified ten focus areas for offshore protection, shown in Figure 83.[91] The purpose of the focus areas is to identify offshore areas that require some form of spatial management, including marine protected areas in some cases. For each of the ten focus areas, objectives and important implementation considerations, including key stakeholders and potential spatial management measures, are specified. Other possible forms of marine protection in addition to marine protected areas include fisheries management areas and seabed protection zones.

[91]Sink, K.J., Attwood, C.G., Lombard, A.T., Grantham, H., Leslie, R., Samaai, T., Kerwath, S., Majiedt, P., Fairweather, T., Hutchings, L., Van der Lingen, C., Atkinson, L.J., Wilkinson, S., Holness, S. & Wolf, T. 2011. *Spatial planning to identify focus areas for offshore biodiversity protection in South Africa.* Offshore Marine Protected Area Project. Final Summary Report. South African National Biodiversity Institute, Cape Town.

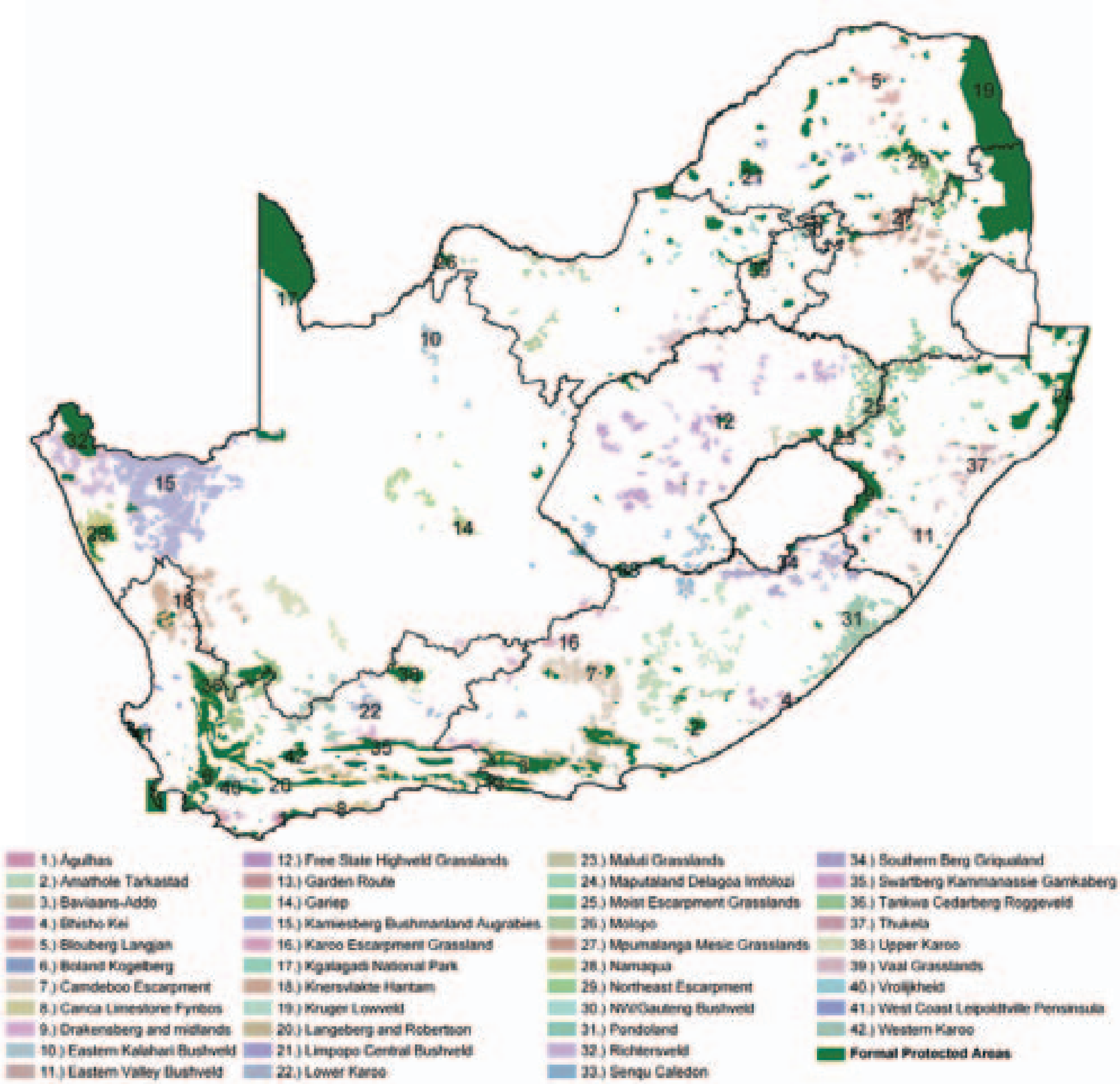


Figure 82.—Focus areas for land-based protected area expansion, identified in the National Protected Area Expansion Strategy 2008. These are large, intact and unfragmented areas of high biodiversity importance, suitable for the creation and expansion of large protected areas.

Focus areas for marine protection in the coastal and inshore environment have yet to be identified.

Action required:

Focus areas for offshore protection represent strategic priorities for expanding South Africa's marine protected area network as well as introducing other spatial management measures to protect ecosystems and contribute to fisheries management. This means that:

- Practical proposed boundaries for each focus area must be determined through finer-scale

Spatial management measures, including marine protected areas, can play a role in protecting spawning grounds and nursery grounds for juvenile fish, contributing to sustaining fisheries.

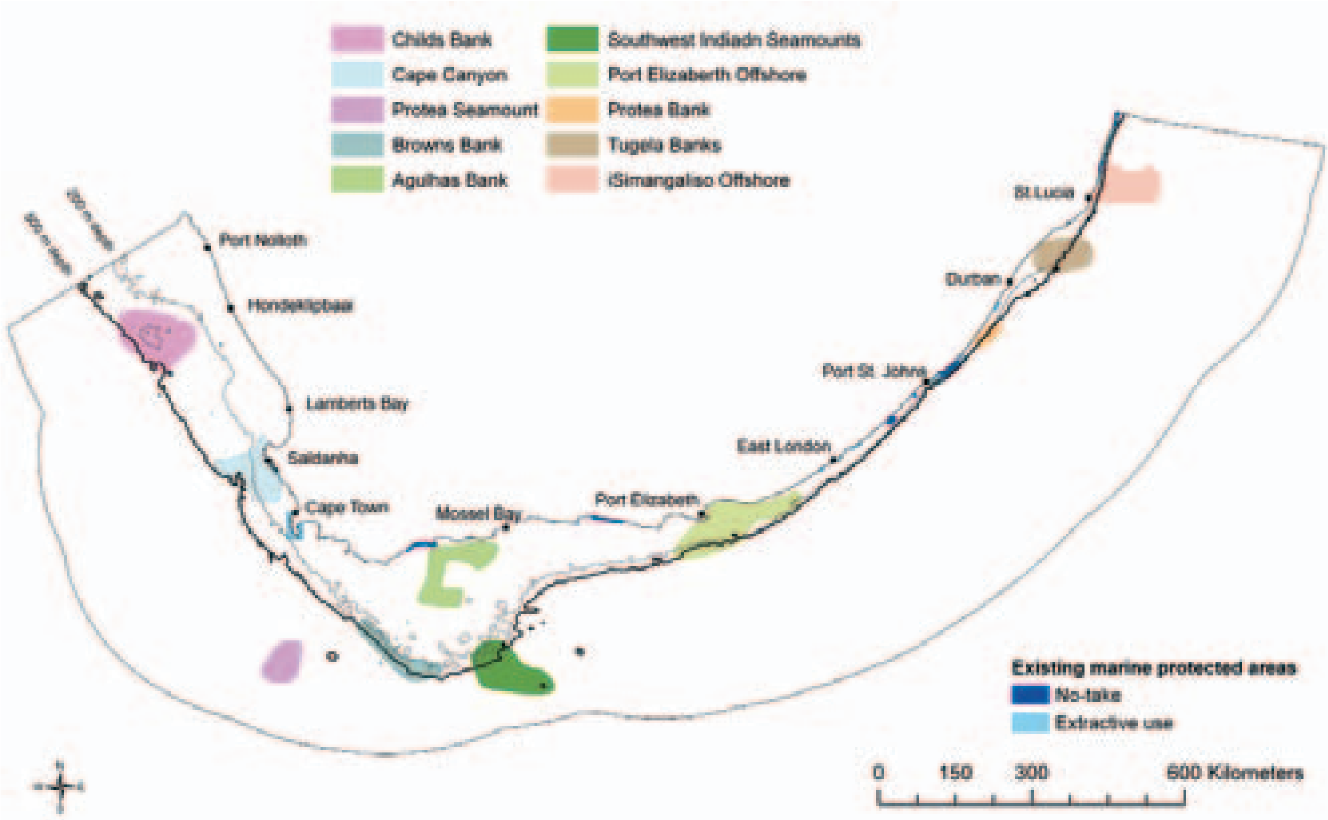


Figure 83.—Focus areas for offshore protection, identified by the Offshore Marine Protected Areas project as priorities for representing offshore marine biodiversity, protecting vulnerable marine ecosystems, contributing to fisheries sustainability, and supporting the management of by-catch. They require some form of spatial management, including marine protected areas in some cases.

interrogation of spatial data and further stakeholder consultation.

- Coordinated implementation of a network of MPAs and other spatial management measures is required.
- The focus areas should be taken into account in decision-making about marine resource use and activities in the ocean to avoid precluding future options for expanding the marine protected area network and implementing other spatial management measures in the most efficient and effective places.

12.2 Priority actions

The National Biodiversity Strategy and Action Plan (NBSAP) and the National Biodiversity Framework (NBF) are the key national documents which set out South Africa's strategic objectives and priority actions for managing and conserving biodiversity.

As explained in Chapter 1, the NBSAP was developed as part of South Africa's commitments to the Convention on Biological Diversity. It was completed in 2005,[92] with a revision due to be initiated in 2012. The NBF must be published by the Minister of Environmental Affairs and reviewed at least every five years as a requirement of the Biodiversity Act. Its purpose is to coordinate and align the efforts of the many organisations and individuals involved in conserving and managing South Africa's biodiversity, in support of sustainable development. South Africa's first NBF was published in 2009.[93]

While the NBSAP provides a comprehensive, long-term strategy, the NBF focuses attention more narrowly on the most urgent strategies and actions for conserving and managing South Africa's biodiversity. It sets five-year targets and points to roles and responsibilities of lead agents and other key stakeholders. As explained in Chapter 1, the NBA will feed into the upcoming revision of the NBSAP, which will be followed by a revision of the NBF.

The NBSAP and the NBF are the primary reference points for priority actions related to managing and conserving biodiversity. The NBA 2011 reinforces many of the existing priority actions and suggests some new areas for intervention that should be considered in the revision of the NBSAP and the NBF. Below we include a brief look at the priority actions that are strongly suggested by this NBA, with a view not to pre-empt the process of revising the NBSAP and NBF, but rather to provide science-based input to strengthen the process. More detail on priority actions is included in the technical reports for the NBA

[92]Department of Environmental Affairs and Tourism. 2005. *South Africa's National Biodiversity Strategy and Action Plan 2005*. Pretoria, Department of Environmental Affairs and Tourism.

[93]Department of Environmental Affairs. 2009. National Biodiversity Framework. *Government Gazette* No. 32474, 3 August 2009.

components, which readers are encouraged to consult in addition to the summary presented here.

Broadly speaking, priority actions suggested by the NBA can be grouped into three major categories, which apply across terrestrial and aquatic environments:

- Reduce loss and degradation of natural habitat in priority areas.
- Protect critical ecosystems.
- Restore and enhance ecological infrastructure.

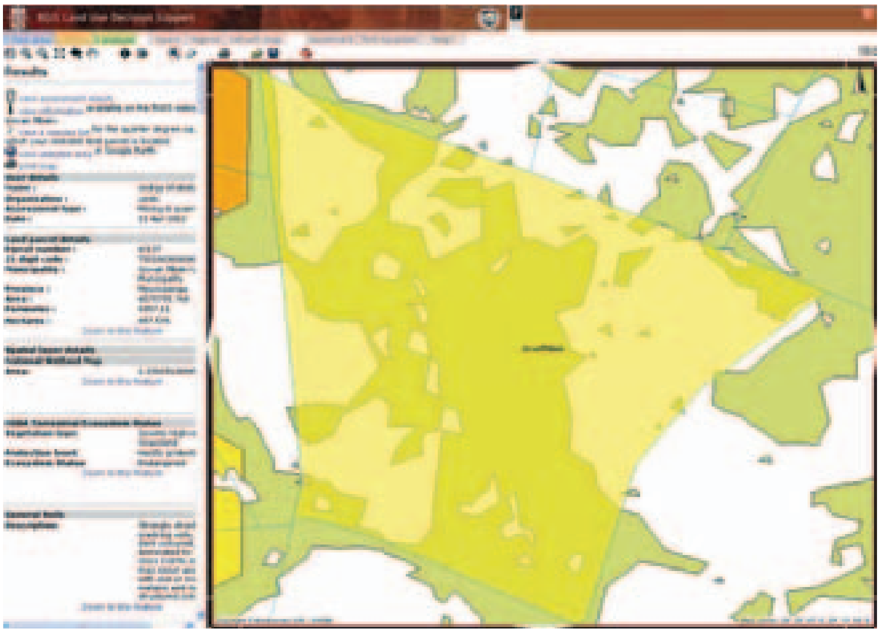
Effective implementation of priority actions in all three of these categories is underpinned by the maps of biodiversity priority areas presented in Section 12.1, which provide a valuable set of biodiversity information tools to assist with planning, decision-making and management.

12.2.1 Reduce loss and degradation of natural habitat in priority areas

This set of actions focuses on preventing loss and degradation of natural habitat in those biodiversity priority areas that are still in good ecological condition. Many of these priority areas occur in production landscapes and are not candidates for formal protection in terms of the Protected Areas Act. Maintaining them in good ecological condition requires that they be taken into account in land-use planning, environmental impact assessment, water resource planning and management, and other planning and day-to-day decision-making in a range of sectors.

Key actions for reducing loss and degradation of natural habitat that are suggested by the NBA include the following:

- Streamlining environmental decision-making, including through increasing the capacity of officials, consultants and developers to use maps of biodiversity priority areas to guide project planning and environmental impact assessment.
- Improving existing land-use decision-support tools (available on SANBI's Biodiversity Advisor website, http://biodiversityadvisor.sanbi.org) to make them more accessible and user-friendly. The spatial biodiversity priority areas discussed in Section 12.1 provide the foundation for land-use decision-support.
- Ensuring that FEPAs and priority estuaries inform the classification of water resources and related water resource development and authorisation processes.
- Ensuring sufficient freshwater flow to the coastal and marine environment, to support the maintenance of marine food webs and the provision of coastal and marine ecosystem services.
- Paying particular attention to keeping intact buffers of natural vegetation along rivers and around wetlands and estuaries, which help to keep these aquatic ecosystems healthy and contribute to water quantity and quality.
- Proceeding with the listing of threatened ecosystems in terms of the Biodiversity Act, with a focus especially on aquatic environments.
- Publishing bioregional plans (maps of Critical Biodiversity Areas and Ecological Support Areas) in terms of the Biodiversity Act.
- Developing and implementing Estuary Management Plans in terms of the Integrated Coastal Management Act, starting with the national set of priority estuaries, and ensuring that these plans are incorporated into the Integrated Development Plans of all coastal municipalities.
- Taking early action to eradicate invasive species (for example: ensuring the total eradication of the invasive alien grass, *Spartina alterniflora*, from the Great Brak Estuary before it takes hold and spreads to other estuaries; exploring methods and potential for eradicating European shore crab, *Carcinus meanus*, which is currently limited to a few harbours).
- Strengthening legislation and enforcement to prevent the release of ballast water in all South African ports and to control the cleaning of ship hulls in



SANBI's Biodiversity Advisor website includes a land-use decision-support tool that helps users to access relevant information about biodiversity priority areas relating to a particular site. This information can be used to streamline environmental decision-making.

harbours, to prevent the introduction of new invasive alien species in the marine environment. Currently mid-oceanic ballast exchange prior to port entry is enforced at some ports but not all. Cleaning of hulls sometimes takes place when ships are anchored near shore and debris is simply allowed to fall to the sea bottom.

- Supporting good environmental practice and effective regulation of the emerging aquaculture and mariculture sector, which otherwise has the potential for serious negative impacts on the health of ecosystems. For example, aquaculture and mariculture should be avoided in biodiversity priority areas including Marine Protected Areas, Critical Biodiversity Areas, Freshwater Ecosystem Priority Areas, priority estuaries, critically endangered and endangered ecosystems.

12.2.2 Protect critical ecosystems

This set of actions focuses on consolidating and expanding the protected area network as well as strengthening the effectiveness of existing protected areas. It deals with formal protection by law, recognised in terms of the Protected Areas Act, including contract protected areas on private or communal land. Such formal protection is not required or possible for all biodiversity priority areas; Section 12.1 provides guidance on which biodiversity priority areas require formal protection. Having invested in careful planning of geographic priorities for expanding land-based and marine protected areas based on sound science, South Africa is poised for strategic, cost-effective implementation of protected area expansion with a focus on ecosystems that are under-protected and areas that are important for climate change resilience.

Key actions for protecting critical ecosystems that are suggested by the NBA include the following:

- Expanding and consolidating the protected area network through a range of mechanisms including acquisition and contract agreements, as set out in the National Protected Area Expansion Strategy 2008.
- Strengthening and expanding the protection of high water yield areas, for example through declaration of Protected Environments in terms of the Protected Areas Act. Only 18% of high water yield areas are currently formally protected in spite of their strategic importance for water security.
- Strengthening biodiversity stewardship programmes, which provide a highly cost effective mechanism for expanding the protected area network and mobilising private resources for conservation gains.
- Increasing the delivery of the existing marine protected area network by implementing more no-take zones, and increasing benefits through diversified non-consumptive tourism activities.
- Ensuring that future revisions of the National Protected Area Expansion Strategy set explicit protected area targets for all marine, coastal, estuarine, river and wetland ecosystem types, as well as for terrestrial ecosystem types, and also for important features that require protection such as high water yield areas.

12.2.3 Restore and enhance ecological infrastructure

This set of actions focuses on active interventions required to restore those biodiversity priority areas that are currently not in good ecological condition, in order to enhance ecological infrastructure and support delivery of ecosystem services.

Key actions for restoring and enhancing ecological infrastructure that are suggested by the NBA include the following:

- Developing a national action plan for restoration of ecological infrastructure, including a focus on managing and controlling invasive alien species, rehabilitating priority wetlands and estuaries, restoring high water yield areas, and erosion control.
- Identifying in more detail priority areas for restoration of ecological infrastructure to maximise service delivery, job creation and ecosystem-based adaptation to climate change. This could further strengthen the scientific basis of natural resource management programmes such as Working for Water and Working for Wetlands, ensuring maximum return on investment. The biodiversity priority areas summarised in this chapter, together with the areas important for climate change resilience presented in Chapter 9, provide an excellent starting point.
- Developing a national strategy for invasive alien species. As discussed in Chapter 11, this strategy should take a hierarchical approach, with a strong focus on those activities that provide the highest return on investment. It should support the implementation of the Alien and Invasive Species Regulations.
- Unlocking additional investment in the restoration and management of ecological infrastructure, particularly to support catchment management, and developing mechanisms to ensure investment is maximised on the ground, for example through a payments for ecosystem services model. This would build on the work of existing natural resource management programmes such as Working for Water.
- Supporting the recovery of over-exploited marine and estuarine resources and threatened fish species through implementing resource recovery plans for over-exploited species and implementing the ecosystem approach to fisheries management, thereby supporting long-term food and job security.

- Restoring the health of St Lucia, South Africa's flagship estuary, and conserving the other estuarine lakes (Verloren, Bot, Klein, Wilderness (Touws), Swartvlei and Kosi). The health of Lake St Lucia is key to the future of South Africa's estuarine biodiversity and should be restored through re-linking with the uMfolozi. The iSimangaliso Wetland Park Authority is currently implementing such a strategy. See Chapter 7 for more on this.

12.2.4 Develop a national coastal biodiversity plan

As mentioned in Section 12.1, the set of biodiversity priority areas identified in South Africa does not yet include coastal ecosystem priority areas for the country. Along the coast, all the environments dealt with in the NBA—terrestrial, freshwater, estuarine and marine—come together, which makes the coast both special and challenging from an ecological point of view. Coastal ecosystems are significant assets that provide many ecosystem services, as highlighted in Box 15 in Chapter 8. They are also subject to the cumulative impacts of multiple pressures from the terrestrial and aquatic environments, including loss of natural land cover, decreasing flows of fresh water, and extractive use of marine resources.

Analysis undertaken for the NBA 2011 shows that nearly a quarter of South Africa's population lives within 30 km of the coast, and already nearly a fifth of the coast has some form of development within 100 m of the shoreline. The coast is likely to be an increasing focus for development because of its socio-economic importance and potential.

For coastal development to be ecologically sustainable, it should be focused on particular nodes, rather than spread along the length of the coast in ribbon style. A systematic plan that helps to identify where best to develop the coast, where coastal ecosystems should be kept natural, and where coastal ecosystems need to be restored and protected, is an urgent priority. A national coastal biodiversity plan should identify coastal ecosystem priority areas, including priorities for consolidating, zoning and expanding coastal MPAs, based on best available science, taking marine, estuarine, freshwater and terrestrial aspects into account. It should cover at least the entire coastal protection zone as defined in the Integrated Coastal Management Act, and should pay particular attention to coastal ecosystems that are important for adapting to the impacts of climate change.

A national action plan for restoration of ecological infrastructure could help to secure ecosystem services, create jobs and support ecosystem-based adaptation to climate change.

A national coastal biodiversity plan should identify where best to develop the coast, where coastal ecosystems should be kept natural, and where coastal ecosystems should be restored and protected.

The biodiversity sector has initiated a Human Capital Development Strategy to ensure concerted investment in the skills needed to unlock the opportunities presented by South Africa's wealth of biodiversity resources.

12.3 The critical role of human capital development

In order to implement the priorities identified here and unlock the opportunities presented by South Africa's wealth of biodiversity resources, a concerted investment is required in South Africa's human capital to study, govern, manage, restore and protect ecosystems. Lack of sufficient skilled and experienced people has been identified as a key constraint in the biodiversity sector, along with many other sectors in South Africa. In response, the biodiversity sector has initiated a Human Capital Development Strategy, coordinated by SANBI and funded by the Lewis Foundation, which provides a mechanism for agencies to contribute in a coherent and synergistic way to skills development and retention, and further demonstrate the potential of ecosystems to contribute to economic and social development.

Investing in skills for biodiversity conservation, management, restoration and protection has the potential to support significant employment creation, often at lower skills levels, and in rural areas. While fewer in number and more expensive to produce, managerial, professional and technical skills are vital for unlocking jobs at lower levels of skill. It is also at these high and intermediate levels where most of the sector's scarce and critical skills are. Critical skills needed include strategic leadership, advocacy, and the ability to work across disciplines. Scarce skills include wetland science, marine taxonomy, resource economics and biodiversity informatics. In addition, stronger human capital development skills are required to address the systemic quality challenges in basic and higher education, develop more broad based scientific literacy and support students and mid-career professionals in completing post-graduate studies.

Growing numbers of black South Africans are entering university studies in the Life Sciences. South Africa also has excellent established biodiversity scientists and conservationists with knowledge to share. However, many students are compelled to exit their studies before they develop the high levels of skills required. The sector is also not adequately retaining and utilising available mentors, and there are shortages of mentors in organisations and universities.

Human capital development in the biodiversity sector is not only essential for achieving biodiversity outcomes but has significant potential to contribute to national job creation and development objectives. For more on the Biodiversity Human Capital Development Strategy see www.greenmatter.co.za.

13. Knowledge gaps and research priorities for strengthening the NBA

Chapter summary

Through this assessment, a number of knowledge gaps and research priorities have been identified, with a view to strengthening future NBAs. They range from gaps in taxonomy through to the need for a more thorough understanding of ecosystem services.

A national assessment of biodiversity depends on a good foundation of knowledge of species and ecosystems, including which ones are found in South Africa and where they occur. Taxonomy is the science of describing, naming and classifying species and has good foundations in South Africa, providing the basis on which our understanding of biodiversity is built. However, the distribution of taxonomists across different groups of organisms is highly uneven. For example, there is one taxonomist for every 28 mammal species in South Africa but only one taxonomist for every 1 319 known insect species, with many more still to be discovered. Globally the number of taxonomists is declining with relatively few young scientists being recruited into the discipline. A national strategy for taxonomy is required, to ensure a strategic approach to taxonomic research and the development of new taxonomic capacity.

Perhaps less well recognised than the importance of describing and classifying species is the importance of mapping and classifying ecosystems as an essential foundation for monitoring, assessing and managing biodiversity. South Africa has some of the best ecosystem mapping and classification in the world, with a long history of vegetation mapping and more recent progress in the aquatic environments, as reflected in this NBA. This work amounts to an emerging national ecosystem classification system, which should be formalised and strengthened. Linked to this work is the development of biodiversity targets for ecosystem types based on their ecological characteristics, as has been achieved for vegetation types in the terrestrial environment.

Following closely in importance to strengthening the emerging national ecosystem classification system is the need for regularly updated, countrywide data on the condition of ecosystems. Without good data on ecological condition, it is not possible to assess ecosystem threat status. The Department of Water Affairs' system of Present Ecological State categories provides the basis for ecological condition assessment for rivers, wetlands and estuaries. The possibility of applying this type of approach in the terrestrial and marine environments should be explored. Programmes for long-term in situ monitoring of ecosystems based on quantitative indices, such as the River Health Programme, need to be strengthened or established in all environments, and opportunities to involve civil society in such programmes should be explored. Other priorities for assessing ecological condition include regularly updated maps of land cover for the country, a consistent national map of degradation in the terrestrial environment, and quantification of the modification in freshwater flow to the coast on a watershed scale.

Mapping and valuing ecosystem services is another research priority, to demonstrate the value of biodiversity and ecosystems, and to enable the recognition of ecosystem services in market transactions, national accounting and the allocation of public sector resources.

These priorities for research and data gathering should inform the National Biodiversity Research Strategy, currently being developed. They will also guide the further development and implementation of the national biodiversity monitoring framework, which includes the headline indicators reported on in the NBA and is coordinated by SANBI in collaboration with a range of partners.

In this final chapter, we look at gaps in knowledge and research priorities, with a specific focus on what is needed to strengthen the NBA. The priorities identified here are not intended to be a comprehensive set of research priorities for the biodiversity sector, which will be set out in the National Biodiversity Research Strategy currently being developed. At the end of the chapter, we discuss how the priorities identified here inform ongoing monitoring of biodiversity.

A national assessment of biodiversity depends on a good foundation of knowledge of species and ecosystems, including which ones are found in South Africa and where they occur. Taxonomy is the science of discovering, describing, naming and classifying species of plants, animals, fungi and micro-organisms. The outputs from taxonomic research provide the basis for all other downstream biodiversity activities including biodiversity planning, conservation status assessments, long-term monitoring, evaluating management impacts, rehabilitation, controlling invasive alien species, sustainable harvesting and so on. South Africa has a long history of taxonomic research and a wealth of taxonomic knowledge and resources; nevertheless, there are many gaps. Box 22 explores some of the challenges and priorities for taxonomic research in South Africa, including the need for a national strategy for this discipline.

These challenges notwithstanding, the need to describe and classify species is generally well acknowledged. Perhaps less widely recognised is the importance of classifying ecosystems as a starting point for meaningful biodiversity assessment and planning. As discussed in Chapter 1, the NBA's headline indicators, ecosystem threat status and ecosystem protection level, can be calculated only if ecosystems have been mapped and classified—the ecosystem equivalent of taxonomic research for species. The ability to map and classify ecosystem types allows us to advance beyond species as the only measure of biodiversity, and assists greatly in taking an ecosystem approach to the management and conservation of biodiversity.

Our approach to defining ecosystem types in the terrestrial, freshwater, estuarine and marine environments is discussed in Panel 5, Panel 6, Panel 7, Panel 8 and Panel 9 in Chapters 4 to 8. In each case a hierarchical approach has been taken, with national ecosystem types (such as vegetation types) nested within broader ecosystem groups (such as biomes). This work, taken together, amounts to an emerging **national ecosystem classification system**, which provides an essential foundation for monitoring, assessing and managing biodiversity.

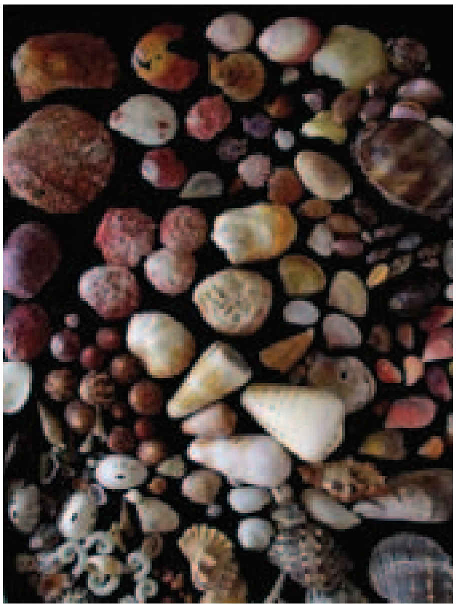
Because much of the work on mapping and classifying South Africa's ecosystem types is relatively new (with the exception of vegetation types in the terrestrial environment which have a long history), the emerging national ecosystem classification system is not yet completely stable and requires refining in some cases. Refining and agreeing on river, wetland, estuarine, marine and coastal ecosystem types is a major priority for improving the strength of the NBA going forward, and will make it possible to report on ecosystem trends over time. Without a stable ecosystem classification system, reporting meaningfully on trends in the state of ecosystems is almost impossible.

Against this backdrop, we highlight priorities for research and knowledge generation in the following areas:

- Formalising and strengthening the emerging national ecosystem classification system.
- Measuring and mapping the condition of ecosystems.
- Further exploring and documenting the contributions of biodiversity to human wellbeing.

Much more detail is included in the technical reports for each of the NBA components, particularly the marine and estuarine reports. Readers whose work relates to these issues are strongly encouraged to consult the technical reports for further detail.

Box 22: The state of taxonomy in South Africa



The ratio of taxonomists to species varies widely for different groups of organisms. For marine invertebrates there is just one taxonomist for every 1 700 species, not counting those species yet to be discovered and described. Taxonomy is an essential foundation for biodiversity science and management.

The estimated 95 500 species currently known from South Africa (see Chapter 10) is a far from complete record of diversity in the country. In the last two and a half years an estimated 254 new animal and 102 new plant species were formally described. A conservative estimate of at least 50 000 plant and animal species from South Africa remain to be described. Continuing at the current rate of species description for these groups means that South Africa's species diversity will only be fully documented in about 350 years time. Prioritisation of groups that most need taxonomic study, that have most value to society and for which progress is feasible, is critical.

There are an estimated 200 permanently employed taxonomists in South Africa, or a ratio of one taxonomist to every 477 known species and every 250 new species. However, the real problem is related to the unequal distribution of the expertise across the groups of living organisms, with the ratio for plants being about 1 taxonomist:225 species, and for insects 1 taxonomist:1 319 species, and with an estimated 30–50% or 20 000 insect species yet to be discovered. The ratio for marine invertebrates is highest of all, at about 1 taxonomist:1 700 species. The ratio for mammal taxonomists is 1 taxonomist:28 species, with few new mammal species remaining to be discovered in South Africa. Globally the number of taxonomists is declining as aging taxonomists retire and relatively few young scientists are

13.1 Building the foundations: national ecosystem classification system

As discussed, a national ecosystem classification system is the ecosystem equivalent of taxonomy for species. It involves mapping and classifying ecosystems in all environments, to develop a stable set of agreed national ecosystem types. Linked closely to this work is the development of biodiversity targets for ecosystem types based on their ecological characteristics, as has been achieved for vegetation types.

Priorities for strengthening the emerging national ecosystem classification system include the following:

- Confirming the classification of river ecosystem types.
- Refining the preliminary classification of wetland ecosystem types as well as improving the underlying map of wetlands through the National Wetland Inventory.
- Refining the classification of estuary ecosystem types based on higher resolution data on catchment hydrology, bathymetry, sediment structure, mouth state, and water column geochemistry.
- Refining the marine and coastal habitat classification and map based on testing the validity of the current classification, high resolution bathymetric mapping, systematic marine biodiversity surveys across broad ecosystem groups, and collation of information to support the development of descriptions of habitat types.
- Mapping ecologically meaningful boundaries of the coastal zone rather than using a default distance seaward and landward from the coastline.
- Conducting research that supports the development of ecosystem-based biodiversity targets for freshwater, estuarine and marine ecosystems, based on the ecological characteristics of the ecosystems concerned. Until such targets have been developed, which may take some time, the use of a flat 20% biodiversity target is fully endorsed.

For river, wetland, estuarine, coastal and marine ecosystem types, agreed names and formal descriptions including important species need to be developed, along the lines of those available for national vegetation types.[94] This is a big task. In addition, systems for updating and managing the spatial data layers and accompanying descriptions need to be established. For the vegetation map, this is done through a Vegetation Map Committee convened by SANBI.

recruited into the discipline. These challenges highlight the need for a more strategic approach to what taxonomists study, and what new taxonomic capacity is developed.

Innovative approaches to taxonomy also need to be developed and exploited. An accurate species name is critical to accessing information about a biological specimen—whether it is toxic, has medicinal properties, or whether it is an invasive alien species or a threatened endemic species can only be determined once the scientific name is available. The International Barcode of Life (IBOL) (see www.ibol.org) is the largest biodiversity genomics project ever undertaken, and offers great potential for resolving many of the challenges of accurately identifying species. Barcoding involves the use of a short fragment of DNA, checked against a reference database of DNA sequences for all species to provide the identification. South Africa is in the process of establishing a regional barcode node of IBOL and there are several initiatives aimed at barcoding different components of the country's biodiversity (see for example http://acdb.co.za/), but much effort is required nationally before effective services can be provided by barcoding technology.

Taxonomic research (having an accurate knowledge of what species occur) and primary biodiversity data (records of species occurrence in space and time) provide the basis of biodiversity assessment, and the research and data compilation are dependent on natural science collections housed in museums, herbaria and universities. A recent assessment of almost 100 of these collections in South Africa suggested that most are in crisis in terms of funding, human capacity, and in many cases infrastructure.

The exceptional wealth of South Africa's biodiversity, coupled with declining or inappropriate capacity to document and identify species, the poor state of biodiversity collections and the opportunities presented by innovative approaches such as DNA barcoding, highlights the need for a coordinated and strategic effort in terms of taxonomy. The first step towards achieving this is to highlight the importance of taxonomy and collections to biodiversity assessment, monitoring and management, followed by a national strategy for taxonomy that is resourced and implemented.

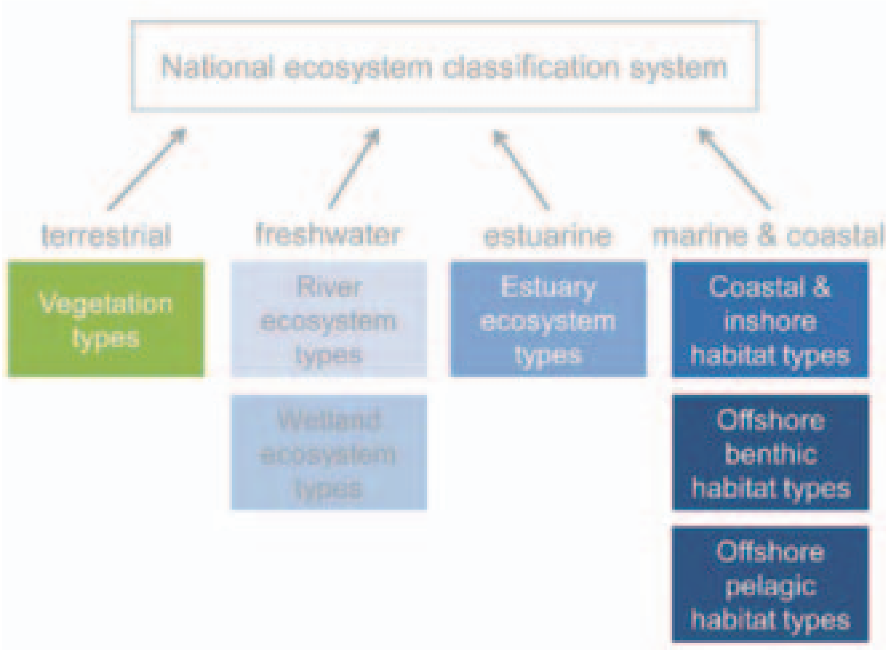
[94] Mucina, L. & Rutherford, M.C. (eds). 2006. The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia* 19. South African National Biodiversity Institute, Pretoria.

13.2 Measuring and mapping ecological condition

Following closely in importance to strengthening the emerging national ecosystem classification system is the need for regularly updated, countrywide data on the condition of ecosystems. Without good data on ecological condition, it is not possible to assess ecosystem threat status, and assessments of ecosystem protection level become less meaningful.

For rivers, wetlands and estuaries, the Department of Water Affairs has developed a set of ecological condition categories which are used consistently across the country. Known as Present Ecological State categories, they range from A (natural or unmodified) through to F (critically or extremely modified), with clear descriptions linked to each category, as discussed in Chapter 3. This system is exceptionally useful and forms the basis for the ecological condition categories used for river, wetland and estuarine ecosystems in the NBA. We recommend that the possibility of adapting this type of approach for use in the terrestrial and marine environments be explored.

In many cases it is not possible to monitor the condition of ecosystems directly, for example through field surveys and sampling; the country is simply too large and resources too limited to make this feasible. However, there are several options for inferring the condition of ecosystems from data that is easier and cheaper to collect, including remotely sensed data and data about pressures on ecosystems.



Strengthening the national ecosystem classification system is a priority, for example through research to support the verification and description of river and wetland ecosystem types, estuarine ecosystem types, and marine and coastal habitat types.

Priorities for research and data gathering related to the condition of ecosystems include the following:

- Regularly updated land cover maps for the country at a suitable spatial scale. The most recent National Land Cover available is for the year 2000. A system for updating the National Land Cover at least every five years is an urgent priority. This data layer is vital for assessing the condition of terrestrial ecosystems, and helpful for assessing the condition of rivers, wetlands and estuaries.
- Mapping of degradation in the terrestrial environment. As noted in the NSBA 2004 and again in the NBA 2011, there is no nationally consistent or complete map of land degradation at an appropriate spatial scale for ecosystem-level assessment, which limits our ability to assess the condition of terrestrial ecosystems. It is difficult to determine consistent definitions of degradation and to identify degraded areas based on remote images. Developing a national map of degradation remains an urgent priority. It would also be helpful for assessing the ecological condition of rivers, wetlands and estuaries.
- Regular national updates of Present Ecological State for rivers and estuaries, preferably at least every five years. Improved data on pressures, including land cover, pollution, hydrology and fishing pressure, would strengthen the results, as would more systematic and extensive survey data from the River Health Programme—see discussion on monitoring in Section 13.4.
- Identification of wetlands of strategic importance for assessing wetland condition. With an estimated 300 000 wetlands in South Africa it will never be possible to assess the condition of each wetland directly. This priority links closely with the discussion on monitoring in Section 13.4.
- Quantification of the modification in freshwater flow to the coast on a watershed scale, using the true catchment area of each estuary. This information is important for assessing the condition of estuaries as well as coastal and marine ecosystems.
- In situ measurements of ecological condition in the marine environment. Most marine ecosystems have never had their condition directly assessed, and there are no regular coordinated national monitoring programmes for marine ecosystems

at the habitat scale. This means that the assessment of the condition of marine habitat types in the NBA 2011 is inferred from data on pressures in the marine environment, not supplemented with data from the field. Actual sampling of the condition of some marine habitats would allow the condition assessment to be calibrated and refined.

It is also important to pay attention to emerging pressures on ecosystems, such as aquaculture, mariculture, genetically modified organisms, crop biofuels, desalination plants, expanding petroleum activities in the ocean and aquatic invasive alien species, so that their actual and potential impact can be better understood and they can be taken into account in assessing ecological condition.

13.3 Further research on the links between biodiversity and human wellbeing

Biodiversity is a national asset and a potentially powerful contributor to economic development and job creation. However, this is not always fully recognised, especially in market transactions, national accounting, and the allocation of public sector resources.

Research to improve understanding and evaluation of ecosystem services is a priority. Spatial assessment and mapping of ecosystem services would facilitate better integration of ecosystem services into biodiversity assessment and planning at all scales, including future revisions of the NBA, and would enable mainstreaming of ecosystem services in planning and decision-making in other sectors and in turn help to reduce loss of biodiversity in priority areas.

At the time of writing, a national study on valuing ecosystems and biodiversity was being initiated, building on the recent global study on The Economics of Ecosystems and Biodiversity (TEEB). In addition, the Global Environmental Facility has invested in a Project on Ecosystem Services (ProEcoServ) to develop innovative and practical approaches to mainstream the value of ecosystem services into national development programmes. South Africa is one of five pilot countries involved, with the CSIR leading the South African component in partnership with DEA and SANBI. The project was initiated during 2011 and will be completed in 2014. This critical work needs to be built upon.

In addition, further research is needed on the links between biodiversity and ecosystem services, the types of ecological infrastructure needed to optimise the delivery of ecosystem services, priority ecosystems for ecosystem-based adaptation to climate change (as discussed in Chapter 9), and the potential for integrated management of natural resources to contribute to job creation and poverty alleviation.

The next NBA will aim to draw on these growing areas of research to incorporate ecosystem services and the socio-economic benefits of biodiversity more fully into the assessment.

13.4 What does this mean for biodiversity-related monitoring work?

Monitoring of biodiversity and ecosystems is a large, multifaceted undertaking, necessarily involving many organisations and individuals. The NBA is not the place to tackle the full scope of biodiversity monitoring needs and priorities. However, we point to the following monitoring priorities that emerge directly from the assessment and that will help to enhance future revisions of the NBA:

- Remote sensing and expert-derived mapping of pressures on ecosystems need to be complemented by in situ measurements of ecological condition. Selection of sites for in situ monitoring should be linked to the national ecosystem classification system, to ensure a stratified sample that represents different ecosystem types. Biodiversity priority areas (see Chapter 12) can also help to guide strategic selection of sites for in situ monitoring.

Research to improve understanding of how biodiversity contributes to the economy is a priority.

Opportunities to involve the public in monitoring of ecosystems should be explored, building on successes to date.

- Programmes for long-term in situ monitoring of ecosystems, based on accepted quantitative indices rather than expert knowledge, need to be strengthened and expanded. The River Health Programme is led by the Department of Water Affairs in partnership with a network of organisations, and has proved successful over several years. It should be revitalised and expanded to include additional river monitoring points as well as wetlands. A National Estuary Monitoring Programme is currently being developed by the Department of Water Affairs. Such programmes can provide insights and lessons for the terrestrial and marine environments. Their advantages include standardised measurements and data procedures and open access to data.
- Opportunities to involve the public as citizen scientists in in situ monitoring of ecosystems should be explored. Examples of success that can be drawn on include the Reef Atlas which harnessed the collaboration of divers, the many altassing projects for species including birds, reptiles, arachnids and butterflies (see Chapter 10), and the Custodians of Rare and Endangered Wildflowers (CREW) programme which involves communities in monitoring threatened plants.
- In situ monitoring of ecosystems should feed directly into five-yearly national updates of ecological condition assessments, highlighted as a priority in Section 13.2.

SANBI's mandate includes monitoring and reporting on the state of biodiversity, and SANBI aims to play a coordinating and facilitating role with respect to monitoring of biodiversity. To this end, SANBI has developed a national biodiversity monitoring framework, in collaboration with a range of partners, which includes the headline indicators reported on in the NBA. The priorities identified here will guide the further development and implementation of the national biodiversity monitoring framework.

Acknowledgements

The NBA 2011 involved many people and organisations over several years, and was characterised throughout by a collaborative spirit and exceptional cooperation across organisational and disciplinary boundaries.

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In addition, DEA and SANBI would like to thank the following organisations for their contributions:

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Glossary

Biodiversity: The diversity of genes, species and ecosystems on Earth, and the ecological and evolutionary processes that maintain this diversity.

Biodiversity assets: Species, ecosystems and other biodiversity-related resources that generate ecosystem services, support livelihoods, and provide a foundation for economic growth, social development and human wellbeing.

Biodiversity Management Plan: A plan aimed at ensuring the long-term survival in nature of an indigenous species, a migratory species or an ecosystem, published in terms of the Biodiversity Act. Norms and standards to guide the development of Biodiversity Management Plans for Species have been developed. At the time of writing, norms and standards for Biodiversity Management Plans for Ecosystems were in the process of being developed.

Biodiversity planning: Spatial planning to identify geographic areas of importance for biodiversity. Also see Systematic biodiversity planning.

Biodiversity priority areas: Features in the landscape or seascape that are important for conserving a representative sample of ecosystems and species, for maintaining ecological processes, or for the provision of ecosystem services. They include the following categories, most of which are identified based on systematic biodiversity planning principles and methods: protected areas, critically endangered and endangered ecosystems, Critical Biodiversity Areas and Ecological Support Areas, Freshwater Ecosystem Priority Areas, high water yield areas, flagship free-flowing rivers, priority estuaries, focus areas for land-based protected area expansion, and focus areas for offshore protection. Marine ecosystem priority areas and coastal ecosystem priority areas have yet to be identified but will be included in future. The different categories are not mutually exclusive and in some cases overlap, often because a particular area or site is important for more than one reason. They should be seen as complementary, with overlaps reinforcing the importance of an area.

Biodiversity sector plan: A map of Critical Biodiversity Areas and Ecological Support Areas accompanied by contextual information, land- and resource-use guidelines and supporting GIS data. The map must be produced using the principles and methods of systematic biodiversity planning. A biodiversity sector plan represents the biodiversity sector's input into planning and decision-making in a range of other sectors. It may be formally published in the Government Gazette as a bioregional plan in terms of the Biodiversity Act, but need not necessarily be.

Biodiversity stewardship: a model for expanding the protected area network in which conservation authorities enter into contract agreements with private and communal landowners to place land that is of high biodiversity value under formal protection. Different categories of agreement confer varying degrees of protection on the land and hold different benefits for landowners. The landowner retains title to the land, and the primary responsibility for management remains with the landowner, with technical advice and assistance provided by the conservation authority.

Biodiversity target: The minimum proportion of each ecosystem type that needs to be kept in a natural or near-natural state in the long term in order to maintain viable representative samples of all ecosystem types and the majority of species associated with those ecosystem types.

Biodiversity thresholds: A series of thresholds used to assess ecosystem threat status, expressed as a percentage of the original extent of an ecosystem type. The first threshold, for critically endangered ecosystems, is equal to the biodiversity target; the second threshold, for endangered ecosystems, is equal to the biodiversity target plus 15%; and the third threshold, for vulnerable ecosystems, is usually set at 60%. Also see Ecosystem threat status.

Biome: An ecological unit of wide extent, characterised by complexes of plant communities and associated animal communities and ecosystems, and determined mainly by climatic factors and soil types. A biome may extend over large, more or less continuous expanses or land surface, or may exist in small discontinuous patches.

Bioregional plan (published in terms of the Biodiversity Act): A map of Critical Biodiversity Areas and Ecological Support Areas, for a municipality or group of municipalities, accompanied by contextual information, land- and resource-use guidelines and supporting GIS data. The map must be produced using the principles and methods of systematic biodiversity planning, in accordance with the

Guideline for Bioregional Plans.[95] A bioregional plan represents the biodiversity sector's input into planning and decision-making in a range of other sectors. The development of the plan is usually led by the relevant provincial conservation authority or provincial environmental affairs department. A bioregional plan that has not yet been published in the Government Gazette in terms of the Biodiversity Act is referred to as a biodiversity sector plan.

Conservation area: Areas of land not formally protected by law but informally protected by the current owners and users and managed at least partly for biodiversity conservation. Because there is no long-term security associated with conservation areas, they are not considered a strong form of protection. Also see Protected area.

Conservation planning—see Biodiversity planning.

Critical Biodiversity Area: Areas required to meet biodiversity targets for ecosystems, species or ecological processes, as identified in a systematic biodiversity plan. May be terrestrial or aquatic.

Critically endangered ecosystem: an ecosystem type that has very little of its original extent (measured as area, length or volume) left in natural or near-natural condition. Most of the ecosystem type has been severely or moderately modified from its natural state. The ecosystem type is likely to have lost much of its natural structure and functioning, and species associated with the ecosystem may have been lost.

Ecological infrastructure: The stock of ecosystems and species, or natural capital, that provides a flow of essential ecosystem services to human communities. Networks of ecological infrastructure may take the form of large tracts of natural land or ocean, or small remaining patches or corridors embedded in production landscapes. If ecological infrastructure is degraded or lost, the flow of ecosystem services will diminish. Ecological infrastructure is just as important as built infrastructure for providing vital services that underpin social and economic activity.

Ecological Support Area: An area that is not essential for meeting biodiversity targets but plays an important role in supporting the ecological functioning of one or more Critical Biodiversity Areas or in delivering ecosystem services. May be terrestrial or aquatic.

Ecosystem-based adaptation (to climate change): The use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change. Includes managing, conserving and restoring ecosystems to buffer humans from the impacts of climate change, rather than relying only on engineered solutions. Combines socio-economic benefits, climate-change adaptation, and biodiversity and ecosystem conservation, contributing to all three of these outcomes simultaneously.

Ecosystem protection level: Indicator of the extent to which ecosystems are adequately protected or under-protected. Ecosystem types are categorised as well protected, moderately protected, poorly protected, or not protected, based on the proportion of the biodiversity target for each ecosystem type that is included within one or more protected areas. Unprotected, poorly protected or moderately protected ecosystem types are collectively referred to as under-protected ecosystems.

Ecosystem services: the benefits that people obtain from ecosystems, including provisioning services (such as food and water), regulating services (such as flood control), cultural services (such as recreational benefits), and supporting services (such as nutrient cycling, carbon storage) that maintain the conditions for life on Earth. Ecosystem services are the flows of value to human society that result from a healthy stock of ecological infrastructure. If ecological infrastructure is degraded or lost, the flow of ecosystem services will diminish.

Ecosystem threat status: Indicator of how threatened ecosystems are, in other words the degree to which ecosystems are still intact or alternatively losing vital aspects of their structure, function or composition. Ecosystem types are categorised as critically endangered, endangered, vulnerable or least threatened, based on the proportion of the original extent of each ecosystem type that remains in good ecological condition relative to a series of biodiversity thresholds. Critically endangered, endangered and vulnerable ecosystems are collectively referred to as threatened ecosystems, and may be listed as such in terms of the Biodiversity Act.

Ecosystem type: An ecosystem unit that has been identified and delineated as part of a hierarchical classification system, based on biotic and/or abiotic factors. Factors used to map and classify ecosystems differ in different environments. Ecosystem types can be defined as, for example, vegetation types, river ecosystem types, wetland ecosystem types, estuary ecosystem types, or marine or coastal habitat types. Ecosystems of the same type are likely to share broadly similar ecological characteristics and functioning. Also see National ecosystem classification system.

[95]Department of Environmental Affairs and Tourism. 2009. *Guideline regarding the determination of bioregions and the preparation and publication of bioregional plans*. Notice No. 291, Government Gazette No. 32006, 16 March 2009.

Endangered ecosystem: An ecosystem type that is close to becoming critically endangered.

Estuarine functional zone: The open water area of an estuary together with the associated floodplain, incorporating estuarine habitat (such as sand and mudflats, salt marshes, rock and plant communities) and key physical and biological processes that are essential for estuarine ecological functioning.

Focus areas for offshore protection: Areas identified as priorities for representing offshore marine biodiversity, protecting vulnerable marine ecosystems, contributing to fisheries sustainability, and supporting the management of by-catch.

Focus areas for protected area expansion: Large, intact and unfragmented areas of high biodiversity importance, suitable for the creation and expansion of large protected areas.

Free-flowing river: A long stretch of river that has not been dammed, flowing undisturbed from its source to the confluence with another large river or to the sea. **A flagship free-flowing river** is one of the 19 free-flowing rivers that have been identified as representative of the last remaining 63 free-flowing rivers in South Africa.

Freshwater Ecosystem Priority Area: A river or wetland that is required to meet biodiversity targets for freshwater ecosystems.

High water yield area: A sub-quaternary catchment where mean annual runoff is at least three times more than the average for the related primary catchment.

Least threatened ecosystem: An ecosystem type that has experienced little or no loss of natural habitat or deterioration in condition.

Main river: A quaternary mainstem, or a river that passes through a quaternary catchment into a neighbouring quaternary catchment. In situations where no river passes through a quaternary catchment, the longest river in the quaternary catchment is the main river. Also see Tributaries.

National ecosystem classification system: A hierarchical system for mapping and classifying ecosystem types in the terrestrial, river, wetland, estuarine, coastal and marine environment. South Africa has a well-established classification system for terrestrial ecosystems in the form of vegetation mapping, and much progress has been made in mapping and classifying aquatic ecosystems as part of the NBA 2011. Factors used to map and classify ecosystems differ in different environments, but in all cases ecosystems of the same type are expected to share broadly similar ecological characteristics and functioning. The national ecosystem classification system provides an essential scientific foundation for ecosystem-level assessment, planning, monitoring and management. Also see Ecosystem type.

Offshore benthic: Relating to the bottom of the ocean or the seabed.

Offshore pelagic: Relating to the water column in the ocean.

Present Ecological State: A set of categories for describing the ecological condition of rivers, wetlands and estuaries, developed by the Department of Water Affairs. Assessment of Present Ecological State takes into account a range of factors including flow, inundation, water quality, stream bed condition, introduced instream biota, and riparian or stream bank condition. The categories range from A (natural or unmodified) through to F (critically or extremely modified), with clear descriptions linked to each category.

Priority estuary: An estuary that is required to meet targets for representing estuarine ecosystems, habitats and estuarine-dependent species, as identified in the National Estuary Biodiversity Plan.

Protected area: An area of land or sea that is formally protected by law and managed mainly for biodiversity conservation. This is a narrower definition than the IUCN definition, which includes areas that are not legally protected and that would be defined in South Africa as conservation areas rather than protected areas. Also see Conservation area.

Protected area target: A quantitative goal for how much of an ecosystem type should be included in the protected area network by a certain date. The National Protected Area Expansion Strategy 2008 sets five-year and twenty-year protected area targets for each terrestrial ecosystem type, based on a portion of its biodiversity target. Protected area targets are revised every five years.

Spatial biodiversity plan: A plan that identifies one or more categories of biodiversity priority area, using the principles and methods of systematic biodiversity planning. South Africa has a suite of spatial biodiversity plans at national and sub-national level, which together should inform land-use planning, environmental impact assessment, water resource management, and protected area expansion.

Species of special concern: Species that have particular ecological, economic or cultural significance, including but not limited to threatened species.

Systematic biodiversity planning: A scientific method for identifying geographic areas of biodiversity importance. It involves: mapping biodiversity features (such as ecosystems, species, spatial components of ecological processes); mapping a range of information related to these biodiversity features and their ecological condition; setting quantitative targets for biodiversity features; analysing the information using software linked to GIS; and developing maps that show spatial biodiversity priorities. The configuration of priority areas is designed to be spatially efficient (i.e. to meet biodiversity targets in the smallest area possible) and to avoid conflict with other land and water resource uses where possible.

Systematic conservation planning—see Systematic biodiversity planning.

Threatened ecosystem: An ecosystem that has been classified as critically endangered, endangered or vulnerable, based on an analysis of ecosystem threat status. A threatened ecosystem has lost or is losing vital aspects of its structure, function or composition. The Biodiversity Act allows the Minister of Environmental Affairs or a provincial MEC for Environmental Affairs to publish a list of threatened ecosystems. To date, threatened ecosystems have been listed only in the terrestrial environment. In cases where no list has yet been published by the Minister, such as for all aquatic ecosystems, the ecosystem threat status assessment in the NBA 2011 can be used as an interim list in planning and decision-making. Also see Ecosystem threat status.

Threatened species: A species that has been classified as Critically Endangered, Endangered or Vulnerable, based on a conservation assessment (Red List), using a standard set of criteria developed by the IUCN for determining the likelihood of a species becoming extinct. A threatened species faces a high risk of extinction in the near future.

Tributaries: Smaller rivers that feed into the main river within a quaternary catchment. Also see Main river.

Vulnerable ecosystem: An ecosystem type that still has the majority of its original extent (measured as area, length or volume) left in natural or near-natural condition, but has experienced some loss of habitat or deterioration in condition. The ecosystem type is likely to have lost some of its structure and functioning, and will be further compromised if it continues to lose natural habitat or deteriorate in condition.

This report presents the results of South Africa's National Biodiversity Assessment 2011. The NBA 2011 follows on from the National Spatial Biodiversity Assessment 2004, broadening the scope of the assessment to include key thematic issues as well as a spatial assessment. It fulfils a core aspect of SANBI's mandate: to monitor and report on the state of South Africa's biodiversity. The assessment covers the terrestrial, freshwater, estuarine and marine environments, as well species of special concern and invasive alien species.

The NBA provides headline indicators of the state of South Africa's ecosystems, and highlights the crucial role of ecological infrastructure in providing ecosystems services that underpin social and economic development. It presents new work on geographic areas that contribute to climate change resilience, and reflects the enormous progress made since 2004 in mapping and assessing biodiversity in aquatic environments. It includes a summary of spatial biodiversity priority areas that have been identified through systematic biodiversity plans at national, provincial and local level.

The NBA is led by the South African National Biodiversity Institute in partnership with a range of organisations. It represents a collaborative effort to translate best available science into policy-relevant indicators and information that can inform action and support wise decision-making in the biodiversity sector and beyond.

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