



Chapter 4 Land

At a glance

This chapter focuses on three important land issues: Land use and productivity, access to land, and land degradation. The major agents of land cover change are discussed in relation to agricultural potential and the level of arable and livestock production. The chapter then highlights the major challenges faced in ensuring the sustainability of the land reform programme for improving access to land resources. It discusses the current state, causes, and consequences of land degradation, and how society is responding to the issue.

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4.1 INTRODUCTION

South Africa is a dry country (although with pronounced spatial and temporal variability), with an east–west rainfall gradient, ranging from more than 1 000 mm to less than 250 mm per year. Land in South Africa has enormous economic, social, and environmental value, but a large proportion of the country’s land surface is susceptible to degradation^{1, 2}.

South Africa covers an area of 121.9 million hectares (ha), of which over 80% (100 million ha) is used for agriculture³, but the country’s agricultural potential is low relative to that of North America and Europe⁴. The agricultural sector is diverse, ranging from an intensive, large-scale commercial agricultural sector to a low-intensity, small-scale, and subsistence farming sector, and its contribution to gross domestic product (GDP) has declined dramatically from 23% in 1920 to only 3.1% in 2003⁵. The sector’s true importance to the economy is much greater when one considers its upstream and downstream linkages to the manufacturing and marketing of inputs and equipment, on the one hand, and the food processing and manufacturing sectors based on agricultural produce on the other⁶. Some six million people depend on agriculture for their livelihoods. Close to a million are employed as farm workers, while the smallholder agricultural sector provides employment for approximately 1.3 million households. Further, a large proportion (approximately 43%) of South Africa’s 46 million people lives in rural areas and depends on natural resources for its livelihood.

Land rights and access to land resources make up one of the most important social and political issues in South Africa today. Communal and freehold commercial land ownership constitutes the two main systems of land tenure in South Africa. Pre-1994 land policies of separate development led to the crowding of black people into the so-called ‘bantustans’ or ‘homelands’. High population densities in many of these areas resulted in over-utilization of the land. Communal areas are used (under freehold title in rare cases, or by traditional tenure or rental) for residence and for producing crops and livestock for subsistence purposes or for sale in local markets. These communal areas have a long history of environmental and political neglect⁷ and most are characterized by overgrazing and soil erosion, with livestock numbers 1.85 times higher on average than the estimated carrying capacity. For the most part, commercial farms are privately owned by white farmers.

4.2 LAND USE AND AGRICULTURAL PRODUCTIVITY

4.2.1 Land use and transformation

Land use profoundly influences the productivity and condition of land, as well as its biodiversity integrity (see Box 4.1). Land-cover change, which reflects an underlying change in land use⁸, is therefore an important indicator of the condition of terrestrial ecosystems.

A large proportion (approximately 43%) of South Africa’s 46 million people lives in rural areas and depends on natural resources for its livelihood.

Table 4.1: Area and percentage land-cover categories in 2000

Land-cover category	Area (hectares – millions)	Percentage (%)
Bare and degraded areas	5.45	4.47
Cultivated areas	12.76	10.46
Grasslands	24.30	19.92
Indigenous forests	0.52	0.43
Mines	0.20	0.17
Forest plantations	1.72	1.41
Shrublands and herblands	42.27	34.66
Urban areas	1.85	1.51
Waterbodies	0.68	0.55
Wetlands	0.87	0.72
Woodlands and bushlands	31.34	25.70
Total	121.96	100.00

Source: Calculated from the National Land Cover (NLC) 2000 map



Patterns of land cover derived from high-resolution satellite imagery in 2001/2002 in South Africa are shown in Map 4.1, while Table 4.1 gives the areas and proportional cover for specific land-cover classes. It is estimated that close to 18% of South Africa's natural land cover is transformed, mainly by cultivation (10.46%), degradation of the natural cover (4.47%), urban land use (1.51%), and forestry (1.41%)^a.

The following points summarize the major area statistics of selected land-cover classes:

- Of the 12.76 million ha of cultivated areas in South Africa, nearly 10.45 million ha (82%) are worked for commercial purposes, 0.79 million ha (only 6.19%) are permanently under cultivation, and more than 10.83 million ha (85%) are rain-fed^b
- Over 0.7 million ha of land are degraded and left bare by soil erosion (sheet and gully erosion); 4.61 million ha of natural vegetation are degraded, mainly in indigenous forests, woodlands, and grasslands; a further 0.19 million ha are degraded by mine tailings, waste rock dumps, and surface-based mining
- Urban areas comprise mainly formal residential suburbs and townships (1 million ha) and informal settlements (0.23 million ha)

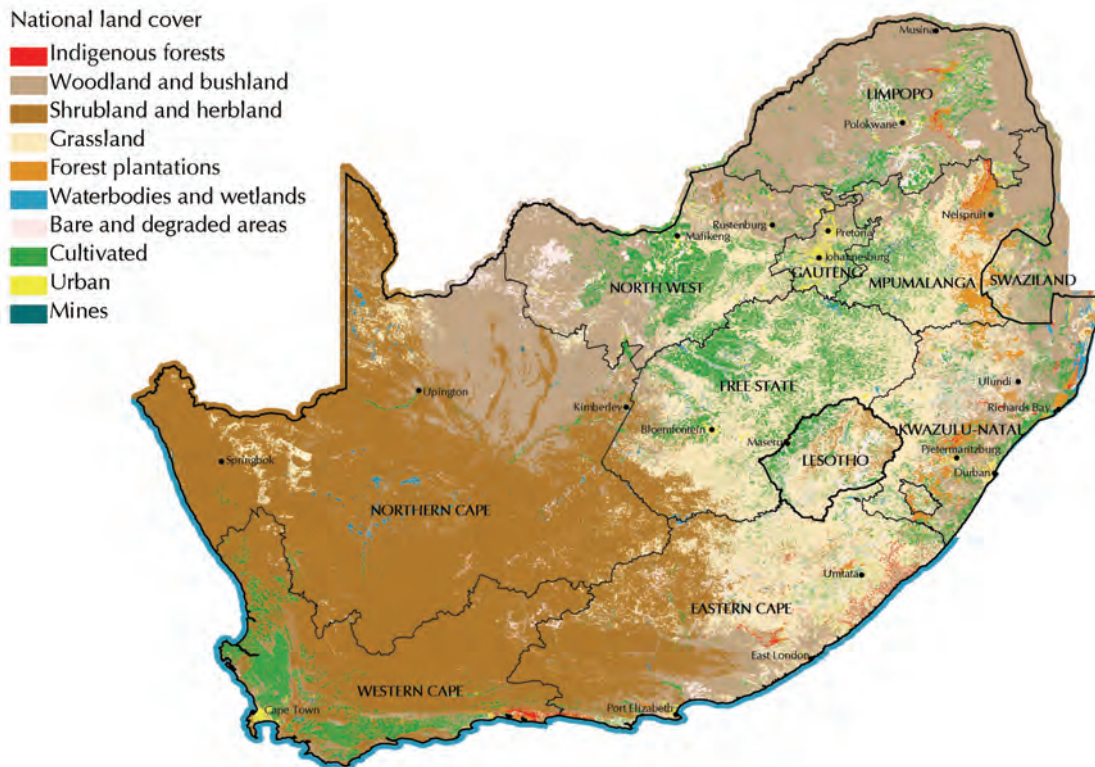
- Savannas (woodlands and bushlands) and grasslands cover 25.70% and 19.92% of South Africa, respectively.

4.2.2 Agricultural production systems

Arable production

Although 80% of South Africa's land surface area is used for agriculture and subsistence livelihoods, only about 11% has arable potential. The remaining 69% is used for grazing¹². Areas of moderate to high arable potential occur mainly in the eastern part of the country, in Mpumalanga and Gauteng (see Map 4.2). Scattered patches also occur in KwaZulu-Natal, the Eastern Cape, and Limpopo. Low to marginal potential areas occur in the eastern half of the country and in parts of the Western Cape. Map 4.2 shows large areas in the drier parts of South Africa that are being cultivated (for example, in the southwestern Free State, the western parts of the Eastern Cape, and the North West Province), but that are not classified as having any potential for arable agriculture. Repeated crop failure and subsequent abandonment of these less than marginal lands can have important consequences for soil erosion and land degradation.

Although 80% of South Africa's land surface area is used for agriculture and subsistence livelihoods, only about 11% has arable potential. The remaining 69% is used for grazing.



Map 4.1: Land-cover in South Africa in 2000

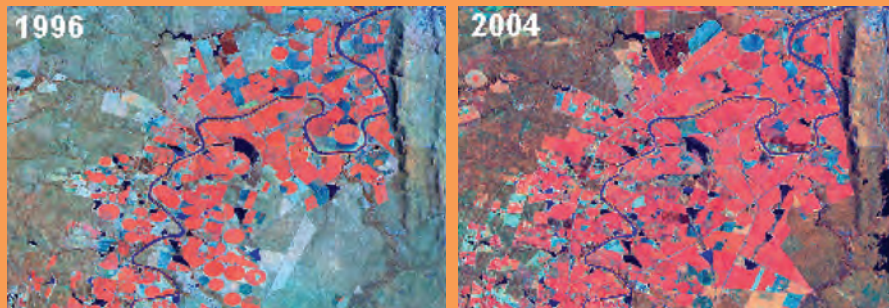
Source: Council for Scientific and Industrial Research and Agricultural Research Council: National Land-cover 2000 (NLC2000)⁹

Box 4.1 Trends in cultivation and afforestation in South Africa

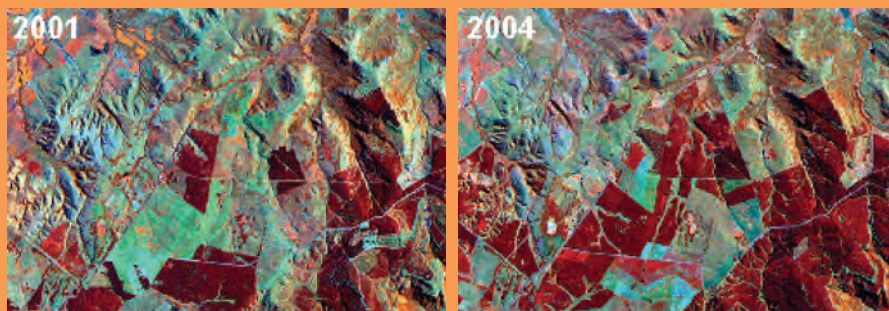
A detailed analysis of land cover change in South Africa from 1911 to 1993 was conducted in 2002 by R. J. Scholes and R. Biggs of the Council for Scientific and Industrial Research. Their study focused on cultivation and afforestation as agents of land cover change. The following points summarize the analysis.

- Cultivated land more than tripled in area during this period – most of the expansion took place up to the 1960s, when it reached a plateau and started to show increased variability, owing to the sporadic cultivation of marginal lands. Much of the expansion took place in the wetter parts of the country (eastern and southern areas), so the impacts have been borne by the highveld grasslands and the southern fynbos.
- Timber plantations increased more than tenfold, mainly after the Second World War.

Satellite images taken at different dates are a simple means for identifying changes in land-cover. The images below show the expansion of irrigated sugar cane and commercial forest plantations, which comes at the expense of natural vegetation. The cultivation shown in the 2004 image requires much more water for irrigation and tree growth than that in the 1996 image.



Satellite imagery showing the expansion of sugar cane cultivation along the Nkomati River, Komatipoort, Mpumalanga Province (red areas denote irrigated fields, blue-green denotes natural vegetation, blue denotes water or fallow fields).



Satellite imagery showing the expansion of commercial forestry near Belfast in Mpumalanga Province (red denotes plantations, blue-green denotes natural vegetation)

The area planted with the major field crops of maize and wheat has declined significantly since 1987. The area under maize cultivation declined from about 4.1 million ha to about 2.9 million ha (that is, by 1.2 million ha or 29%) while that under wheat cultivation declined from about 1.9 million ha to about 0.9 million ha (that is, by 1.0 million ha or 53%)¹³. There have been no major long-term shifts for other field crops. Especially in the drier parts of the country, many farmers have been searching for alternative forms of revenue to field crops and livestock farming⁶, which in part explains the decrease in area planted. Nevertheless, total

maize production has increased as farmers adjusted to a more competitive environment (resulting from increased costs and reduced subsidies) by using resources more optimally and improving yields by adopting new technologies and crop varieties. Average maize yields increased from 1.7 tonnes per ha ($t \cdot ha^{-1}$) in 1987 to $3.3 t \cdot ha^{-1}$ in 2004, while wheat yields increased from $1.2 t \cdot ha^{-1}$ in 1985 to $2.1 t \cdot ha^{-1}$ in 2004.

The above trends point to an intensification of agriculture, with increasing inputs to the land (such as fertilizers and irrigation), so fertilizer application rates may

play a role. Despite limited data, specifically for fertilizer application rates for maize and wheat production, it is estimated that more than two million tonnes of fertilizer are applied annually to South African soils. Fertilizer sales have increased in South Africa over the medium term, with sales peaking in 1980, dropping from 1980 to 1985, and increasing since then (see Figure 4.1). Higher yielding crop varieties and increased pest control might also partially explain the increased production. Despite the desirable increase in productivity, intensification of agriculture can have undesirable environmental consequences. It leads to impacts on biodiversity that tend to be localized, as opposed to extensification (expansion of areas under cultivation), which leads to habitat loss on a larger scale⁸. The effects of increased fertilizer runoff on water systems can however, be extremely significant.

Livestock production

Approximately 69% of agricultural land in South Africa is used for extensive grazing because it is unsuitable for more intensive uses. Total animal production has been increasing since 1975. Areas used for grazing declined in the 1990s owing to expanding human settlements and activities (such as crops, forestry, conservation, and mining)¹⁵. This decline

was most notable in Gauteng and the Western Cape, with their high rates of urbanization, but communal districts also lost grazing lands.

The long-term grazing capacity of South Africa, based on 13 years of satellite data¹⁶, is shown in Map 4.3. Grazing capacity is clearly related to rainfall, with an east-west decrease in grazing capacity across the country.

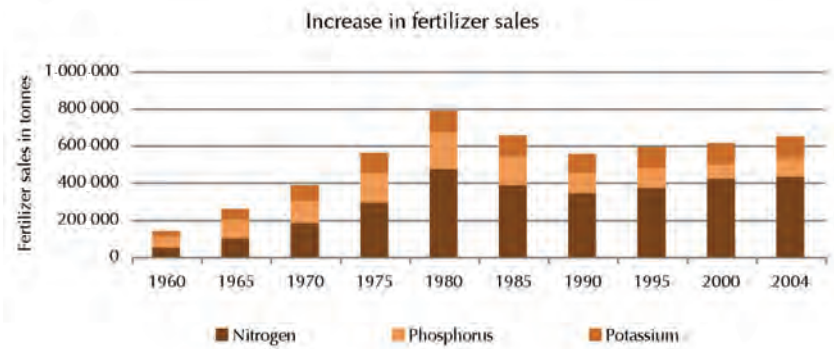
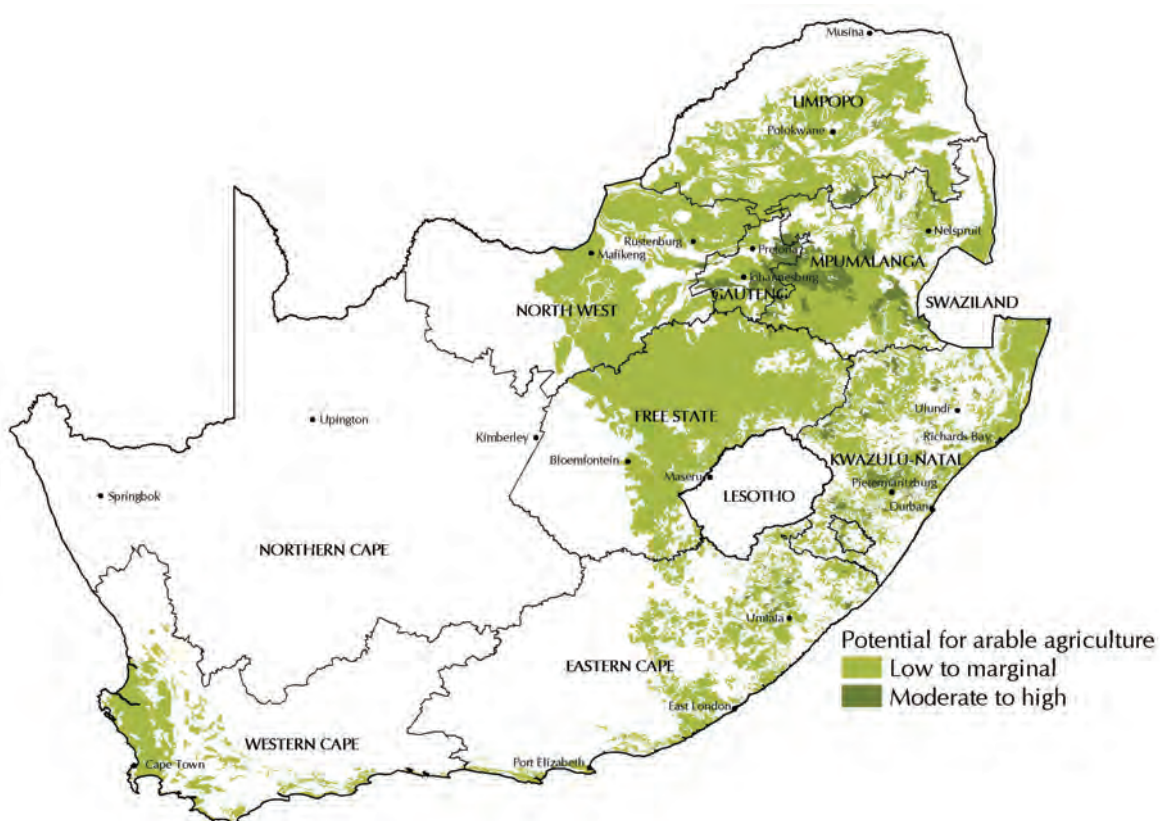


Figure 4.1: Fertilizer sales in South Africa, 1960–2004

Source: Fertilizer Society of South Africa (2005)¹⁴



Map 4.2: The distribution of arable potential in South Africa

Source: Classification by the Agricultural Research Council – Institute for Soil, Climate & Water

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Box 4.2 Patterns of wildfires across Africa in 2005

Each year, people set fire to African landscapes to create and maintain farmland and grazing areas. They use fire to keep unwanted plants from invading crop or rangeland, to drive grazing animals away from areas more suitable for crops, to remove crop stubble and return nutrients to the soil, and to convert natural ecosystems to agricultural land. The burning area shifts from north to south over the course of the year, in step with the continent's rainy and dry seasons.

The series of images below shows Africa's seasonal fire patterns from January to August 2005. The images are based on fires detected by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra and Aqua satellites. Each image is a composite of 10 days of fire detections (marked in red and yellow) made by the sensors. Each coloured dot indicates a location where MODIS detected a fire during the compositing period. When MODIS detected a fire at a location only a few times during the 10-day period, the area is marked in red. When MODIS detected a fire at that location many times, the area is marked in yellow.

The series of images begins with the first 10 days of 2005, when fires were widespread across the area just south of the Sahara that includes both the Sahel (a semi-arid zone of transitional vegetation between the Sahara and the rainier savannas to the south) and savannas. From January to early March the yellows fade, indicating fewer fires at those northern locations; an exception to this gradual tapering off is on the coast of West Africa, in the region of Guinea and Senegal. Meanwhile, the number of fires is on the rise in the equatorial forests in the heart of the continent. By late May, the number of northern fires had greatly reduced and, by late July, burning in the Sahel and northern savannas had dropped off almost completely, while southern Africa was ablaze.



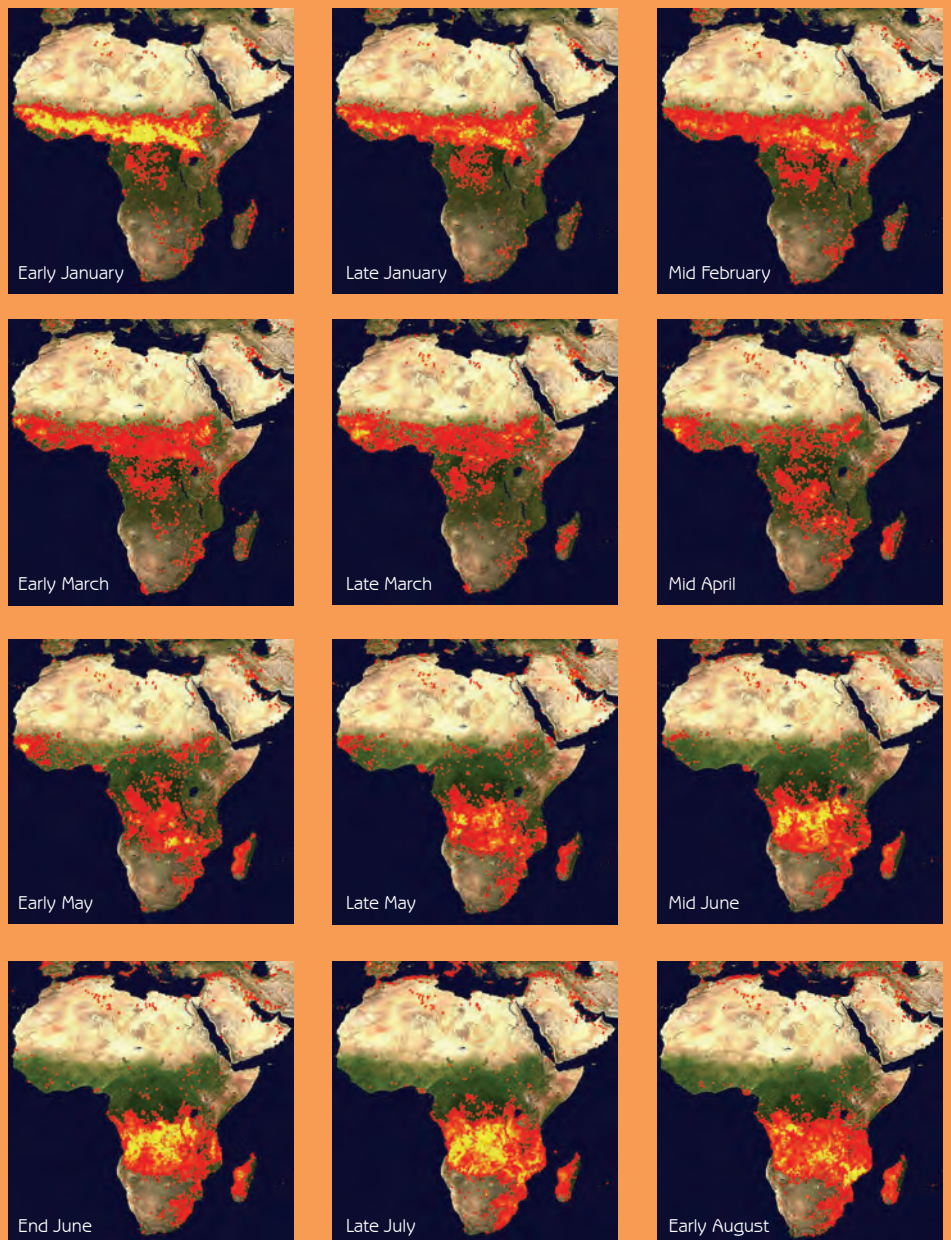
Raging fires at the top of Table Mountain.
Photography: IMAGES24.co.za / Die Burger

Although fires are a part of the natural cycle of the seasonally dry grasslands and savannas of the continent, ecologists, climatologists, and public health officials are concerned about Africa's intense burning. The frequency with which fires return to previously burned areas helps to determine the species of plants (and therefore animals) that can survive. When the fire-return interval is too short, the land may become degraded and unusable for farming or grazing. In semi-arid areas, land degradation through overuse of fire or through overgrazing can create pockets of desert. The massive burning that occurs in Africa each year creates carbon dioxide and

aerosol particles, both of which play a role in global climate change. Finally, the smoke and accompanying gases and particles create a public health hazard; during an area's burning season, the amounts of ground-level ozone and other air pollutants can become hazardous to human health (see Chapter 8, section 8.2.2).

In South Africa, about 1.18% of the country's land surface is burnt every year. In the period 1997–2000, 10 603 fires burnt 14 206 km² of land⁴⁸.

http://earthobservatory.nasa.gov/Newsroom/NewImages/images/images.php3?img_id=17016



The comparison of annual stocking rates (for cattle, sheep, and goats) over the past 14 years with long-term grazing capacity shows that total stocking densities in all provinces exceed the long-term grazing capacity of the veld. This is important, considering that one of the main drivers of desertification is thought to be long-term herbivory at greater levels than the productive potential of the landscape can support⁸. Cattle numbers have increased by nearly 1 million head from 12.6 million in 1994 to 13.5 million in 2004^{12,c}. With the exception of the Limpopo, the Northern Cape, and the Western Cape, stocking density (excluding game species) has increased or remained the same in all provinces in South Africa since 1994. There are, however, enormous differences in stocking rates between communal lands and commercial farming areas. Overstocking is generally most evident in provinces with large areas of communal rangelands, namely in the Eastern Cape, North-West, KwaZulu-Natal, Limpopo, and Mpumalanga.

It is important to note that the management objectives of communal farmers are often different from those of commercial farmers. Communal farmers use animals for meat, milk, ritual slaughter, bridal payments, and many other things¹⁵, so as many animals as possible are often kept on the veld, irrespective of their quality. This often results in higher than recommended stocking densities, and the communal rangelands are regarded as South Africa's most degraded areas².

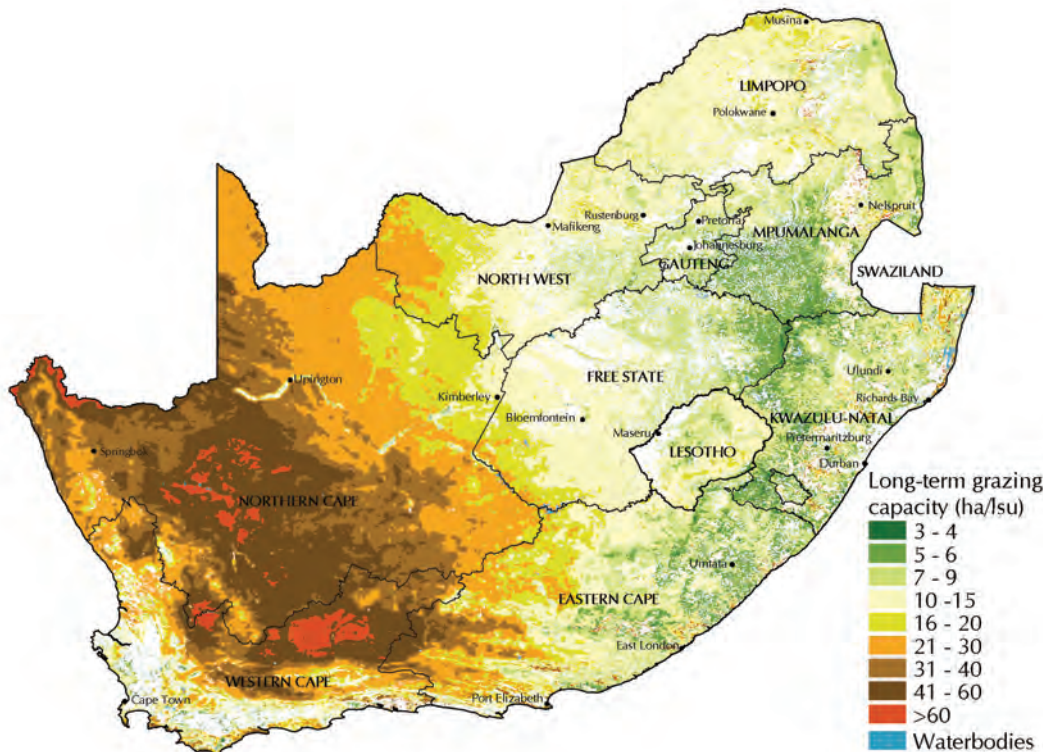
Food production

One of the biggest challenges to African development is to maintain food self-sufficiency in the face of increasing human populations, static or degenerating agricultural production, and environmental degradation. In South Africa, total food production for the country is not the primary determinant of food security¹⁷ (particularly in rural areas where smallholder food production in small home gardens and larger plots plays a larger role¹⁸). Nevertheless, trends in production relative to population growth indicate whether or not agricultural expansion and intensification are necessary to feed the country's growing population. Trade-offs would be needed between environmental well-being and agricultural expansion and intensification but, given South Africa's limited agricultural potential and water resources, further expansion will be limited.

Total food production in South Africa has increased over the last 40 years, mainly through improvements in productivity, but the production per capita in South Africa and SADC countries is declining (see Figure 4.2).

There have been large drops in production (notably, 1981–1983 and 1989–1993) that coincided with major droughts followed by periods of recovery. But these recovery periods have not been sufficient for food production to keep up with population growth. This could become an

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Map 4.3: Long-term grazing capacity (hectares/large stock unit)

Source: Morgenthal et al. (2004)¹⁶



Drought is a serious concern for South African farmers, and many use irrigation systems. *Photography: Wilma Strydom*

climate change and current climate variability on agricultural productivity may oblige the country to import more agricultural and food products to meet increasing demand. The value of agricultural imports has increased significantly in the last 40 years to nearly R14 billion in 2003¹², with 1 189 and 35 million tonnes of wheat and barley, respectively, having been imported in 2004²⁰. Wheat is now imported every year, and, in times of drought, large sums are spent on maize imports. The value of exports has also increased, however (from R372.5 million in 1975 to R23 000 million in 2003¹²).

4.3 ACCESS TO LAND AND LAND RIGHTS

Access to land is one of the region's most socially and politically sensitive issues²¹. Recent incidents and developments, such as the land invasions in Zimbabwe, the Land Summit held in July 2005 in South Africa, the first expropriations of South African farming land for restitution purposes, and the debate around foreign land ownership, have raised the public profile of this topic. The dispossession and forced removal of people during previous political dispensations resulted in large inequities in access to land and its resources, and insecurity of tenure for much of the population²².

An estimated 28% (13 million) of the population of South Africa is crowded in the former homeland areas (13% of the land, covering 15.86 million ha), where land rights are often unclear or contested and the system of land administration is disordered. The state legally owns most of this land and there have been several unsuccessful attempts to implement legislation^d for the reform of rights and administration of communal areas.

Many social, economic, and environmental consequences arise from this inequity and from government's responses. Overcrowding continues to put pressure on terrestrial resources including soil productivity and biodiversity, where unsustainable land use practices and lack of basic services (such as electricity and sanitation facilities) contribute to increased land degradation and desertification. Where there is no electricity, for example, wood is harvested for energy, which causes deforestation (particularly in areas of Limpopo such as Bushbuckridge, in KwaZulu-Natal, and in the Eastern Cape). Where there is no sanitation, soil and water can become contaminated.

On private farms, workers and their families face continued tenure insecurity and inadequacy or absence of basic services. It is estimated that nearly one million people have been evicted from farms since 1994²³. Most (77%) of these are women and children and, with little education and work experience, it is difficult for them to re-establish their lives in their places of relocation.

Growing urbanization is leading to the expansion of

Growing urbanization is leading to the expansion of informal settlements characterized by poverty, crime, lack of basic services, and lack of security of tenure.

area of concern as it may have an impact on food security, not only in South Africa, but in the region also.

Drought is a serious concern for many South African farmers, in both the commercial and subsistence sectors. Most (75%) of the country's maize production occurs in the Free State and North West provinces, both of which are regarded as semi-arid to arid, so, in the absence of continued external energy inputs (such as irrigation and fertilizers) and subsidies, most of the production can be considered marginal¹⁹.

Although South Africa is largely independent of agricultural imports or food aid, the potential impacts of

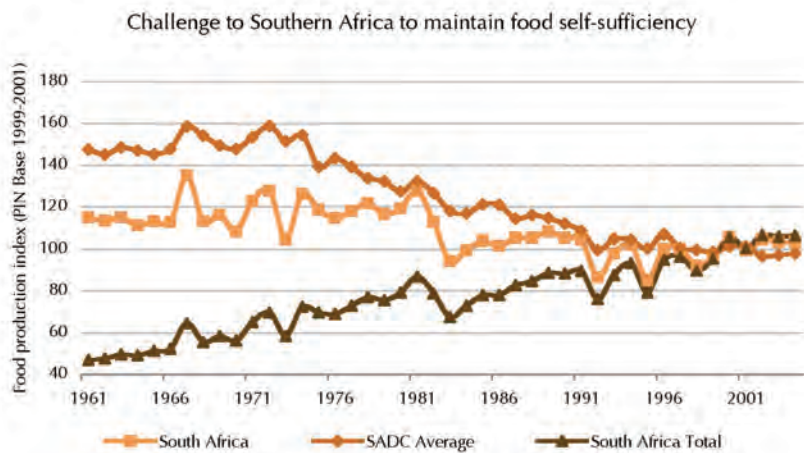


Figure 4.2: Food production index in South Africa and SADC countries relative to 1999–2001 base years

Source: Food and Agriculture Organization statistics <http://faostat.fao.org/>



informal settlements characterized by poverty, crime, lack of basic services, and lack of security of tenure²².

The government's land reform policy, set out in the 1997 White Paper on South African Land Policy, falls under the jurisdiction of the Department of Land Affairs (DLA). This policy uses a market-based, demand-driven approach²¹, which is currently under review. The policy has three components⁶: restitution, redistribution, and tenure reform.

- Restitution involves returning land or providing compensation to those who were dispossessed after 1913, and is being dealt with by the Land Claims Court and Commission established under the Restitution of Land Rights Act (No. 22 of 1994).
- Redistribution increases black ownership of rural land through discretionary grants allocated to people to acquire land through the market. It is being implemented through the Settlement/Land Acquisition Grant (SLAG), although, since 2001, the Land Redistribution for Agricultural Development (LRAD) programme has been implemented to promote commercial agriculture²¹ (based on the Provision of Land and Assistance Act [No. 126 of 1995]).
- Tenure reform improves the security of tenure of dwellers on rural and periurban land. The Extension of Security of Tenure Act (No. 62 of 1997) prevents illegal evictions from commercial farms and the Land Reform (Labour Tenants) Act (No. 3 of 1996) protects labour tenants from eviction.

A major political target is to ensure that 30% of agricultural land is transferred to black South Africans by 2014²⁴. Given the progress to date, delivery will have to increase fivefold to meet this target⁶. Land delivered (by restitution, redistribution, and tenure reform) by the end of 2004 amounted to 3.5 million ha, that is, only 4.3% of commercial agricultural land.

The Land Summit held in Johannesburg in July 2005 discussed progress on land and agrarian reform with stakeholders. The 'willing-buyer, willing-seller' policy of government, which was strongly criticized by some groups, has been discontinued and a policy of controlled expropriation has been adopted. Between July and October 2005, government expropriated six white-owned farms where negotiations over land prices had reportedly been unsuccessful.

An achievement of the land reform programme was the settling of nearly 73% of a total of about 80 000 claims by early 2005²⁵ (as shown in Figure 4.3), although these statistics should not be read as indicators of the contribution of restitution to agrarian reform²⁶. Of these claims, only 854 444 ha (representing less than 1% of commercial agricultural land) had been transferred by March 2005. Some 17 866 claims have still to be processed, of which 10 063 are urban and 7 803 rural. To date, 72% of claims

lodged are urban and 28% rural, indicating the urban bias of the restitution programme.

South Africa's land reform programme has had a limited impact on the redistribution of land, securing of tenure rights, reduction of poverty²⁸, or the development of sustainable, financially viable agrarian enterprises, and has not met the set targets^{6, 22}. In fact, most restitution settlements have involved 'cheque-book' or financial compensation rather than land, with some R2.4 billion having been paid out²⁶. The major reasons cited for the limited impact include inadequate budgets, despite the substantial increase in the restitution budget since 2001; the lack of capacity of state departments to support beneficiaries; and over-ambitious political target setting. There needs to be more focus on the high demand for land in urban and periurban areas^{6, 26}, as only an estimated 9% of blacks not currently farming seek to become farmers. Furthermore, the manner in which the land reform programme has been implemented (with the lack of post-settlement support, financial and otherwise) has often rendered land unproductive and fallow²⁹. Land redistribution that leads to sustainable, financially viable agrarian enterprises will be vital to relieve the pressure on land in communal areas and to improve the flow of benefits from what is often currently underutilized land, thus advancing rural livelihoods³⁴.

Some success relates to communities gaining access and rights to conservation areas and the consequent benefits³⁰. Examples include the following:

- The Maluleke community gained access to the northern Pafuri region of the Kruger National Park
- The Mier and the San communities were each awarded

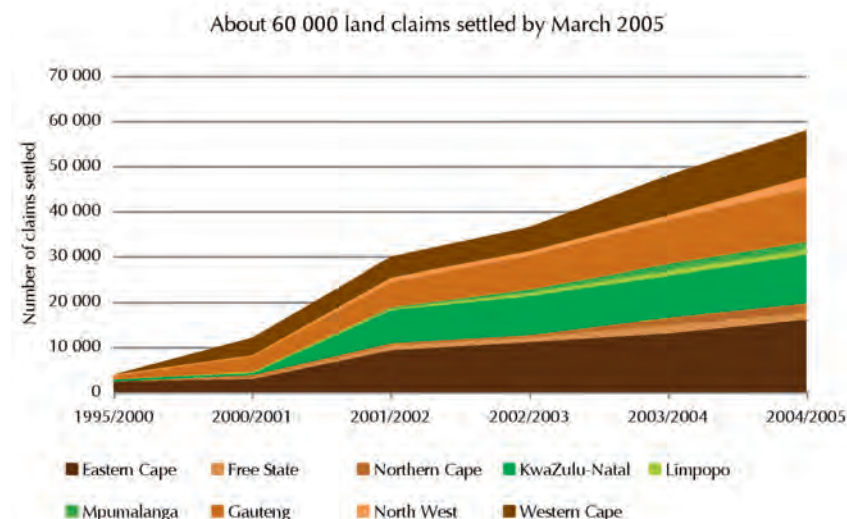


Figure 4.3: Progress made on the settlement of restitution claims, 1995–February 2005

Source: Commission on Restitution of Land Rights (2004)²⁷

Both degradation and desertification are important forms of land transformation and are among the world's – and South Africa's – most critical environmental issues, intricately linked to food security, poverty, urbanization, climate change, and biodiversity.

25 000 ha of land inside the South Africa section of the Kgalagadi Transfrontier Park

- The Mbangwani community was awarded 'ground title' to a 1 262-ha portion of the Ndumo Game Reserve.

There is widespread concern, however, regarding the quality of the development plans compiled for beneficiaries and their land, and the inadequacy of the 'post-settlement support' for communities once land has been transferred. An illustration is the above example of the Mier and San communities, where the San settlement subsequently disintegrated into a severely dysfunctional one, with farms in disarray²⁶.

It is generally recognized that sustainable land development, which in South Africa includes the land reform process, cannot be achieved without giving due consideration to both the biophysical and the socio-economic environment. In as far back as 1998, the Department of Land Affairs recognized the need to incorporate environmental planning in the land reform process. With support from the Danish Cooperation for the Environment and Development (DANCED), guidelines on the integration of environmental planning into land reform and land development were developed and published in September 2001; they were then tested in selected land reform projects in the eastern Free State and Mpumalanga. These guidelines are based on the principle that the sustainability of land reform is determined by the beneficiary's capacity to secure a sustainable livelihood from the land, which, in turn, is fundamentally dependent on the good planning and

management of existing natural resources. At the institutional level, the guidelines recommend that issues of environmental planning and land reform be dealt with thoroughly in the integrated planning process of district municipalities, and that land reform projects be implemented in accordance with those plans. These guidelines have now been confirmed as Department of Land Affairs policy.

4.4 LAND DEGRADATION AND DESERTIFICATION

In terms of the United Nations Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, particularly in Africa (UNCCD), to which South Africa is signatory, land degradation refers to the reduction or loss of biological or economic productivity of agricultural lands, woodlands, and forests that result mainly from human activities³¹. Desertification refers to land degradation in drylands^e that results from both climatic variability and human activities. Desertification occurs when several degraded patches of land expand and join to form large, unproductive areas. Thus, desertification occurs over a larger scale than land degradation and results in the 'permanent'^f loss of productivity and supply of ecosystem services^g.

Both degradation and desertification are important forms of land transformation and are among the world's – and South Africa's – most critical environmental issues, intricately linked to food security, poverty, urbanization, climate change, and biodiversity. Globally, desertification affects 70% of all drylands, and 73% of Africa's agricultural drylands are degraded¹⁵. As much as 91% of South Africa comprises drylands, making it susceptible to desertification. Furthermore, a large proportion of the population depends on livelihoods derived from the natural resource base.

South Africa has grappled with land degradation issues for over a century. Although the importance of desertification and its potential impacts on agriculture, food security, and biodiversity are acknowledged, there have been no comprehensive national-scale studies of land degradation and desertification trends.

The 1999 study by Hoffman *et al.*² is the only national one on land degradation. Based on the perceptions of more than 400 agricultural extension workers and resource conservation technicians, it is not, however, a quantitative analysis of observable measurements³². The patterns of degradation that it reports (while showing significant correlations with available measurements of degradation) are applicable only in a relative sense, and the study is difficult to repeat for monitoring purposes. It is therefore not yet possible to develop a clear picture of national trends since 1999, and it is hard to say with certainty whether or not the condition of land has improved, deteriorated, or remained the same. Although the Hoffman *et al.* data were



An aerial view of Port Alfred, one of the coastal areas where development is increasing.

Photography: South African Tourism

presented in the 1999 State of the Environment Report, a summary of the major findings and follow-up literature are presented below.

4.4.1 Levels of degradation

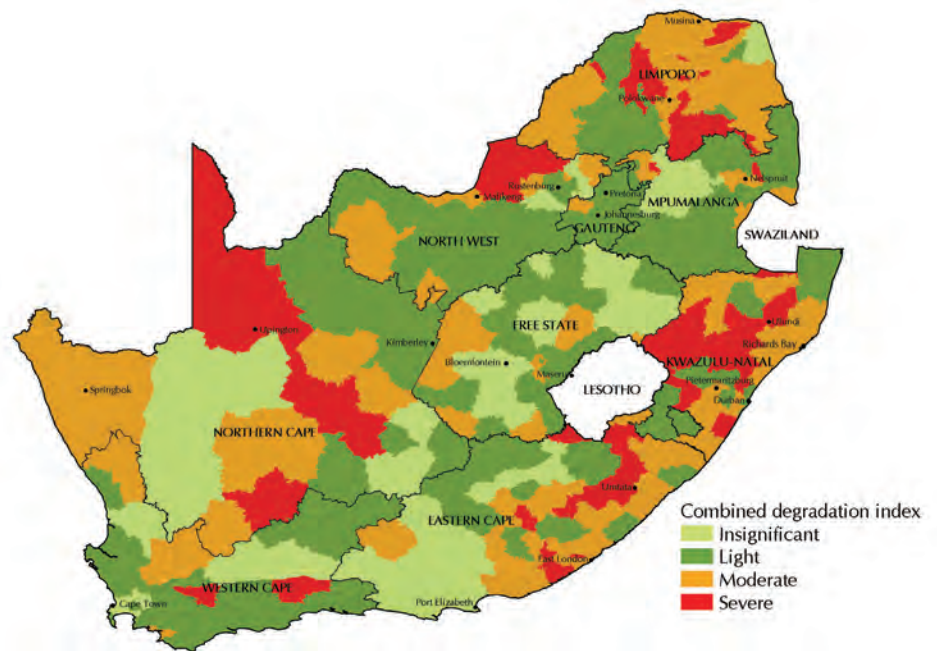
Areas of severe degradation (that is, degradation of both soil and vegetation) and desertification in South Africa are perceived to correspond closely with the distribution of communal rangelands, specifically in the steeply sloping environments adjacent to the escarpment in Limpopo, KwaZulu-Natal, and the Eastern Cape⁵⁵ (see Figure 4.4 and Map 4.4). Many communal areas in the Limpopo, North West, Northern Cape, and Mpumalanga provinces are also severely degraded. The commercial farming areas with the most severe degradation are located in the Western and Northern Cape provinces. Wind and water erosion are the major natural causes of soil degradation, while change in species composition, loss of plant cover, and bush encroachment are the most frequent forms of vegetation degradation².

4.4.2 Soil degradation

Soil degradation is most severe (and generally perceived to be occurring at an increasing rate) in most communal croplands, grazing lands, and settlements in South Africa¹⁵. Soil degradation in the form of sheet and gully erosion is estimated to cover an area of 0.72 million ha. As is the case worldwide, water erosion is also South Africa's most widespread soil degradation problem and affects 70% of the land¹⁵. Estimates in the Peddie District in the Eastern Cape show an increase of 12–13% and 2–6% in sheet and gully erosion, respectively, between 1938 and 1988. About 25% of South Africa is highly susceptible to wind erosion and, by 1985, an estimated 2.2 million ha were severely affected by it³⁵. One of the areas particularly prone to wind erosion is the western half of the summer rainfall cropland in the western Free State and the greater part of the North West province.

Relative to overall global conditions, South Africa has more widespread and serious physical soil degradation, in the form of crusting (surface sealing) and soil compaction. Crusting is becoming an increasing problem in overgrazed, bare patches and where there is overhead and micro-irrigation, and it continues to be a serious problem in the rainfed, grain-producing areas of the Western Cape⁴. Farmers in the western summer rainfall areas are successfully combating subsurface soil compaction, caused by intensive mechanization, but elsewhere it remains a concern. Serious soil compaction problems in high-potential cropland in Mpumalanga are caused by opencast and strip coal mining, and soil compaction is also a problem in forestry areas.

Quantitative national-scale data on chemical soil degradation are scarce. Soil acidification, caused by



Map 4.4: The distribution of land degradation in South Africa as represented by the Combined Degradation Index

Source: Hoffman et al. (1999)²

chemicals, is a major widespread soil degradation issue in South Africa and it is on the increase, especially in low-income cropping areas^{4, 15}. The mining and coal-burning industries (primarily the electricity generation activities) in Gauteng and Mpumalanga cause acidification and pollution of soils (see Chapter 8, section 8.2.6). Soil fertility degradation is serious in small-scale farming areas and also in some commercial cropping areas^{4, 15}.

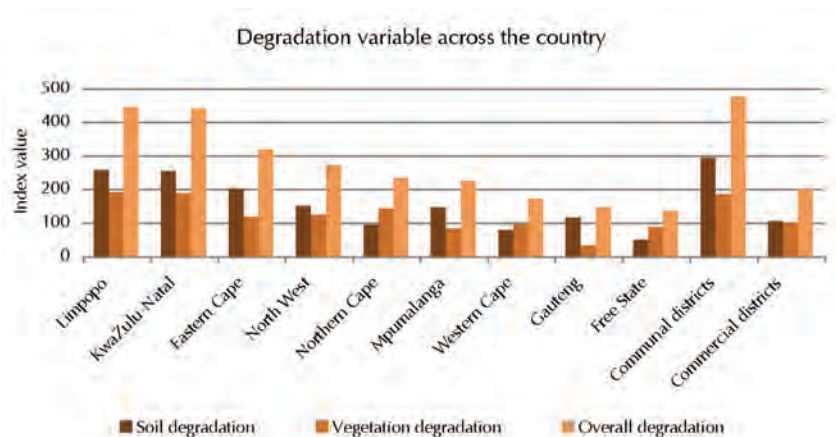


Figure 4.4: Levels of soil, vegetation, and overall degradation in South Africa

Source: Hoffman et al. (1999)²

Alien plant invasion is one of South Africa's most critical environmental issues and an important contributor to vegetation degradation and loss of productivity of land.

4.4.3 Vegetation degradation

The areas with the highest rates of vegetation degradation are the provinces of Limpopo and KwaZulu-Natal and the communal areas of the Eastern Cape. They have high proportions of grazing lands and experience problems of decreased vegetative cover, bush encroachment, alien plant invasions, and changes in species composition. Shrub and bush encroachment is also severe in the dry areas of the Northern Cape, the western parts of North West, and the southern and southwestern Free State, mainly on privately owned or state-managed land.

Alien plant invasion is one of South Africa's most critical environmental issues and an important contributor to vegetation degradation and loss of productivity of land. (For the status of invasion, see Chapter 5, section 5.5.)

Deforestation is a significant form of vegetation degradation in several districts of Limpopo, in KwaZulu-Natal, and in the Eastern Cape³⁴, and it is on the increase in communal areas in these provinces. It results from the clearing of trees for cultivation, settlement, or the use of wood and non-wood forest products, and large areas of woodland (estimated at 1.2 million ha) have been converted to fields and settlement sites. The deforestation of closed forests is less extensive but remains a threat to some forest types.

4.4.4 What causes land degradation?

The causes of degradation and desertification include socio-economic, biophysical, climatic, and land-use factors, and the interactions between them³⁵. Large areas of South Africa have soil parent materials (geology) that produce soils inherently vulnerable to various forms of soil degradation, such as crusting, compaction, and water and wind erosion. Once eroded, most of these soils also have very low resilience (recovery potential)³⁵. The low, unreliable, and aggressive rainfall aggravates the situation³⁵.

Demographic and economic factors related to historical land policies and inappropriate land uses, superimposed on these vulnerable resources, are major contributors to the high levels of land degradation in South Africa, especially in the former 'homeland' areas. High unemployment, number of dependants per household, rural population, and area of human settlements are very likely the most important socio-economic factors influencing soil degradation in these areas. Biggs *et al.* (2004)³⁵ relate the correlation of degraded areas with communal areas to overstocking, while Boardman *et al.* (2003)³⁶ found similar problems in commercial grazing systems in the Central Karoo. The main cause of desertification in some areas is thought to be long-term herbivory at levels greater than the productive potential that the landscape can support (>200%).

Elsewhere, poor land-suitability evaluations, particularly in the 'betterment' schemes, resulted in the delineation of arable areas where poor soil quality, unstable soils, and inappropriately steep slopes³⁷ were to be found. ('Betterment' planning, implemented in the former homelands from the 1930s onwards, was an attempt to regulate these areas and control land usage. Under betterment, designated areas were divided into distinct land-use zones for residential, arable, and grazing usage, and all people were forced to move into the residential zones. Furthermore, through betterment, people were also dispossessed of arable and grazing land.)

Climatic conditions, specifically drought and variability of rainfall, have also played a fundamental role in land degradation. Unreliability of rainfall is especially high in semi-arid subtropical regions such as South Africa³⁴. The annual coefficient of variationⁿ of rainfall in South Africa varies from 20% in the more humid eastern parts of the country to more than 40% in the arid west. This high variability is partly due to the influence of the El Niño Southern Oscillation (ENSO) phenomenon, a quasi-periodic fluctuation in the world's climate, which brings alternating droughts and wet periods to southern Africa. Prolonged (>2 years), severe, region-wide droughts (over more than 50% of each of the countries affected) have been experienced in South Africa approximately once every



Large areas in South Africa are degraded due to land use at levels greater than productive potential. *Photography: South African Tourism*

18–20 years over the historical record. Periods of increased degradation coincide with periods of prolonged drought. Rather than being an unusual event, drought is something to be expected in South Africa, and persistent 'emergency' drought relief to certain areas indicates the demands being placed on the country's natural resources beyond their capacity to fulfil them, which may be either a symptom or a cause of land degradation.

The uses and management of land profoundly affect soil erosion, with arable agricultural uses (notably the pineapple industry in the Eastern Cape, and maize and cassava there and elsewhere) leading to the largest soil losses³⁸. Commercial forestry increases sediment production and gully erosion in plantations in the southern Cape area, while land preparation for tree planting in the KwaZulu-Natal midlands has substantially increased soil loss. Severe soil erosion occurs in the smaller game parks and nature reserves, notably on sandstone areas such as the Waterberg or granite areas such as the Mpumalanga lowveld and the Limpopo Province. There, vegetation degradation is caused by overgrazing on vulnerable soils carrying palatable sweetveld, as well as by incorrect browser: grazer ratios.

Mining is also an important contributor to land

degradation. Mine wastes cover over 200 000 ha in South Africa, and are concentrated in the Gauteng, Mpumalanga, Limpopo, North West, and Northern Cape provinces. These wastes lead to loss of soil productivity through loss of soil fertility and contamination from acid mine drainage. In addition, soil becomes unproductive owing to subsidence above shallow mining operations, open cast operations, and lowered water tables.

4.4.5 The costs and consequences

Land degradation undermines the productive potential of land and water resources, so the consequences are considerable and diverse in terms of the goods and services provided by natural ecosystems (see Box 4.3), and it directly affects human welfare as well as the protection of biodiversity.

Degradation of catchment areas results in the deterioration of the quality, quantity, and ecological integrity of surface water resources, including rivers, dams, and estuaries. More specifically, soil erosion results in sedimentation of dams, while increased invasion by alien species has serious impacts on stream flows, land

Despite electrification drives, fuel wood is still the main source of energy of an estimated 75% of rural families.

Box 4.3 The consequences and costs of degradation and desertification in South Africa

- **Soil erosion** costs an estimated R2 billion annually including off-site costs for purification of water whose poor quality is caused by the siltation of dams. Soil loss is partly responsible for farmers' abandoning the land in many areas, especially in the former homelands.
- The **loss of nutrients** from soils costs an estimated R1.5 billion annually. The commercial farming sector spends more than R2 billion a year on fertilizers. The subsistence farming sector in many instances cannot afford this cost and operates with inadequate fertilization. In both cases, improved land management practices would result in reduced loss of fertility and more effective use of natural soil fertility.
- Land degradation causes **loss in grazing and arable potential** – 10 million ha of rangeland are moderately to severely degraded by bush encroachment, while loss of topsoil through erosion and mining makes commercial farming financially unviable in many areas.
- Invasion of lands by alien plants results in an estimated 7% **decrease in water runoff**, threatens biodiversity, and lowers productivity of agricultural lands. The reduction in available water will double in 15 years if no decisive action is taken.
- **Poor water quality** is a consequence of several factors, including high silt and nutrient load from accelerated erosion, nutrient load from excessive fertilization, pollution from mining and industry, and poorly maintained sanitation systems.
- **Loss of wood fuel and other non-timber products:** Despite electrification drives, fuel wood is still the main source of energy of an estimated 75% of rural families. In addition, the rural poor as well as urban households use a wide array of woodland products, including medicines, with an estimated value of R5 500 per household per year. Access to these resources is declining because of land degradation, and the impact of this decline is most severe for the poorest of the poor. A 1% decline in access to this resource represents a total loss of about R150 million per year.
- **Lower land productivity** affects food security, specifically in areas of subsistence agriculture, where people are more vulnerable to climatic variability.
- There is **reduced rural productivity** because more time is needed to access resources such as fuel and water.
- **Severity of flooding** is linked directly to soil and vegetation degradation, particularly surface crusting, compaction, and loss of vegetation cover; these symptoms of degradation and desertification allow less water to seep into the soil so more flows over the surface of the land, causing flooding.
- **Degraded landscape quality** leads to loss of tourism potential.

Adapted from: Department of Environmental Affairs and Tourism (2004), South Africa's National Action Programme to Combat Land Degradation and Hoffman and Ashwell (2001)



Alien plants seriously affect stream flow and biodiversity.

Photography: Wilma Strydom

that desertification costs the world US\$42 billion a year¹⁵. In South Africa, about 35% of the country's net agricultural income is overstated because the environmental costs are not currently included in the accounts. Soil degradation alone costs South Africa an average of nearly R2 billion annually in dam sedimentation and increased water treatment costs, for example¹⁵. The costs associated with neutralizing the effects of acid rain (caused by energy generation) on soils in Mpumalanga are estimated at R25 million per year, while the loss of soil nutrients through degradation costs R1.5 billion per year.

4.4.6 Combating land degradation

The challenge for South Africa and the region is to utilize land sustainably, so as to feed, house, and sustain a growing population and economy, as well as to protect our natural heritage (see Box 4.4). The need for sustainable land management exists within the context of limited water resources, an increasingly variable climate, greater competition for land by different land uses (notably for the development of human settlements on the periphery of urban areas), and severe degradation in many areas. Both the Johannesburg Plan of Implementation and the Environmental Initiative of the New Partnership for Africa's Development (NEPAD) emphasize the need for sustainable land management. Key to sustainable land use is recognition of the cross-cutting nature of the land resource. The following summaries highlight South Africa's main major responses to degradation.

United Nations Convention to Combat Desertification, and National Action Programme

South Africa became a signatory to the United Nations Convention to Combat Desertification (UNCCD) in 1995 and ratified it in September 1997. The UNCCD is the key global policy instrument to address land degradation and poverty in arid, semi-arid, and dry sub-humid parts of the world. Following the requirements of the UNCCD, South Africa prepared a National Action Programme (NAP) for combating desertification, which Cabinet approved in 2004.

The Department of Environmental Affairs and Tourism is the focal point of the UNCCD, although the institutional framework responsible for its implementation includes diverse stakeholders. The NAP focuses on the development of integrated and holistic strategies to combat desertification, rather than on understanding its extent and causes⁴². The programme subtitled "Combating Land Degradation to Alleviate Rural Poverty", emphasizes poverty alleviation for resource-poor land users. It took seriously the need to tackle diverse and related problems of land degradation⁴². A shortcoming exists, however, in the implementation of

The challenge for South Africa and the region is to utilize land sustainably, so as to feed, house, and sustain a growing population and economy, as well as to protect our natural heritage.

productivity, and biodiversity. South Africa's dependence on local agricultural production for food provision combined with the disastrous effects of droughts on agriculture leads analysts to the conclusion that degraded, less productive soils increasingly impair the country's ability to feed its growing population and to sustain livelihoods, particularly among the rural poor¹⁵.

There is a major challenge in improving household food security. Malnutrition has been worsening, with the prevalence of underweight children increasing from 9.3% to 10.3% in the late 1990s; and stunting rose from 22.9% of children aged 1–6 years in 1994 to 23.3% in 1999³⁹. Between one quarter and one third of households cannot meet their children's dietary requirements⁴⁰, particularly in rural areas (most notably in the Eastern Cape and Mpumalanga). South Africa's targets are to bring the prevalence of underweight children <5 years of age down to 5.6% by 2015, and that of stunting in the same age group down to 11.9% by 2015.

In addition, food production per capita is decreasing while agricultural and food imports are increasing. Future climate change alone may force marginal agriculture out of production, thereby causing downstream losses in farm labour and general loss of livelihoods⁴¹. In combination with the loss of productivity of land through degradation, these indicators present concerns for sustained food provision.

Although the true costs of land degradation are poorly understood, it has considerable effects on the economy. The United Nations Environment Programme has estimated

the NAP, in addition to the monitoring, evaluation, and reporting components of the NAP's implementation. Objective and rigorous methods are still needed for assessing degradation trends.

Sub-regional action programme – New Partnership for Africa's Development

Under the New Partnership for Africa's Development (NEPAD), South Africa forms part of the Southern African Development Community (SADC) Sub-regional Action Programme to Combat Desertification (SRAP), which the SADC Council of Ministers approved in 1997. It provides an effective collective response to problems of land degradation, drought, and desertification, especially those that cross national boundaries⁴⁵. The SRAP's priority programmes include:

- Capacity and institution building
- Improvement of early warning systems
- Cooperation for sustainable management of shared natural resources and ecosystems
- Collection, management, and exchange of information
- Development and transfer of appropriate technologies to communities
- Development of alternative sources of energy
- Socio-economic issues.

South Africa is currently involved in the following transfrontier projects:

- Kalahari-Namib Project on Transboundary Desertification Control in Botswana, Namibia and South Africa
- Demonstration Phase Activities of the Africa Land and Water Initiative in the Limpopo River Basin in southern Africa
- Capacity building for integrated rangeland management in the SADC region
- Assessment of the surface water resources of southern Africa
- Protection and Strategic Uses of Groundwater Resources in the Transboundary Limpopo Basin and Drought-prone Areas of the SADC Region.

Landcare, the Comprehensive Agricultural Support Programme, and the Integrated Sustainable Rural Development Programme

The focus of soil resource management has shifted from narrowly focused conservation works programmes (such as the construction of contour banks and erosion structures), to a more holistic and integrated approach. Three important programmes have been instituted: LandCare (see Box 4.5), the Comprehensive Agricultural Support Programme

Box 4.4

Opportunities to improve livelihoods and the quality of the environment

Some former homeland areas have higher agricultural potential than present commercial farming areas, and much of this high potential land is underutilized for arable production¹. These areas have the potential for arable development and consequent improvement in food security and livelihoods, but, as part of a national focus on rural agrarian reform, communities need to be supported in their endeavours. The Department of Agriculture, through its extension service, is central to the success of any such programme and needs to be strong, well resourced, and closely integrated with local governance structures whether at village, municipal, or provincial levels. With international support, a stronger focus on land degradation will provide an important

opportunity for the Department of Agriculture to expand its extension service.

Land degradation is perceived to be the greatest threat to biodiversity in the future. Scholes and Biggs (2004)⁸ suggest that the greatest opportunity for protecting biodiversity is the avoidance of degradation in grazed landscapes. Degradation is very difficult to measure, however, and agreement needs to be reached as to the definitions, measurement, and extent of land degradation in South Africa. In particular, the costs to people's livelihoods associated with the loss of goods and services need to be better assessed. Bridging such data gaps provide occasion for involving local people in participatory approaches to development.

Although land degradation is an international concern, the United Nations Convention to Combat Desertification (UNCCD) is focused primarily on Africa, which offers all African countries an opportunity to incorporate issues of land degradation into their development programmes. The implementation of the UNCCD by means of South Africa's National Action Programme, for example, can help to combat poverty in the nation and to improve food security through integrated, cross-cutting, multi-sectoral projects, which in turn will assist progress towards achieving the Millennium Development Goals.

Successes in community-based soil conservation in some former homeland areas can serve as examples for similar successes elsewhere.



There is considerable uncertainty regarding the effects of climate change. Although there are few studies on its potential impacts on land degradation in South Africa, indications are that the most severely degraded areas of South Africa could become more susceptible to degradation.

(CASP), and the Integrated Sustainable Rural Development Programme (ISRDP). A portion of the latter's funds is allocated to resource management activities involving communities and land users.

Conservation tillage

The agronomic, economic, and environmental benefits of conservation tillage are being increasingly recognized worldwide⁴⁴. Certain environmentally friendly crop-production systems have been used for several decades in South Africa. The adoption of conservation tillage practices increased from 500 000 ha in 1975 to 1.5 million ha in 2005⁴⁵, but only a small proportion of this area was farmed in a way that adhered to more stringent 'conservation agriculture' principles. Farmers face rapidly escalating costs and are increasingly aware of the environmental effects of crop production, so the adoption rate of conservation agriculture practices (which can help to prevent erosion and loss of nutrients) will probably increase in future.

4.5 EMERGING ISSUES

The following issues are regarded as potentially important for the future.

- Challenges faced by the land reform process. The most notable constraint to the sustainability of the land reform process is the inadequacy (or in some cases

absence) of the support and extension services needed to enable new beneficiaries to be successful farmers. In order for the intended social and economic benefits to accrue to target communities, some additional interventions will be required.

- Climate change. There is considerable uncertainty regarding the effects of climate change. Although there are few studies on its potential impacts on land degradation in South Africa, indications are that the most severely degraded areas of South Africa could become more susceptible to degradation⁴⁶. The common patterns shown by the latest global climate models⁴⁷ include:
 - Wetting in the eastern part of South Africa, stretching from northern parts of the Eastern Cape to Limpopo (the extent to which the wetting extends into the interior is not known for certain)
 - Drying in the Western and Northern Cape provinces, in the northwestern parts of Limpopo, and in the western parts of North West
 - A shorter rainfall season in the Western Cape, with the eastern interior regions of the province experiencing increased late summer rainfall.

These patterns indicate that degradation in parts of the Western Cape, Northern Cape, North West, and Limpopo provinces may be exacerbated by climate change.

Box 4.5 Landcare Programme, National Department of Agriculture

Landcare is a community-based programme, which encourages the sustainable utilization of natural resources through management that is efficient, sustainable, equitable, and consistent with the principles of ecologically sustainable development. It encourages community interest and action through the formation of Landcare groups, which assess local problems, determine priorities, and undertake action. Its motto is 'local people taking local action in their local area'.

The programme originated in Australia in the early 1980s and was adopted by South Africa in 1989, when the Department of Agriculture and other stakeholders recognised it as an innovative way to promote sustainable land resource management. A National Landcare Secretariat has now been set up within the Department of Agriculture to run the National Landcare Programme. This 'grassroots' programme is supported by both the public and private sector through networking between a series of partnerships, the most important of which are those formed at the local level.

As an example of how such partnerships can work, the Agricultural Research Council-Institute for Soil, Climate and Water (ARC-ISCW) has linked up with farmers in five different projects in South Africa to help resource-poor farmers to improve their crop yields, utilize their resources sustainably, and thereby contribute to the upliftment of their local communities. The projects are located in four provinces: Mpumalanga, the Eastern Cape, KwaZulu-Natal, and the Free State. Each of the project locations has natural resource problems (such as soil acidity, poor soil fertility, or high run-off potential) in addition to socio-economic problems related to land tenure, poverty, and lack of entrepreneurs, for example. The ARC-ISCW works in tandem with other research institutions, local government, traditional structures, and farmers in these areas to try to design solutions to the problems faced. The multidisciplinary nature of the projects maximises their benefits to the community.

Source: National Department of Agriculture (2005). *LandCare South Africa: Frequently Asked Questions*.
www.nda.agric.za/docs/landcarepage/FAQ.htm



4.6 CONCLUSION

Land productivity is intricately linked to social, political, and environmental issues. Degradation of land is perceived to be particularly severe in communal areas and poses a serious threat to the sustained supply of ecosystem services, and thereby also to household food security, rural livelihoods, and biodiversity. Despite increasing food productivity per unit land area, the potentially detrimental effects of climate change on agricultural productivity, in combination with the increasing population, suggest that national food security should be closely monitored. Since 1975, food production per person has decreased (in particular, production of South Africa's major food crop, maize) and food imports have increased.

The current land reform programme faces substantial challenges for dealing effectively with and implementing South Africa's land reform policy, which has fundamental implications for human well-being in the country. The opportunity exists for agricultural development in the former 'homelands', since these areas have sufficient agricultural potential for sustainable production.

Integrated and holistic programmes are needed for sustainable land management. Opportunities exist to optimize the utilization of land in South Africa for supporting livelihoods, and at the same time to improve environmental conditions. It is recognized that the avoidance of land degradation, particularly in grazed landscapes, is a critical opportunity for protecting South Africa's biodiversity. One of the most important conditions for making the most of these opportunities, however, is the availability of reliable information and data on land resources. This chapter is based largely on outdated information. There is an urgent need for reliable temporal and spatial data for land cover and use, and for degradation and desertification.

NOTES

- a. Trends in the change in land cover are difficult to assess because of data limitations. The analysis of land use presented in the 1999 National State of the Environment Report (NSoER) using land cover data from 1994/1995 cannot be compared accurately to these latest data, because there are differences in the definitions of the land-cover classes and because the 1994/1995 data were mapped at a less detailed scale. Other published sources of global and regional land cover maps suffer from similar inadequacies and inconsistencies. Consequently, while the 1999 NSoER reported that 25% of land was transformed by 1994/1995, this was most likely an overestimation, and the current figure of 18% should not be interpreted as a decrease.
- b. Dryland cultivation is not irrigated and therefore dependent on rain.
- c. The national increase in cattle numbers may partially be due to intensive rearing of stock in feedlots.
- d. The 2004 Communal Land Rights Act and the 2003 Traditional Leadership and Governance Framework Act legislate for the reform of rights and administration.
- e. 'Drylands' is a collective term for arid, semi-arid, and sub-humid lands.
- f. 'Permanent' in the context is generally accepted as meaning 'a single generation' (that is, 20–50 years).
- g. The supply of ecosystem services includes the supply of grazing, crops, water, wood and medicinal plants, biodiversity, and the aesthetic and spiritual qualities of landscapes.
- h. Natural variation of a climate parameter (for example, rainfall) is measured by the coefficient of variation, which is the average percentage by which that parameter deviates from its mean value.
- i. These figures should be interpreted with caution: the 1994 survey included children aged 6–71 months, while that of 1999 included children aged 12–71 months.

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Chapter 5 Biodiversity and ecosystem health

At a glance

This chapter begins by emphasizing the point that our lives and well-being depend directly on healthy ecosystems for air, water, food, and shelter, as well as for recreation and aesthetic, cultural, and spiritual needs. It outlines the main factors having an adverse impact on the country's ecosystem health, which include the over-exploitation of natural resources and climate change. It then describes the current state of our rivers, wetlands, estuaries, and marine ecosystems, as well as the status of species in major ecosystems. The last section details our responses in addressing the loss of biodiversity and ecosystem health, and it identifies climate change and genetically modified organisms as key emerging issues.

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People's dependence on living, healthy ecosystems and the services they provide is often particularly apparent in rural communities, where lives are directly affected by the availability of common property resources such as food, water, medicinal plants, and firewood.

5.1 INTRODUCTION

Biodiversity³ refers to genes, species (plants and animals), ecosystems, and landscapes, and the ecological and evolutionary processes that allow these elements of biodiversity to persist over time¹. It is the activities of plants, animals, and microorganisms and their interactions with their environment that determine many of the properties of ecosystems, such as how much plant material is produced and how rapidly waste matter is decomposed or nutrients made available. These activities provide the ecosystem services that directly benefit humanity².

South Africa's biodiversity provides an important basis for economic growth and development. For example, it underpins our fishing industry, the horticulture and agriculture based on indigenous species, tourism, aspects of our film industry, and the commercial and non-commercial medicinal applications of indigenous resources, and it provides the rangelands that support commercial and subsistence farming. Keeping our biodiversity intact is also vital for ensuring ongoing provision of ecosystem services such as the production of clean water through good catchment management, prevention of erosion, carbon storage (to counteract global warming), and clean air. Loss of biodiversity puts aspects of our economy and quality of life at risk, and reduces socio-economic options for future generations.

People's lives and well-being depend directly on healthy ecosystems, which, in addition, yield food and shelter, as well as providing for recreation, aesthetic, cultural, and spiritual needs (see Boxes 5.1 and 5.2). Human well-being

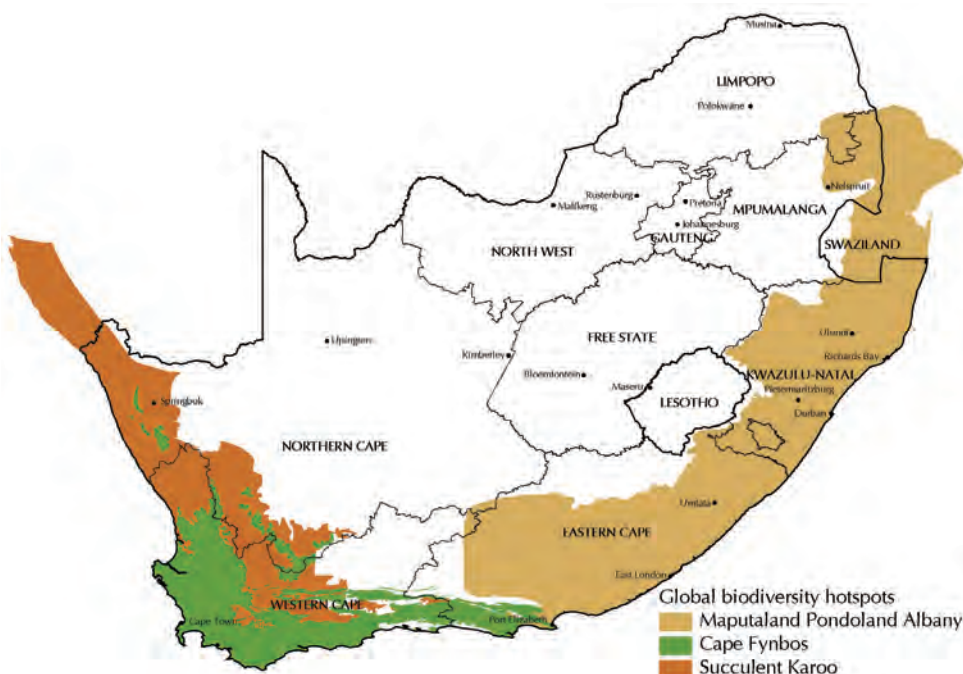
relates to resource security and the basics for sustaining life, health, social, and cultural relations, and the freedoms and choices that are available. Figure 5.1 shows the relationships between biodiversity, ecosystem services, and human well-being. Although placing a financial value on these services is complex and contentious, studies have demonstrated that ecosystem services are of enormous value to modern economies.

A synthesis of more than 100 studies attempting to assess global ecosystem services estimated that their aggregated annual value lies in the region of between US\$20 trillion and US\$60 trillion, with an average of about US\$40 trillion⁴ (updated to mean 2000 US\$ value). This value is similar to the world's total gross national product (GNP). The economic value of unconverted, intact, and conserved ecosystems is much greater (from 14% to almost 75% higher than the value of natural areas that have been converted for agriculture, housing, and other uses¹⁰).

People's dependence on living, healthy ecosystems and the services they provide is often particularly apparent in rural communities, where lives are directly affected by the availability of common property resources such as food, water, medicinal plants, and firewood⁵. Urban and wealthier sectors of society are somewhat buffered from changes in ecosystem services, as they purchase basic necessities and scarce commodities made available with the help of technology. For example, towns and cities use water treatment plants to perform the water cleaning services normally undertaken by healthy rivers and wetland systems⁵.

South Africa is one of the world's most biologically diverse countries, with a rich and spectacular array of terrestrial, aquatic, and marine ecosystems^{6, 7}. It occupies only 2% of the world's land surface, yet contains a disproportionately large share of global biodiversity, being home to nearly 10% of the planet's plant species and 7% of the reptile, bird, and mammal species⁸ (see Figure 5.2). The country contains three globally recognized biodiversity hotspots: the Cape Floristic Region; the Succulent Karoo, shared with Namibia; and the Maputaland-Pondoland-Albany hotspot, shared with Mozambique and Swaziland (see Map 5.1). The Cape Floristic Region is the smallest (<90 000km²) and is the only floral kingdom to occur exclusively within the geographical boundaries of one country⁹.

Its extraordinary plant diversity helps to rank South Africa as the country with the fifth highest number of plant species in the world. Our seas, which support many livelihoods, include the Atlantic, Indian, and Southern Oceans, with a wide range of habitats from kelp forests to coral reefs¹⁰. In addition, our coast is home to 15% of the world's coastal species⁷, which contribute significantly to the country's economy¹¹. Nevertheless, South Africa's biodiversity is increasingly threatened by human activities, which in turn threaten the very resource base upon which we depend⁷.



Map 5.1: Biomes and biodiversity hotspots of South Africa



Box 5.1 Traditional medicine: Silverglen medicinal nursery, Durban, and Barberton Commercial Medicinal Plant Initiative

South Africa has a large and active trade in traditionally used indigenous plants. Over 70% of South Africans are thought to use traditional medicine as their primary form of health care and, in KwaZulu-Natal alone, approximately 4 000 tonnes of plants are traded each year, with considerable benefits to the economy. In 1995, the annual expenditure on medicinal plants in South Africa was R768 million – which promoted additional economic activity and job creation, with several hundred thousand people directly employed in the industry. Increasing demand for plants for medicinal and other purposes, however, has resulted in over-exploitation of wild populations, reduction in supply, and increased cost. It is widely acknowledged that wild populations need to be used sustainably and that further supplies of plants should be provided through cultivation.

Several projects in South Africa promote the cultivation of local plants. In Durban, the Silverglen medicinal plant nursery cultivates about 250 at-risk species, many of which are supplied to

other nurseries and private buyers. This nursery covers an area of 3 hectares (ha) in the Silverglen Nature Reserve in Chatsworth and is run by the Durban Parks Division of eThekweni municipality. Although relatively little is produced for commercial trading, the nursery can provide growers with 'starter kits' and is conducting research into methods of harvesting medicinal plants sustainably and resuscitating traditional conservation practices. It is hoped that their work will assist conservationists and users of the resource to develop management guidelines for collecting these species.

The national Department of Environmental Affairs and Tourism has also invested in the establishment of a commercial medicinal plant project in Barberton, Mpumalanga. Located in the Umjindi local municipality, this project is funded under the department's poverty relief programme and involves partnership between the Mpumalanga Parks Board, the provincial Department of Agriculture and Land Administration, the South African Essential Oil Producers Association, the

Siyaphambili Development Trust, the Tinjajela Trust, and other local stakeholders. Since its establishment in May 2003, the project has acquired land for two nurseries and food gardens and hopes to benefit over 200 local people. It should also help to alleviate pressures in the area caused by the collection of rare and endangered medicinal plants from wild populations.

Sources: Department of Environmental Affairs and Tourism (2004). Deputy Minister Rejoice Mabudafhasi at the launch of commercial indigenous plant project, Barberton. South African Government Information: Speeches and Statements. <http://www.info.gov.za/speeches/2004/04092015451003.htm>

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5.2 WHAT CAUSES LOSS OF BIODIVERSITY AND DECLINES IN ECOSYSTEM HEALTH?

Current and predicted future pressures on declining ecosystem health include loss of natural habitat (which includes land-use changes, loss of coral reefs, and damage to sea floors due to trawling), climate change, invasion by alien species, modification of rivers, water abstraction, external inputs of nutrient loading and pollution, over-exploitation (of, for example, fish stocks), and others. The relative importance of these pressures differs considerably amongst ecosystems¹², but all are likely to contribute to the continued decline of species' populations and loss of biodiversity over the next few decades. Human activities currently dominate all ecosystem functions in South Africa. This section outlines the main drivers of change and their impacts on the country's ecosystem health. (Some pressures are dealt with more extensively in other chapters. For example, for pollution and water abstraction see Chapter 6, section 6.2.2; Chapter 7, section 7.3.6; and Chapter 8, section 8.2.3.)

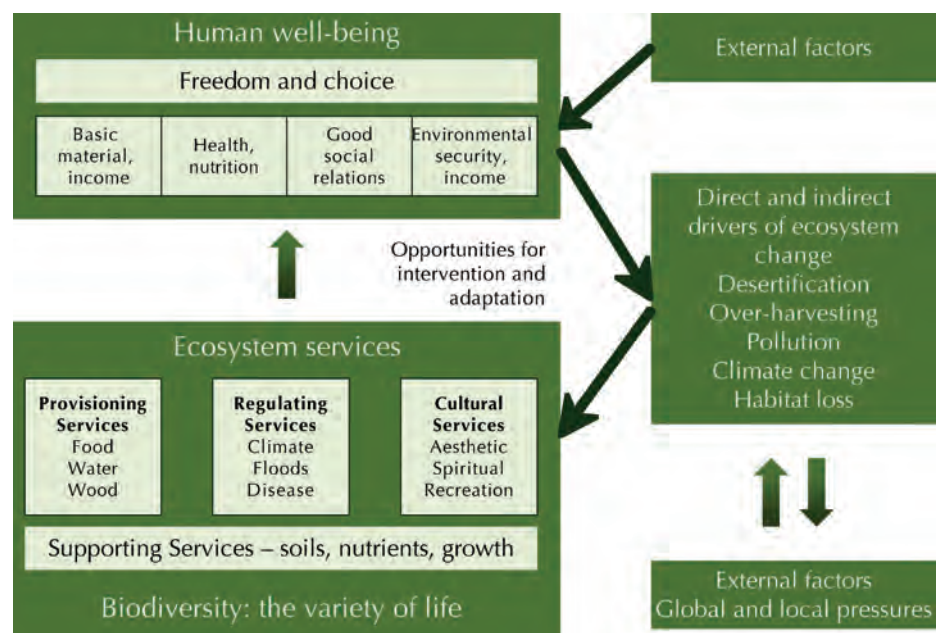


Figure 5.1: Ecosystem services and human well-being

Box 5.2 Valuing open space in Durban

Open spaces in cities provide many ecosystem services and goods that are undervalued by most of the public who benefit from them. This could be because such goods and services are supplied free of charge and not measured in monetary terms. In recent years, advances have been made in international research that focus on ecosystem valuation. A case study in the eThekweni municipality illustrates these principles.

In the eThekweni municipality, many diverse open spaces and ecosystems supply benefits that, in turn, contribute to the economic value of the specific systems. For example, it has been estimated that wetlands are annually worth around R200 000 per ha and forests around R21 000 per ha. The value of an ecosystem increases according to its richness in diversity, which enables that ecosystem to supply a broader variety of services. The total replacement value of the ecosystem services supplied by the 63 000 ha of open space mapped in the 2002 spatial plan/open space system for the eThekweni municipality is an estimated R3.1 billion per year. It is noteworthy that this figure excludes the value of the role of open space in the tourism industry of Durban, which alone was estimated to be worth R3.3 billion in 2001.

Ecosystem	Rand value (millions)
Beaches and rock outcrops (1 039 ha)	30.2
Alien vegetation (3 787 ha)	24.8
Forest (10 581 ha)	195.3
Disturbed woodlands (2 823 ha)	29.5
Field crops (741 ha)	0.7
Dry valley thicket/ broadleaved woodland (18 306 ha)	267.5
Grassland (2 828 ha)	6.8
Tree crops (14 ha)	0.2
Recreational (1 712 ha)	4.1
Utility (289 ha)	0.5
Wetland forest (201 ha)	33.7
Wetland (non-woody) (5 485 ha)	1 108.8
Near shore ocean (i.e. the ecosystem in the area of ocean just off the shore) (50 000 ha)	837.2
Water (3 093 ha)	428.8
Wooded grasslands (11 145 ha)	116.4
Settlements (865 ha)	6.4
Total value – R3.1 billion	3 090.9

Source: eThekweni Municipality (2002). *Durban Environmental Services Management Plan*. http://www.durban.gov.za/eThekweni/Services/Downloads/dmoss_pop_doc_1

The conversion of natural ecosystems for other uses is one of the most significant causes of biodiversity loss in South Africa.

5.2.1 Loss, fragmentation, and degradation of natural habitat

The conversion of natural ecosystems for other uses is one of the most significant causes of biodiversity loss in South Africa. Land-cover change alters or destroys natural habitat, frequently with secondary consequences of degradation and fragmentation of remaining habitats, all of which result in losses of biodiversity, declines in ecosystem health, and changes in the provision of ecosystem services.

Along rivers, the removal of riparian vegetation for cultivation and to create access to rivers, for example, undermines the ecological integrity of fresh water ecosystems because of the important role of such vegetation in maintaining channel stability and as a source of food (through leaf-fall, for instance) into the aquatic system. Degradation of habitat quality through inappropriate land-use management (such as overgrazing) also occurs in these ecosystems.

Terrestrial ecosystems

In the terrestrial environment, loss and degradation of natural habitat is the biggest cause of biodiversity loss and decline in ecosystem functioning. Nearly 18% of South Africa's land-cover is transformed^b, mainly through cultivation (10.46%), urbanization (1.51%) and plantation forestry (1.41%) (see Chapter 4).

Land-cover change also causes declines in the populations of species. Based on a Biodiversity Intactness Index (BII)¹³, non-mobile species, such as plants, are affected to a greater extent than mobile species, such as birds. Larger organisms and predators are more affected by human activity than are smaller, non-predatory species. Abundance of mammals and reptiles tends to respond closely to habitat changes, whereas birds and frogs respond less predictably. Provincially, levels of intactness are lowest in the grasslands, fynbos, and forest, and Gauteng is the province with the lowest BII score, owing to its high level of

urban development. The Free State is particularly affected by cultivation, and plantations have a major impact in Mpumalanga.

Other than the magisterial district-level estimates of land degradation by Hoffman *et al.* (1999)¹⁴ (see Chapter 4), we do not have adequate data to assess the state of land degradation throughout the country at a finer scale. This data gap is critical, as the impacts of degradation on biodiversity are significant⁷. The Southern African Millennium Ecosystem Assessment³ identified the expansion of degraded areas into areas currently under sustainable use as the most immediate threat to biodiversity. We do know that both vegetation and soil degradation are most severe in the Limpopo, KwaZulu-Natal, and Eastern Cape provinces, and that the communal rangelands are particularly adversely affected.

These assessments highlight the current pressures facing ecosystems but say very little about change or about trends in these pressures. A significant gap exists in our knowledge about trends in land-cover change (see Chapter 4). Some indication of the extent of the problem can be deduced from the fact that the area under cultivation in South Africa has more than trebled in the last 50 years, while plantation areas have increased tenfold.

Aquatic ecosystems

Organisms in many aquatic ecosystems are adapted to highly variable flows of water and, in some cases, to variable water quality. With the increased control of flows, however, by means of weirs and dams (which lead to reductions of flow and changes in the seasonal patterns of river flow), the result is loss of biodiversity and productivity as well as the introduction or increase of invasive species. Degradation and reduced productivity in aquatic ecosystems through pollution and poor land management has implications for food security and economic activities. Disturbance and loss of wetlands due to the pressures of land transformation and over-abstraction of groundwater reduces their storage capacity, water purification ability, fish populations, and wildlife habitats. Loss of water storage capacity reduces the availability of water in rivers during the dry season, resulting in longer drier periods and, conversely, more intense flows in the wet season, which exacerbate flooding.

Coastal ecosystems

Development pressure and land-use change are major causes of coastal habitat modification and loss. As much as 40% of South Africa's population lives within 100 km of the coast. The result has been substantial development pressure for infrastructure, such as housing and roads, even though there was only a small change in the density of the population within coastal provinces at a municipal level between the 1996 and 2001 Censuses.

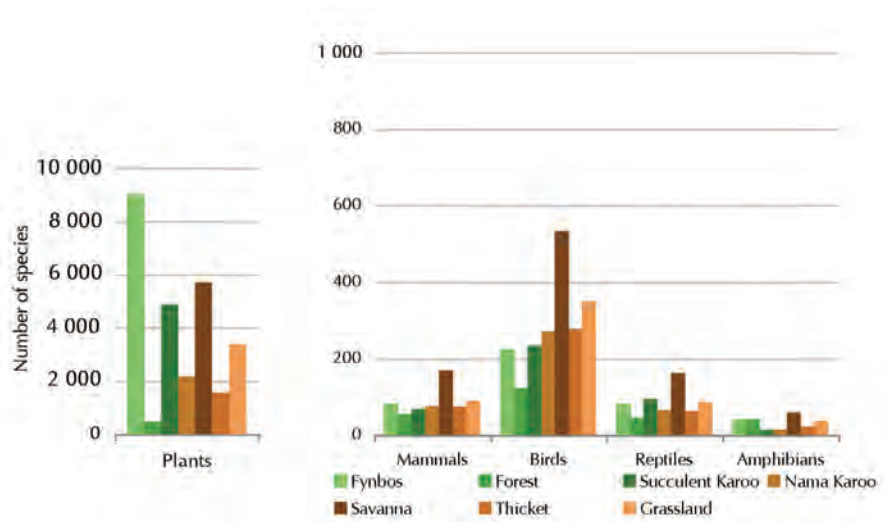


Figure 5.2: Species richness per taxonomic group of the biomes of South Africa

Source: *Endangered Wildlife Trust, 2002*⁸

The National Land Cover Database¹⁵ classifies the current state of coastal land in South Africa as natural, degraded, urban, and agricultural. Not surprisingly, the sparsely populated Namakwa region has the largest proportion of natural land cover (98%), with Cacadu (92%), Eden (76%), Amatole (75%), and Nelson Mandela (74%) districts also having high percentages of natural land. The Nelson Mandela, Namakwa, and Overberg regions have only 1% degraded land, while on the west coast a mere 2% of the total land cover is classified as degraded. By contrast,



A humpback whale off Hermanus, the world's best land-based whale watching spot. *Photography: South African Tourism*

While not all alien species thrive in their new environments, some do, becoming 'invasive', that is, spreading at the expense of indigenous species and causing significant changes to habitats and ecosystem functioning.

the O.R. Tambo region in the Eastern Cape has South Africa's highest proportion of degraded land (20%).

The areas of natural or undeveloped coastal land in South Africa are increasingly under threat from:

- Large-scale urban developments, mostly residential or recreational estates (such as golf estates)
- The construction of new harbours and ports or the expansion of existing ones
- Industrial development (for example, the Coega Industrial Development Zone, a new export-processing zone being built on a greenfields site in combination with the new, deep-water Ngqura harbour, whose development will require the dredging of an estuary).

5.2.2 Invasive alien species

An 'alien' species is one that has been introduced by humans, deliberately or accidentally, into an area in which it did not previously occur ('indigenous' species, by contrast, are native to a given place). In today's globalized world (where travel and transport of goods are fast, easy, and increasing), species spread effortlessly among countries and continents. While not all alien species thrive in their new environments, some do, becoming 'invasive', that is, spreading at the expense of indigenous species and causing significant changes to habitats and ecosystem functioning.

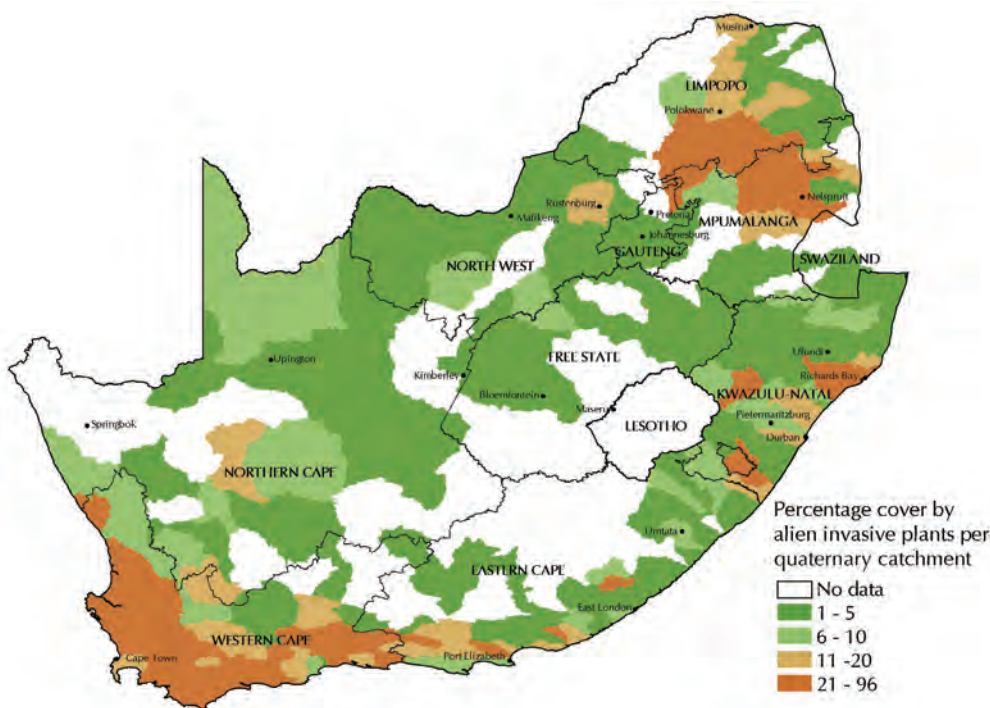
One of the main reasons why alien species flourish is that "they are no longer controlled by their natural predators and pathogens (diseases) with which they have co-evolved in their natural range"¹⁶. Correspondingly, indigenous species are at a competitive disadvantage when they encounter such alien species (having had no evolutionary history of them) and are easily out-competed.

Invasive alien species can occur on land, in the ocean, or in freshwater systems, and can be drawn from any group of organisms. Our knowledge of them, however, is best by far for terrestrial species and ecosystems. Invasive alien plants have invaded over 10 million hectares (ha) of our country. Over 750 tree species and 8 000 herbaceous species have been introduced, with some 1 000 introduced species now naturalized (that is, neither indigenous nor invasive) and 200 considered invasive. Of those considered invasive, 117 are categorized as 'major invaders', and 84 are considered 'emerging invaders'¹⁷. 'Major invaders' are those species that are well established, and that already have a substantial impact on natural and semi-natural ecosystems. 'Emerging invaders' currently have less influence, but have attributes and potentially suitable habitat that could result in increased range and consequences in the next few decades.

Plants constitute most of the invasive species in South Africa, making up 63% of the 319 species listed as harmful, and they threaten 55% of the Red Data-listed plants in the country^{18,19}. According to the Working for Water Programme, the impacts of invasive alien plant infestations are expected to double within 15 years if left uncontrolled (see the web site of the Department of Water Affairs and Forestry at <http://www.dwaf.gov.za/wfw>).

Our knowledge of the distribution of alien invasives is limited to plants, and even for this group the data are not updated frequently enough. (See Map 5.2 for the proportion of each quaternary catchment that is infested with alien plant species.) Most of these species are located in the water catchment areas of the South-western Cape, on the east coast, and in the northeast grasslands and savanna regions, with some areas being over 80% infested. Other data do exist for some parts of the country (see, for example, Lloyd *et al.* [1999]²⁰, Cowling *et al.* [1999]²¹, and the Southern African Plant Invaders Atlas [SAPIA] database). Efforts have also been made to improve our knowledge of the impacts of invasive aliens through modelling the potential distribution of 71 of the most important and emergent invasive plant species²² (see Map 5.3). This figure highlights the high invasion potential of the eastern coastal regions and of the grasslands and savannas of the interior of the country.

Studies of invasive aliens in South Africa have tended to concentrate on plants, neglecting other taxa, but attention is now being directed towards the threat posed by other taxonomic groups of alien species. This is exemplified in the case studies presented by McDonald *et al.* (2004)¹⁸,



Map 5.2: Percentage cover by alien invasive plants per quaternary catchment

National Spatial Biodiversity Assessment 2004⁷

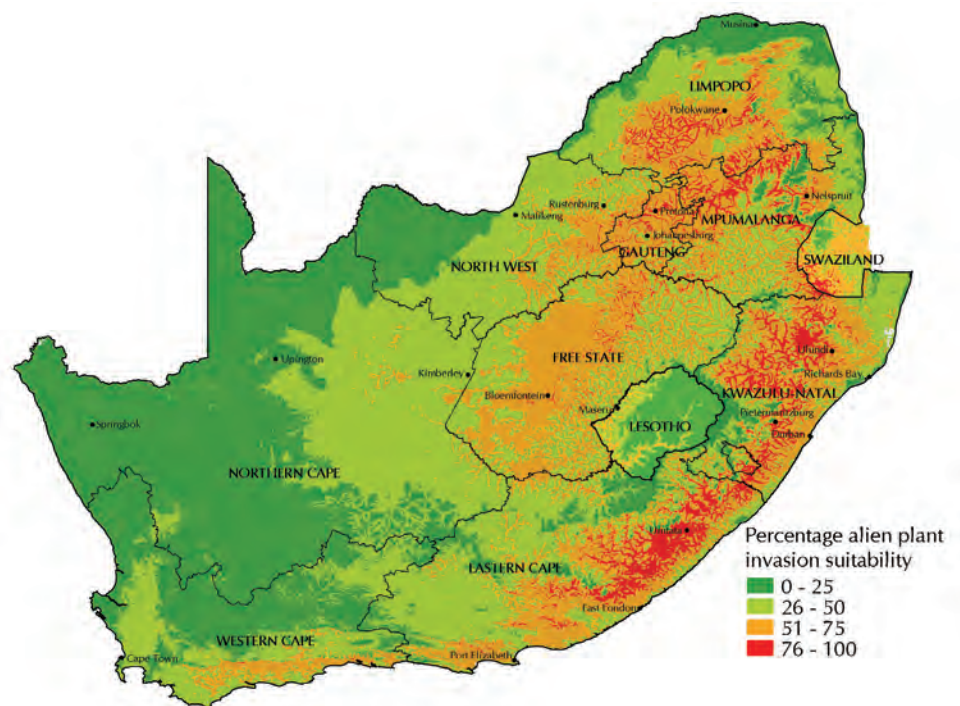
which describe the introduction of alien freshwater fish (such as trout [*Parasalmo mykiss*, *Salmo trutta*] and bass [*Micropterus* spp.]) that threaten rare indigenous fish such as red-fin minnows (*Pseudobarbus* sp.) and Treur River barbs (*Barbus treurenensis*). Alien pests associated with these introduced species, such as ribbon-worm (*Nemertea* sp.), have caused large-scale infestations of indigenous fish species. In addition, the breakdown of bio-geographical barriers in aquatic systems, arising from inter-basin transfers and other forms of flow manipulation, have given some opportunistic species a foothold in catchments where they are not otherwise found. At least four species of native South African fish, not naturally found there, have been introduced to the Great Fish River from the Orange River. These include the smallmouth yellowfish, the Orange River mudfish, the sharptooth catfish, and the rock barbel²³, which now compete with naturally occurring, local fish species. The introduction to local species of closely-related species and sub-species of birds and mammals, such as the mallard duck (*Anas platyrhynchos*) and domesticated guinea fowl (*NNumida meleagris*), as well as the movement of a large number of antelope species to areas outside their natural ranges, has led to hybridization and loss of genetic integrity and diversity within various indigenous species. The Varroa mite (*Varroa jacobsoni*), as well as an invasive wasp, *Vespula germanica*, have recently been introduced into South Africa and are seriously affecting the health and status of the country's indigenous honey bees and, consequently, the vital pollinating service that these bees provide¹⁸.

Invasive alien species also threaten biodiversity in the coastal and marine environments. Marine fauna and flora have intentionally, or more often accidentally, been transported around the globe by humans²⁴, most often through the ballast water of ships discharged, along with any surviving organisms, when cargo is loaded at ports or harbours. The highly dynamic nature of South Africa's marine environment seems to have prevented many marine alien invasive species from becoming established. Of the ten currently known marine invasive species, only two (the Mediterranean mussel, *Mytilus galloprovincialis*, and the ascidian, *Ciona intestinalis*) are considered to have major adverse ecological or economic effects, while one (the European green crab, *Carcinus maenas*) has the potential for negative impact. Invasion by the Mediterranean mussel has displaced indigenous intertidal species along much of South Africa's coastline. Since 2001, one ascidian species, one anemone, one oyster, and one red algae (almost half the total number of recorded alien invasive species) have been recorded as invasive species in South Africa.

Microscopic algae (phytoplankton) are also easily transported around the world in ship ballast water and, once discharged, can become invasive. There is some indication that two species of toxic phytoplankton responsible for red tide blooms in South-western Cape waters in recent



Fly-fishing opportunities continue to increase due to the abundance of trout. Photography: South African Tourism



Map 5.3: Potential distribution of alien invasive plant species
National Spatial Biodiversity Assessment 2004⁷



years are alien species that were introduced from foreign parts.

5.2.3 Over-exploitation

Economies and human settlements depend in diverse ways on the exploitation of natural resources, and this is rapidly becoming over-exploitation as populations and consumption grow.

- Trade-driven exploitation is on the increase on the local as well as the global scale, as nations consume plant and animal products and their derivatives (such as those of freshwater and marine fisheries) and trade them at home and abroad. In a multibillion rand industry, wildlife and wildlife commodities are traded legally and illegally around the world, including food, medicines and cultural artefacts, live animals for the food and pet markets, and timber and ornamental plants. In South Africa, the national value of trade in medicinal plants alone (approximately 20 000 tonnes), is estimated at an annual R270 million^{25, 26}.
- Natural resources are used to support human settlements, including the abstraction of fresh water for domestic and agricultural purposes, generation of electricity (involving modifications to rivers through hydropower development, or acid rain caused by coal-fired power stations), deforestation for timber products, and agricultural over-use of soils. These kinds of over-exploitation take place at regional and sometimes global scales, as these resources are often supplied from places that are geographically remote from the area where the demand exists. In parts of South Africa, much of the population is urbanized, (in Gauteng, for

example, 94% of the population is currently urbanized, with a population density of 375 people per km²)¹¹.

- In South Africa and other African countries, the uncontrolled use of natural resources on a local scale for subsistence purposes creates significant pressure on ecosystems. Included in this form of over-exploitation are unsustainable levels of: grazing by livestock, fuel-wood harvesting, collection of building materials (such as thatch, wood, and reeds), bushmeat hunting, and the harvesting of medicinal plants. At the community level, over-exploitation can have severe consequences on biodiversity, and the combined effects of deforestation and subsistence agriculture are expected to denude natural woodlands totally in southern Africa's communal areas by 2020²⁷.

The natural resources that currently support a large proportion of the population are rapidly declining because of over-exploitation. This decline is not evenly spread across South African ecosystems, but is concentrated in the forests, grasslands, KwaZulu-Natal coastal belt, and the Cape Floristic Region – all areas of high biodiversity and conservation priority. A 2004 study of the trade and economic value of forest and woodland resources in the medicinal plant market in Johannesburg estimated that these resources accounted for approximately 63% of the species traded, with 10% of those species shared with the grassland biome²⁶.

Subsistence and commercial over-harvesting of indigenous plants is driving some species to extinction locally and even nationally, especially rare and slow-growing species with medicinal value, such as some endemic bulbs and succulents²⁸. Taxa threatened by commercial exploitation include cycads, colophon beetles, the Knysna seahorse, and the southern bluefin tuna.

There is still lack of awareness and information regarding the threats to many plant and animal species that are harvested for trade in bushmeat, medicinal plants, bioprospecting, or the pet industry, or collected just for rarity value by overzealous collectors (as is the case with colophon beetles). With the currently inadequate levels of baseline data about the distribution and abundance of organisms, it is at present virtually impossible to assess the overall impacts of biodiversity exploitation²⁹.

In the coastal and marine environments, commercial exploitation of species is of enormous economic value to the country and in some cases directly causes over-exploitation (for details, see Chapter 7, section 7.4). Abalone (perlemoen), for instance, faces severe crisis, and extreme management measures have been implemented in an attempt to prevent the targeted species, *Haliotis midae*, from commercial extinction. A combination of extremely high international demand and exorbitant prices, coupled with insufficient enforcement capacity within South Africa, has led to the establishment of highly organized



Trade in medicinal plants is valued at R270 million annually.

Photography: Janet Peace



illegal abalone fishery syndicates. Illegal harvesting of abalone has always been a factor (abalone occur in shallow water, are easily removed and thus do not require expensive fishing gear), but, since 2000 the levels of abalone poaching have escalated dramatically, to the extent that recent data indicate that the fishery is unlikely to remain sustainable, unless improvements in compliance occur immediately. Even more dramatic was the complete closure of the recreational abalone fishery for the first time in history for the 2003/2004 abalone fishing season.

Compounding the effects of abalone poaching is the ecological change occurring at the centre of the most productive abalone region, between Cape Hangklip and Hermanus in the South-western Cape. An increase in rock lobster (*J. lalandii*) abundance in this region was initially detected in 1994³⁰. Rock lobsters consume small invertebrates, including sea urchins (*Parechinus angulosus*) which provide essential shelter for juvenile abalone^{31, 32}. Decreasing abundance of sea urchins, due to increased predation by rock lobster, results in reduced recruitment to the abalone fishery.

By-catch from commercial fishers is another serious problem in the marine environment, leading to incidental mortality of non-target species. Such mortality rates can vary between 5% and 70% of the total catch. A serious by-catch issue is the mass mortality of seabirds killed by long-line fishing operations. (For details of other pressures on freshwater and coastal and marine ecosystems, see Chapter 6, section 6.2.2 and section 6.3.3, and Chapter 7, section 7.3 and section 7.4.)

5.2.4 Climate change

Possibly the greatest looming threat to biodiversity is climate change induced by human activities. Cyclical climate change over very long time-horizons is a natural phenomenon and has occurred in the prehistoric past. Current, human-induced warming of the global atmosphere, however, linked to the 30% increase in atmospheric carbon dioxide concentration since the start of the industrial revolution, is different in that it is happening 10 times faster than in the earlier instances, and over a landscape already fragmented by human activities³³.

The Intergovernmental Panel on Climate Change (IPCC) states that global average surface temperatures have increased, global mean sea level is rising, and the concentration of ozone in the stratosphere has decreased. Annual average precipitation has also changed and the intensity and frequency of extreme weather events seem to have increased³⁴. Data from the monitoring of sea-surface temperature, mean sea level, and rainfall in South Africa suggest that changes in the local environment are echoing global patterns. Across the world, ecosystems are showing the effects of a changing climate³⁵. Several South African studies completed during the 1990s strongly indicated that

the biodiversity of southern Africa is at risk^{5, 36, 37, 38} from the effects of climate change, and quantitative evidence of impacts on species in the region is now emerging. For example, populations of *Aloe dichotoma* are declining in the northern (drier) part of its range, but they appear more stable in the southern part³⁹. There is also evidence to suggest that expansion of tree cover into formerly open grasslands and savannas (bush encroachment), beginning around the 1960s, may have been predisposed by steadily-rising global carbon dioxide concentration⁴⁰.

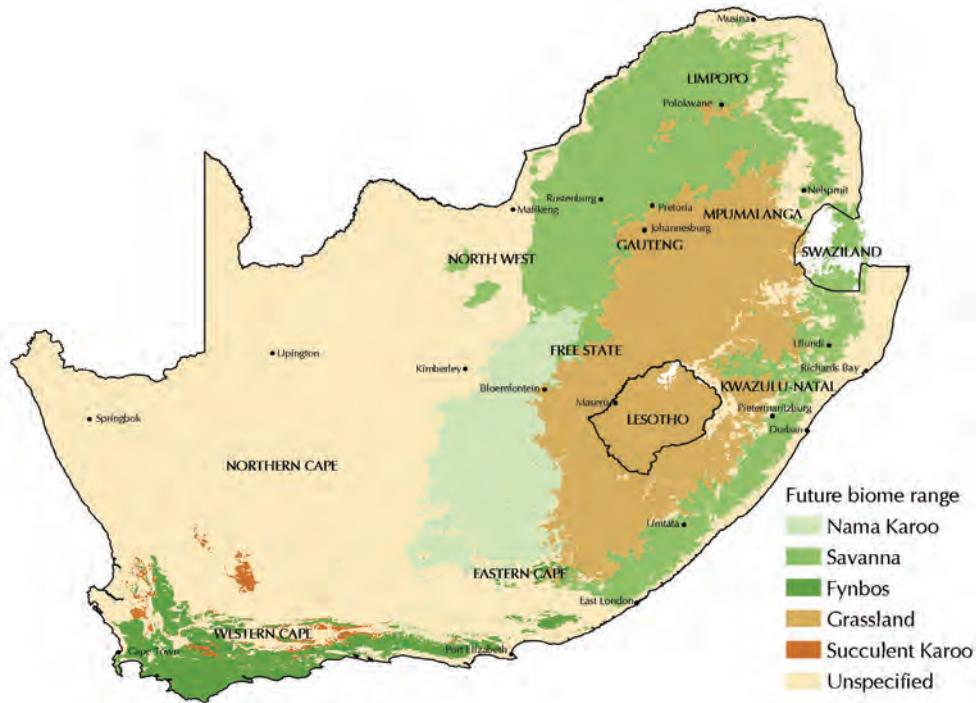
In 2001, the South African Country Study on Climate Change predicted that the most dramatic responses to climate change would be in the biodiversity and human health sectors⁴¹. The area that climatically suits South Africa's seven existing terrestrial biomes could shrink by 40% by 2050⁴² (see Map 5.4). Much of the area currently occupied by grasslands could decrease and, through increasing susceptibility to invasion by savanna species, expand the extent of the savanna biome. A disturbing prediction is the likelihood that the country could lose its succulent Karoo biome from South Africa, home to the world's largest diversity of succulent flora and arguably the world's most botanically diverse arid region.

Countrywide, habitats are expected to shift along a west-to-east gradient of aridification, leading to an increased probability of extinction, as available intact habitat is today greatly restricted. This is due in part to the fragmentation of landscapes and ecosystems by human activities such as agricultural, urban, and industrial expansion. Forty-four per cent of plant and 80% of animal species will undergo some alteration to their existing distribution ranges. Most range shifts in South Africa in both plant and animal species are predicted to take place in an easterly direction towards the eastern highlands, a pattern consistent with the predictions of significant future increases in aridity in the western parts of the country and less intense aridification in the east.

Adding to the likelihood of local extinctions is the fact that these predicted range shifts would require species to move into the currently more transformed landscapes of South Africa where habitat availability is restricted. Such movements, especially for larger species, are further constrained by infrastructure such as roads, fences, and towns. The existence of intact ecological corridors linking different parts of the landscape, will help to mitigate the impacts of climate change and should be seen as a crucial element of South Africa's climate change adaptation strategy¹.

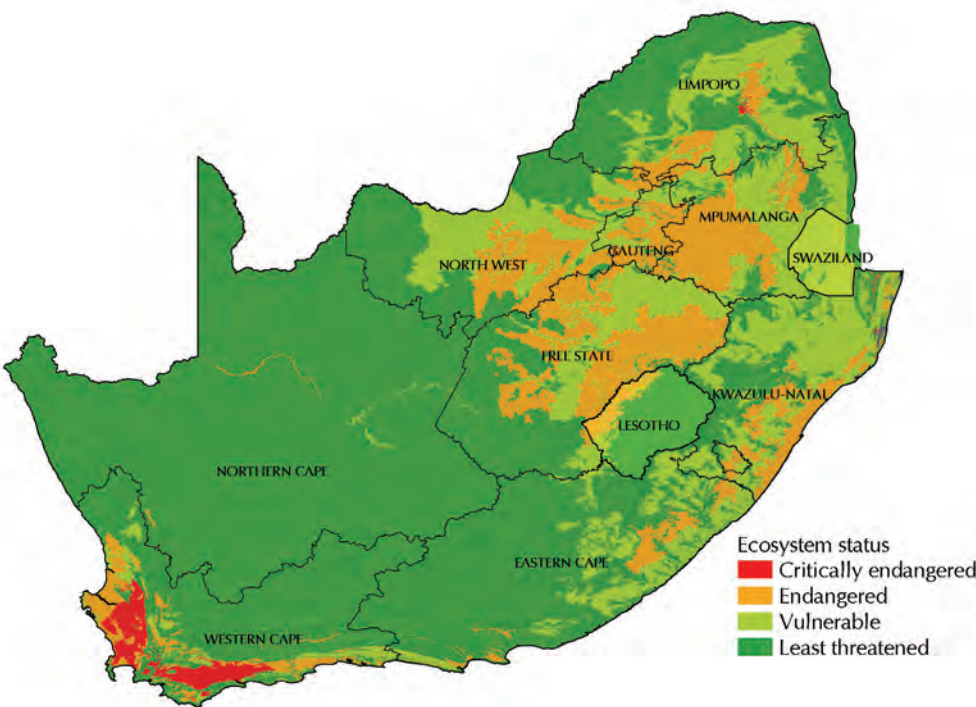
In estuarine, coastal, and marine environments, tide gauge measurements from South Africa indicate that sea levels have risen by approximately 1.2 mm each year over the last three decades⁴³. This trend is expected to accelerate in future, with recent estimates suggesting a 12.3-cm rise by 2020, a 24.5-cm rise by 2050, and a 40.7-cm rise by 2080⁴⁴. The potential impacts include increased coastal erosion, sea water flowing into estuaries

Possibly the greatest looming threat to biodiversity is climate change induced by human activities.



Map 5.4: Predicted reduction in existing biomes of South Africa due to climate change

Source: National Spatial Biodiversity Assessment 2004⁷



Map 5.5: Ecosystem status of terrestrial ecosystems

Source: National Spatial Biodiversity Assessment 2004⁷

and land, increased salt-water intrusion into estuaries and groundwater, raised groundwater tables (causing surrounding areas to flood more easily), and increased vulnerability to extreme storm events⁴⁵. The direct effects of rising sea levels on the ecological functioning of marine biota are less obvious: some regions might be adversely affected (such as salt marshes), whereas others are predicted to undergo a shift in distribution patterns and/or zones (for example, rocky shores).

Rainfall fluctuations change the amount of freshwater runoff. This is significant in the marine environment, as any reduction in freshwater flow has direct impacts on estuaries and the marine biota that utilize these systems (such as estuarine dependent fish species)⁴⁶. Reduced freshwater flow also decreases the extent to which wastewater discharges are diluted before they reach estuaries, thereby increasing the concentration of pollutants in the coastal zone and limiting the capacity of estuarine systems to support natural biota⁴⁶.

Migrant birds, fish, and prawns use South African estuaries extensively as sheltered areas that provide feeding and nursery grounds. Most of the country's estuaries have already been severely degraded (mainly through reduced freshwater input, pollution, and habitat destruction), resulting in harmful effects on many species that depend on estuaries^{47, 48}.

The anticipated further reductions in the amount of freshwater entering estuaries in South Africa are likely to damage these systems even more. Comparison of the natural (that is, before human activity) Mean Annual Runoff (MAR) with current conditions in the major estuaries around the coast shows that the most drastic reduction in freshwater flow has occurred in the Orange River (reduced MAR of 39% since records began) with similarly severe reductions in other West Coast systems (reduced MAR of 30%)⁴⁹. Other major water-catchment areas along the coast show a reduction in MAR of between 4% and 21%.

5.3 THE STATE OF SOUTH AFRICA'S ECOSYSTEMS

This section describes the status of the ecosystems and species as well as the protection levels of South Africa's terrestrial, riverine, estuarine, and marine ecosystems. In some cases, data are not readily available. The coverage of terrestrial systems is given here in some detail; for freshwater and marine ecosystems, details are presented below, and in Chapters 6 and 7, respectively.

5.3.1 Terrestrial ecosystems

The National Spatial Biodiversity Assessment (NSBA) assessed the state of South Africa's terrestrial ecosystems in relation to the pressures outlined above. (See Map 5.5 for the NSBA results.) It categorizes ecosystems into four

classes of threat based on their degree of habitat loss, relative to the biodiversity targets^{c, 50} that have been set for these ecosystems.

- **Least threatened** ecosystems are still largely intact (>80% natural habitat).
- **Vulnerable** ecosystems are reasonably intact (<80% and >60% natural habitat), but are nearing the threshold beyond which they will start to lose ecosystem functioning.
- **Endangered** ecosystems have lost significant amounts of their natural habitat (<60% but still containing more natural habitat than the biodiversity target), which impairs their functioning.
- **Critically endangered** ecosystems have so little natural habitat left that their functioning has been severely impaired (they have less natural habitat than their biodiversity targets), and species associated with this ecosystem class are in decline or becoming locally extinct.

These categories of threat align with those used internationally for assessing the extinction risk of species.

Of South Africa's terrestrial ecosystems, 34% are threatened (that is, those classified as vulnerable, endangered, and critically endangered). These lie primarily within the South-western Cape's fynbos biome, the central grasslands, and the eastern coastal regions of the country. Of these:

- 21 terrestrial ecosystems (5%) are critically endangered: of these, 14 are in the fynbos biome, 5 in the forest biome, 1 in the grassland biome, and 1 is a wetland vegetation type
- 58 terrestrial ecosystems (13%) are endangered, most of which are in the grassland and savanna biomes
- 70 terrestrial ecosystems (16%) are vulnerable: most of these are in the fynbos and grassland biomes.

There are 17 vegetation types in South Africa that have been assessed as being highly fragmented, occurring especially in the Western Cape (most are fynbos vegetation types, such as Renosterveld) and in the grasslands and KwaZulu-Natal coastal belt⁵¹ (see Table 5.1).

The protection from threat of vulnerable components of biodiversity through the establishment of conservation areas is widely accepted as one of the primary ways to conserve biodiversity directly.

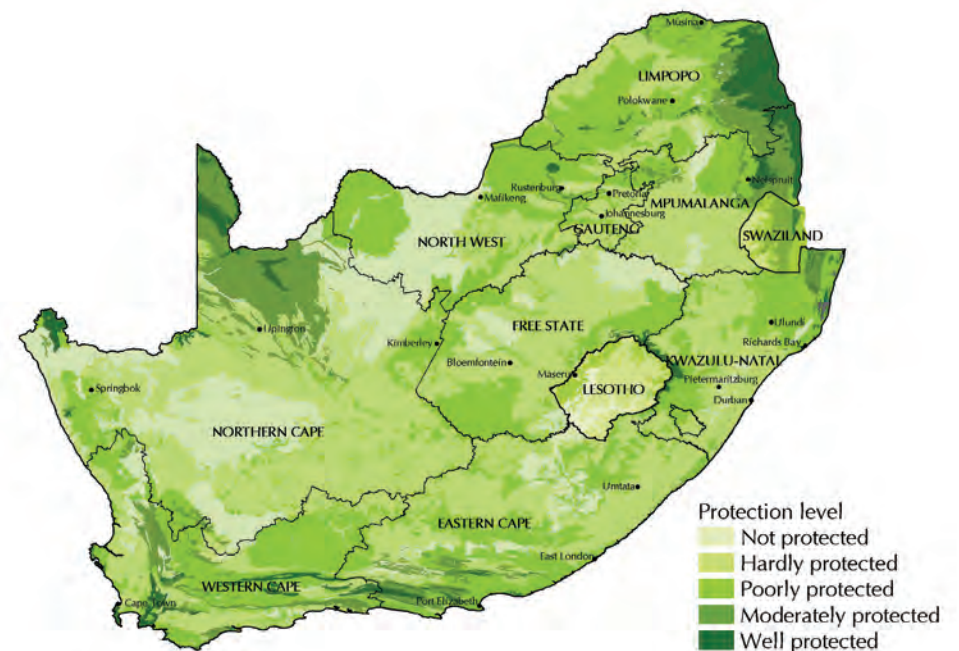
South Africa's conservation areas include the formal statutory protected areas (PAs) (Type 1); the less formal PAs, such as mountain catchment areas and state forests of the Department of Water Affairs and Forestry (DWAF) (Type 2); and informal landowner activities such as game farms and conservancies (Type 3). Currently, just under 6% of land in South Africa is formally protected in Type 1 and

Type 2 PAs. The conservation estate consists of 479 Type 1 PAs (representing 77% of the total protected area in Types 1–3) and 471 Type 2 PAs. Only a few PAs are greater than 100 000 hectares (ha) in area, and most of them cover between 1 000 and 10 000 ha².

South Africa has a long history of proclaiming conservation areas, but the traditionally ad hoc establishment of conservation areas focused on land with low agricultural or high tourism potential. The resultant conservation area network is therefore biased towards certain ecosystems, and is far from wholly representative of the country's diversity of biomes and habitat types.

The 2004 NSBA⁷ measured the proportion of the conservation target of each ecosystem (in terms of vegetation types) that had been achieved in Type 1 protected areas. (For NSBA protection level assessment results, see Map 5.6.) It reveals that 110 South African vegetation types out of 447 are not protected at all, and that an additional 90 vegetation types, with less than 5% of their biodiversity target protected, are not adequately conserved. More than 300 vegetation types have less than half of their biodiversity target conserved in statutory PAs. Only 67 vegetation types are adequately conserved (in relation to their biodiversity targets): 22 types of fynbos, 18 types of savanna, and 7 types of forest. No grassland types are adequately conserved.

Correcting these biases in coverage as well as ensuring proper management of biodiversity and ecosystem processes in these conservation areas are essential ingredients for ensuring conservation success.



Map 5.6: Protection levels of terrestrial ecosystems

Source: National Spatial Biodiversity Assessment 2004⁷

Table 5.1: Critically endangered vegetation types in South Africa

Vegetation type	Biome	Remaining area (%)	Biodiversity target (%)	Protected (%)
Piketberg Quartz Succulent Shrubland	Fynbos	0	26	0.0
Lourensford Alluvium Fynbos	Fynbos	7	30	4.2
Swartland Shale Renosterveld	Fynbos	9	26	0.5
Swartland Silcrete Renosterveld	Fynbos	10	26	0.6
Cape Vernal Pools	Wetlands	12	24	0.0
Central Ruens Shale Renosterveld	Fynbos	13	27	0.4
Western Ruens Shale Renosterveld	Fynbos	14	27	0.0
Elgin Shale Fynbos	Fynbos	18	30	5.9
Cape Flats Sand Fynbos	Fynbos	19	30	0.1
Eastern Ruens Shale Renosterveld	Fynbos	19	27	0.4
Swartland Granite Bulb Veld	Fynbos	20	26	0.6
Ruens Silcrete Renosterveld	Fynbos	22	27	0.1
Peninsula Shale Renosterveld	Fynbos	23	26	18.7
Swartland Alluvium Fynbos	Fynbos	25	30	1.7
Woodbush Granite Grassland	Grassland	26	27	0.0
Cape Lowland Alluvial Vegetation	Fynbos	31	31	0.7
Swamp Forest	Forest	95	100	100.0
Mangrove Forest	Forest	96	100	46.9
Lowveld Riverine Forest	Forest	97	100	100.0
Sand Forest	Forest	98	100	100.0
Ironwood Dry Forest	Forest	100	100	100.0

Note: These were identified based on extent of habitat transformation and biodiversity target. For all of them, the percentage of remaining natural habitat is less than the biodiversity target (set to represent 75% of the plant species associated with the vegetation type).

Source: Taken from Rouget et al. (2005)²²

5.3.2 River ecosystems

Owing to the water-scarce nature of most of South Africa, our rivers are vulnerable to over-exploitation and modification, which has implications for aquatic ecosystem functioning and biodiversity. Biodiversity conservation can be particularly challenging in water-limited countries such as South Africa, where the main rivers are heavily used, with multiple demands from urban settlements, agriculture, and industry.

A 2004 integrity assessment of South Africa's rivers⁵² demonstrated that 48% are moderately modified, 26% are largely to critically modified, while 26% are intact. Insufficient data on river integrity at a national scale is a major limitation to this assessment, however. The results are based on an assessment of main rivers only, and ignore the substantial conservation potential of numerous tributaries within catchments where the main river is not intact. This

highlights the importance of healthy tributaries as refuges for conserving biodiversity.

The status of river ecosystems was derived in a similar way as that of terrestrial ecosystems, based on the extent of remaining intact (that is, natural or near-natural) river length of each main river ecosystem in relation to its biodiversity target⁵². Main river ecosystems were combined spatially with river integrity data to calculate the intact length of each main river ecosystem. Intact length was compared to the total length of each main river ecosystem to derive conservation status categories of each ecosystem, defined as follows:

- **Least threatened (LT)** river ecosystems have an intact length >60% of their total length
- **Vulnerable (VU)** river ecosystems have an intact length >40% of their total length
- **Endangered (EN)** river ecosystems have an intact length below their biodiversity target (in this case, 20% of their total length)
- **Critically endangered (CR)** river ecosystems have an intact length below their biodiversity target (this target is 10 % of their total length).

The results (see Map 5.7) indicate that 82% of main river ecosystems are threatened. Water management areas in the south of the country (Berg, Breede, and Gouritz), and those associated with the middle and upper Vaal River are most in need of protection, that is, these rivers risk irreversibly losing the ability to support their biodiversity components (natural river habitat, plants, and animals). These ecosystems have lost so much of their original natural habitat that ecosystem functioning has broken down and species associated with the ecosystem have been lost or are likely to be lost. Of the 82% of river ecosystems that are threatened, 44% are critically endangered, 27% are endangered, and 11% are vulnerable.

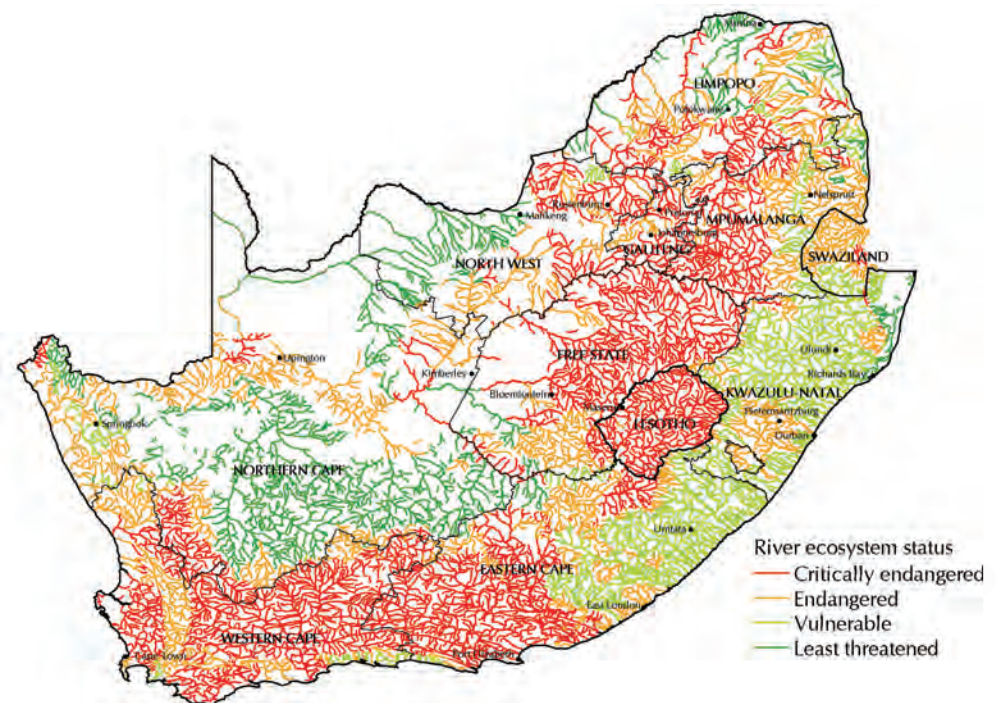
When the river ecosystem status outputs are compared with those of terrestrial ecosystems (compare Maps 5.2 and 5.7), it becomes clear that the state of river biodiversity in the country needs urgent attention. The results show that the state of terrestrial biodiversity in the country (despite itself needing attention) is generally better than that of river and marine ecosystems⁷.

Formal protected areas in South Africa focus primarily on conserving terrestrial ecosystems and, in the process, inadvertently capture portions of river ecosystems that run through them. Little emphasis has been placed on proclaiming protected areas for the primary purpose of conserving entire river lengths (mainly because this is not a practical management option for rivers, which generally traverse great distances in the landscape) or that encapsulate important catchment areas. Statutory reserves or conservation agreements protect only 7% of the total



Orange River below van der Kloof Dam. *Photography: South African Tourism*

river length in South Africa (this does not include privately owned areas). Approximately one third of South Africa's main rivers define the boundaries of protected areas rather than occurring within them, and therefore they cannot be considered protected. This situation emphasizes the polarity between conservation approaches to terrestrial and



Map 5.7: Ecosystem status of South African rivers



Wetlands perform many essential functions such as the “enhancement of water quality, erosion control, water storage, streamflow regulation, flood attenuation, and maintenance of biodiversity” and supply many essential goods and services.

Wetlands are essential in an arid, water-scarce country such as South Africa, yet an estimated 50% of South Africa’s wetlands have been destroyed.

freshwater biodiversity over the past century⁵², but there is evidence that significant recovery of river system health can occur downstream of protected areas.

5.3.3 Wetlands

The National Water Act (No. 36 of 1998) defines a wetland as “land which is 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”. There are many wetland types including springs, mires, bogs, floodplains, vleis, seeps, coastal lakes, estuaries, and mangrove swamps.

Wetlands perform many essential functions such as the “enhancement of water quality, erosion control, water storage, streamflow regulation, flood attenuation, and maintenance of biodiversity” and supply many essential goods and services^{53, 54}. They have significant social and economic value, providing food, plant, water, medicinal resources, and livelihood to rural communities, and contribute in important ways to tourism, subsistence farming, grazing, and environmental education and awareness⁵⁴. More important, a healthy wetland system indicates a healthy functioning ecosystem. Most wetlands are either fed by groundwater inflows, or they lose water by seepage into the subsurface, or both. During drier months, groundwater is generally the only source of water for many of these ecosystems⁵⁶.

Wetlands are essential in an arid, water-scarce country such as South Africa, yet an estimated 50% of South Africa’s wetlands have been destroyed^{57, 58}. This serious

loss is caused, for example, by the building of dams, incorrect burning and overgrazing, invasive alien species, the use of wetlands for waste disposal and the abstraction of water, the drainage of wetlands for agricultural cultivation or urban development, and inappropriate land management. The exploitation and degradation of South Africa’s wetland ecosystems is set to rise as the human population grows and increases its demand for water and land for settlement in and around urban areas⁵⁹.

Little reliable information exists on the distribution and state of wetlands. The NSBA used data from 1995 and the latest vegetation map to identify 740 wetlands divided into 17 wetland types and 12 wetlands/estuaries of international significance. Cowan’s (1995)⁶⁰ wetland dataset is the best available for the country, although the NSBA identified significant gaps in this dataset, especially in some parts of the country, for example the Eastern Cape. For reliable future assessments of the state of South Africa’s wetlands, a more comprehensive wetlands map as well as information on the state of wetlands are required (such a map is in development through the National Land Cover 2000 Project).

About 10% of the number of wetlands in South Africa are fully protected and another 8% are partly protected; 16% of the country’s wetlands have no legal protection, and there is no available information on about 66% of them, which is a serious impediment to our ability to protect and manage this valuable resource adequately.

Possibly the most important factor in the conservation of South African wetlands is South Africa’s participation as a founding member of the Ramsar⁶ Convention on Wetlands (it was the fifth contracting party in 1975). To meet its Ramsar obligations and to promote the conservation of wetlands throughout southern Africa, the country implemented the South African Wetlands Conservation Programme. Since 1975, South Africa has had 17 sites added to the Ramsar List of Wetlands of International Importance (see Table 5.2).

The international importance of wetlands is demonstrated by their visitors, such as the wading birds from as far away as the Russian tundra that winter in the wetlands of southern Africa, and the fact that some southern-breeding birds fly to other parts of the world as part of their life cycles. According to the Ramsar Information Pack (available at <http://www.ramsar.org>), “These [wetland] functions, values and attributes can only be maintained if the ecological processes of wetlands are allowed to continue functioning. Unfortunately, in spite of important progress made in recent decades, wetlands continue to be among the world’s most threatened ecosystems, owing mainly to ongoing drainage, conversion, pollution, and over-exploitation of their resources”. The protection of wetlands needs to combine water resource management with land-use management.



Highmoor wetland near farmland. Photography: Janet Peace



To date, implementation of catchment management planning in South Africa has been weak, owing to fragmented institutional arrangements, confusion about overlapping jurisdiction and areas of responsibility, and lack of appropriate management strategies that bring wetlands to the fore in the water and natural resource sectors⁶¹.

5.3.4 Estuarine ecosystems

An estuary is a portion of a river system that has, or can have, interaction with the sea. Concern about the state of South Africa's 259 estuaries stretches back to at least the 1970s, when few estuaries were found to be in their original state, especially in KwaZulu-Natal^{62, 63, 64}. A DWAF national assessment of the condition of South African estuaries in the 1980s^{65, 66} found that about a quarter of KwaZulu-Natal's estuaries and a fifth of those in the then Cape Province were in a poor condition.

In 2000, an assessment by Whitfield⁶⁷ on the condition of South African estuaries (including those of the old Ciskei and Transkei) classified them as follows:

- **Excellent:** estuary in near pristine condition (negligible human impact)
- **Good:** no major negative anthropogenic influences on either the estuary or catchment (low impact)
- **Fair:** noticeable degree of ecological degradation in the catchment and/or estuary (moderate impact)
- **Poor:** major ecological degradation arising from a combination of anthropogenic influences (high impact).

The NSBA used the Whitfield (2000)⁶⁷ results with some adjustments (as more recent assessments were subjective or geographically biased). Ecosystem status (from least threatened to critically endangered) was determined on the basis of the proportion of estuaries in each type within each zone that were in a good or excellent state of health⁶⁸.

South Africa's estuaries are in relatively good health. The condition of 28% of them is considered to be excellent; that of another 31% is good; 25% is classified as fair and 15% as poor. Estuaries along the south and southeast coast tend to be healthier than those in the rest of the country (see Map 5.8) and the estuaries along the Wild Coast are healthiest of all. On average, health is also relatively good for the major systems on the west coast and in northern KwaZulu-Natal. Estuaries tend to be in fair to poor health along the intensively developed areas of the Cape southwest coast, around Port Elizabeth, and along most of the KwaZulu-Natal coast.

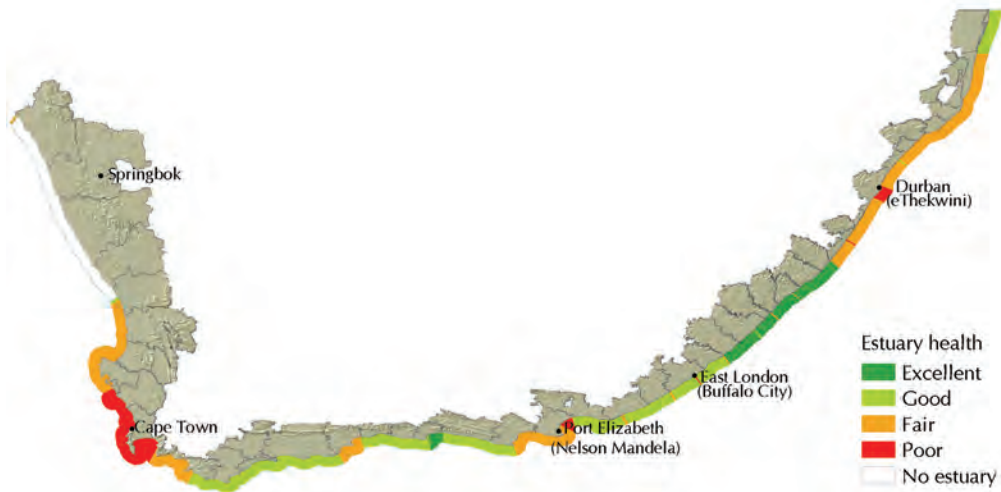
In terms of ecosystem status for estuary types, most of the groups occurring in transition zones between ecoclimatic areas are endangered or critically endangered. In the subtropical zone, all but permanently open estuaries are endangered or critically endangered, and all estuary types

Table 5.2: South African Ramsar sites

Province	Ramsar sites
Free State	Seekoivlei Nature Reserve
Gauteng	Blesbokspruit
KwaZulu-Natal	Kosi Bay System
	Lake Sibaya
	Ndumo Game Reserve
	St Lucia System
	Turtle Beaches & Coral Reefs of Maputoland
	Ukuhlamba Drakensberg Park
Limpopo	Nylsvley Nature Reserve
Mpumalanga	Verloren Valei Nature Reserve
North West Province	Barberspan
Northern Cape	Orange River Mouth
Western Cape	De Hoop Vlei
	De Mond State Forest
	Langebaan Lagoon
	Verlorenvlei
	Wilderness Lakes

in the cool temperate zone are endangered or critically endangered. In the warm temperate zone, permanently open estuaries are endangered, but other estuary types are in better condition.

The overall level of protection of South African estuaries is low. Of the 41 estuaries within protected areas, only 14 (5.4%) have a high level of protection and, of these estuaries, most are very small. This is a long way from the minimum target of 30% of estuaries protected at a high level as recommended by Turpie *et al.* (2004)⁶⁸. Several well-protected estuaries occur in KwaZulu-Natal, including some of the country's largest estuaries (St Lucia and Kosi). A series of small estuaries has high-level protection within the Tsitsikamma National Park in the Eastern Cape. Further west along the coast, the Heuningnes and Kromme estuaries also fall within securely protected areas. For the remaining estuaries, protection is only partial (that is, only parts of the estuary are protected, or only areas below the high tide mark), as is the case for the estuaries within the Pondoland Marine Protected Area.



Map 5.8: Estuary health in South Africa

Source: National Spatial Biodiversity Assessment 2004⁷

species (some 250) targeted by South African commercial fisheries, more species-level interventions may be required in the marine environment than in the terrestrial environment.

The assessment of priorities needing most urgent attention showed that the west-coast biozones not only have the least protection (zero), but also currently experience the greatest threats. Immediate conservation intervention in these biozones is required to prevent irreversible negative impacts.

The NSBA's spatial evaluation of existing marine protected areas (MPAs) in South Africa shows that, while 23% of the coastline is protected by MPAs, only 9% of the area of these MPAs are fully protected (that is, classified as no-take zones). In addition, MPAs are not distributed evenly along the coast and therefore do not represent the full spectrum of South Africa's coastal marine biodiversity. The entire Namaqua bioregion on the west coast has no MPA, whereas more than 20% of the Delagoa bioregion (on the Mozambique border) is protected in no-take MPAs. The state of the offshore environment is worse, with less than 1% of South Africa's Exclusive Economic Zone (EEZ) within MPAs and, of this tiny proportion, less than 0.2% is no-take. A proposed Namaqualand MPA would more than double the sea-surface area under protection, but would still fall far short of the 20% internationally recommended target⁶⁹.

Protection status data in the NSBA (see Map 5.10) show that 23 of its 34 biozones have zero or little protection. These include the Namaqua biozones, the lower slope, and the abyss in South Africa's EEZ. Well-protected biozones include many of the supratidal biozones and the biozones of the Delagoa bioregion. The NSBA cautions that MPAs do not always ensure adequate protection of biodiversity, and that more effort is needed to ensure compliance within MPAs.

5.4 THE STATUS OF SPECIES

5.4.1 Terrestrial species

Threatened species constitute a widely used indicator of the status of biodiversity. Red Data Books and lists based on World Conservation Union (IUCN) criteria are used to highlight species at high risk of extinction. These assessments are excessively time- and resource-demanding, however, and are therefore infrequently conducted, particularly at a regional or local scale. As a result, the indicator is often based on outdated or global assessments.

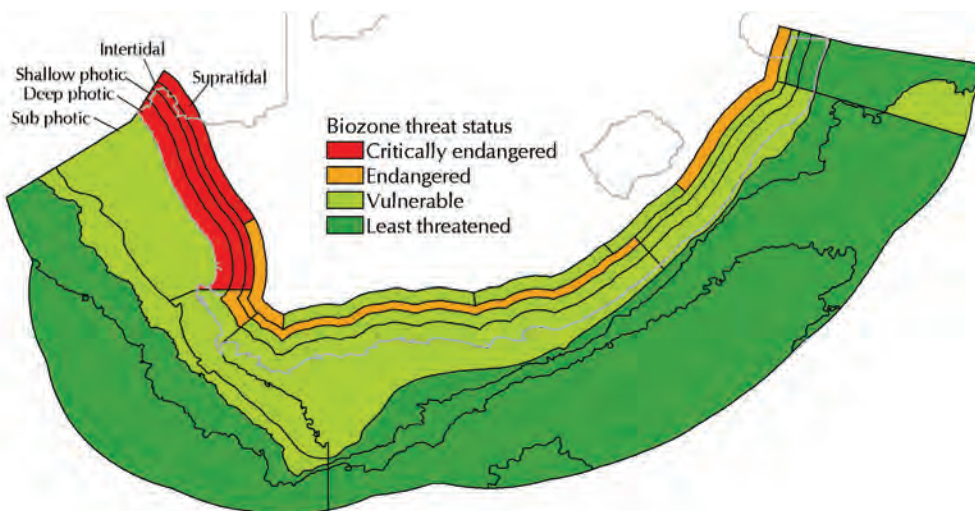
Recent South African assessments of the status of birds, mammals, and frogs have demonstrated that almost 10% of South Africa's birds and frogs are threatened, and 20% of its mammals are threatened (Figure 5.3)^{70, 71, 72}. The country's plants are currently being assessed by the

5.3.5 Marine ecosystems

The NSBA was the first national spatial assessment of marine ecosystems. It mapped 34 biozones (broad marine ecosystems), defined as depth zones (moving from the coast to the abyss), subdivided by bioregions (moving from west to east). (For the threat status of these biozones, see Map 5.9.) The assessment found that 65% of South Africa's marine biozones are threatened. Of these, 12% are critically endangered, 15% are endangered and 38% are vulnerable.

The extraction of living marine resources is the overriding threat to South African marine biodiversity and affects all depth strata and all bioregions. Pollution and mining are the next most serious threats, but mining is restricted to particular biozones, especially on the west coast. Mining and commercial fishing are responsible for the critically endangered status of the west-coast biozones (see Map 5.9). All threats are predicted to increase in the next ten years, especially those posed by invasive alien species and mariculture. Owing to the high number of

The extraction of living marine resources is the overriding threat to South African marine biodiversity and affects all depth strata and all bioregions.



Map 5.9: Ecosystem status of marine biozones

Source: National Spatial Biodiversity Assessment 2004⁷

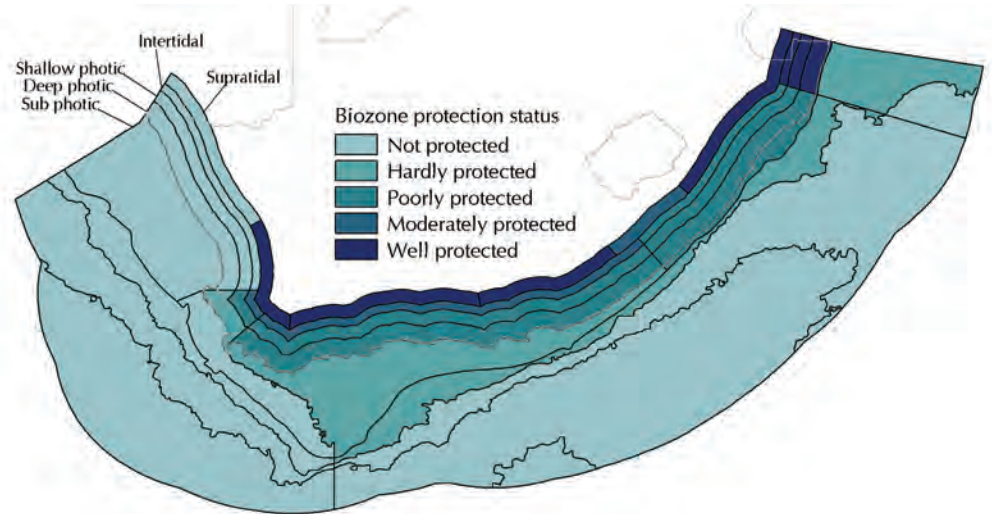
South African National Biodiversity Institute's threatened species programme. Previous assessments show over 10% of plant species threatened with extinction in South Africa⁸.

The threatened species indicator becomes most useful when it is spatially explicit (that is, when it is possible to locate the area where threatened species occur). The 2002 national assessment by the Endangered Wildlife Trust (EWT) attempted to correlate the numbers of threatened species (excluding plants) with biomes (see Figure 5.4). It found that no particular biome contains more threatened species than any other, but if the plants had also been fully assessed, the fynbos would probably have been highlighted.

5.4.2 Freshwater species

Although many taxa inhabit our rivers, most conservation information is limited to fish. No known fish species have become extinct in South Africa, but there are records of some species being eliminated from certain river systems, and many species showing range reductions¹. Approximately 36% of freshwater fish are threatened, but there is a need to reassess their conservation status¹. A summary of the status of six flagship species is presented below⁸:

- Nile crocodile (*Crocodulus niloticus*): distribution has declined and is largely confined to conserved areas, owing to habitat destruction and indiscriminate slaughter. Nile crocodiles are important as top predators of fish such as barbel. (No detailed predation data currently available.)
- Cape clawless otter (*Aonyx capensis*): the main threats to the survival of this clear freshwater-dependent mammal are water extraction, construction of dams, and invasive aquatic plants. Their numbers and distribution are declining steadily, with some local extinctions caused by loss and degradation of habitat.
- African jacana (*Actophilornis africanus*): this bird is associated with aquatic habitats that contain floating hydrophytes, typically seasonal pans and floodplains, and slow-moving rivers. Wetlands suitable for breeding are increasingly threatened by water management and extraction schemes. (No detailed data currently available.)
- East coast rocky (*Sandelia bainsii*): This freshwater fish occurs only in short sections of several rivers in the Eastern Cape. It is now considered critically endangered (in the past 30 years its population numbers have dropped exponentially), the main threats being habitat change, alien fish through inter-basin transfers (notably the sharptooth catfish), dam building, and excessive water extraction.
- Small scale redbfin minnow (*Pseudobarbus asper*): unlike their redbfin minnow cousins confined to the Cape fold belt, this species has adapted to several Karoo streams



Map 5.10: Protection levels of marine biozones

Source: National Spatial Biodiversity Assessment 2004⁷

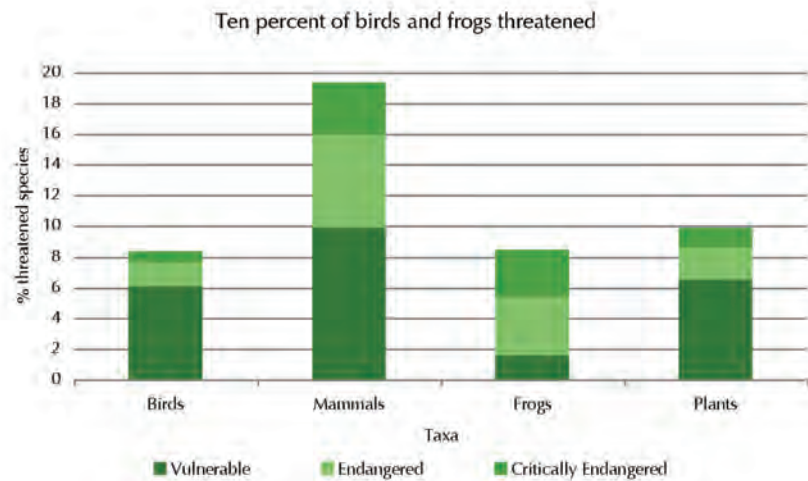


Figure 5.3: Threatened species per taxonomic group

Source: Endangered Wildlife Trust, 2002⁸

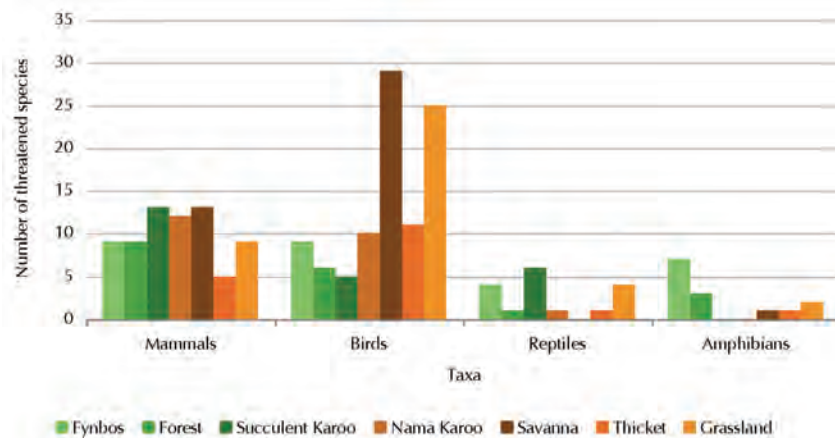


Figure 5.4: Number of threatened species per taxonomic group per biome

Source: Endangered Wildlife Trust, 2002⁸

Box 5.3 Rare antelope declines in the Kruger National Park

Between 1986 and 1995, populations of three rare antelope species declined drastically in the Kruger National Park. Only about 25 roan antelope, 500 sable antelope, and 250 tsessebe remained. These low numbers threaten the possible loss of a substantial part of the park's large herbivore diversity.

Decline of antelope species

What has caused this decline?

All three species are at the limits of their distribution range in the Kruger National Park, and occur more commonly in wetter savannas to the north. Hence the persistently low rainfall in this period with extreme droughts associated with El Niño conditions in 1982/3 and in 1991/2 is an obvious factor to consider. Despite the dry conditions – and while numbers of kudu, waterbuck and warthog also decreased drastically – zebra, wildebeest, giraffe and impala maintained high abundance levels.

Why were the latter species more resistant to the dry conditions? Calf production had remained unchanged during the period of the declines for all of the species affected. Changes in population trends must therefore have resulted from a decrease in survival of adults. If decreases in abundance resulted from reduced food production because of low rainfall, juveniles would have been affected most. Could predators, in particular lions, play a role? Although there was no information on lion numbers, the prey base for lions (mainly zebra and buffalo) had increased. If the lion population had increased as a consequence, other ungulates would have incurred a higher risk of predation, simply because there was a greater chance that they would encounter lions. The pattern was clear in the north of the Park. Following the 1982/3 drought, zebra numbers doubled in the north and rangers reported seeing more lions here, where lions had not formerly been very numerous. An increase in the prey base had enabled lions to move in and establish pride territories, thus increasing the exposure of roan, tsessebe, and sable in this region to predation.

But why then were the populations of zebra, wildebeest, and buffalo, the three main prey species for lions, unaffected? A previous analysis showed that numbers of wildebeest and zebra tend to increase under dry conditions, because they are less vulnerable

to predation owing to the reduction of grass cover to hide stalking lions. Buffalo, however, are more vulnerable to being killed when rain is low, and they helped to support the supposed increase in lion abundance after 1983. The species that declined after 1986 all seemed to do best when the rainfall was high, so the dry conditions through the late 1980s probably contributed to their susceptibility to predation.

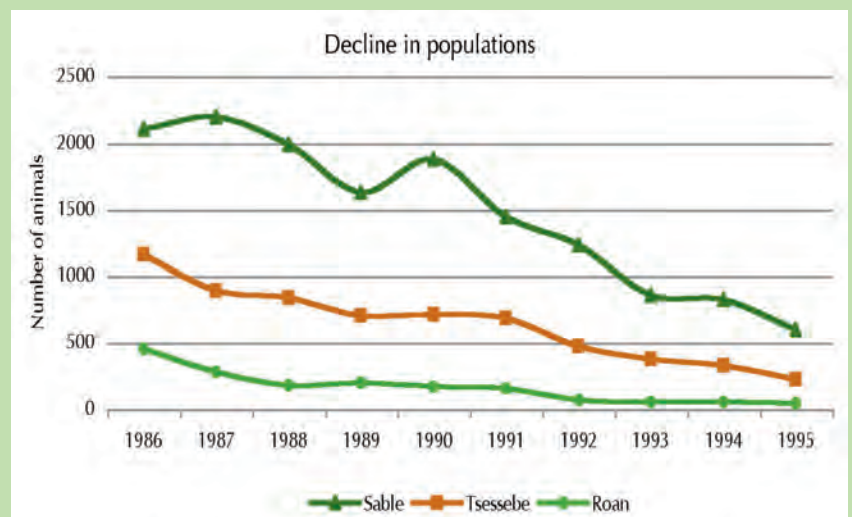
However, the doubling in numbers of zebra seemed largely to be a response to the widened distribution of surface water throughout the park, as a consequence of the policy of adding additional waterpoints in the form of boreholes, dams, and weirs. This seemed to have benefited mainly the common, water-dependent ungulates at the expense of less common species, and, in particular, the abundance of lions through the expansion in their prey base.

This picture shows how the effects of changing rainfall ramify through an ecosystem by affecting different species in different ways. The more fundamental message is that the augmentation of surface water caused the loss of regions where other ungulate species could escape high predation risks and thus, in the past, persist through drought conditions. Park managers are currently removing many of the artificial waterpoints that had previously been established, but have to consider also the attraction that these provide for tourists.

Sources: Text by Norman Owen-Smith (University of the Witwatersrand) and based on research by Ogotu and Owen-Smith (2005)⁷³, Owen-Smith (in press)⁷⁴, Owen-Smith and Mills (in press)⁷⁵, Owen-Smith (2005)⁷⁶, Owen-Smith and Mason (2005)⁷⁷, Owen-Smith et al., (2005)⁷⁸, Ogotu and Owen-Smith (2003)⁷⁹, Harrington et al., (1999)⁸⁰.



A group of sable antelope at waterhole. *Photography: South African Tourism*



Decline of antelope species

where, in response to intermittent flow patterns, they have evolved to mature early and produce large numbers of eggs to take advantage of 'boom and bust' conditions. Introduction of the alien catfish, however, is severely reducing their numbers in the Gamtoos River system.

- Basking malachite damselfly (*Chloroestes apricanus*): described only in 1975, this damselfly was known from ten locations in the clear, unspoilt streams of the Stutterheim area of the Eastern Cape. It is now known only from two sites, but the removal of alien invasive trees, especially black wattle, is helping this sun-loving species to recover.

5.4.3 Wetland species

Wetlands are crucial habitat for many species, often performing a vital role in the life cycle stage of a species (for example, for migratory stopovers or as breeding grounds). They support high concentrations of birds (especially waterfowl), mammals, reptiles, amphibians, fish, and invertebrates, and they are renowned for their high levels of endemic and specialized species. Unlike terrestrial ecosystems, the richness of freshwater biodiversity is still little known. Identification and classification of wetland species is hampered by the fact that many of them may spend only part of their lives in wetlands. The African jacana flagship species found in freshwater systems could equally be considered a flagship wetland species.

5.4.4 Estuarine species

There is also little information on the status of estuarine species, a serious gap in the overall conservation database. The estuaries of the Western and Eastern Cape are vital in providing a sanctuary for endemic species⁸. Six flagship species include⁸:

- Knysna seahorse (*Hippocampus capensis*): this estuarine fish is endemic to South Africa and is known only from the Knysna and Swartvlei estuaries of the southern Cape coast. It is considered the most endangered seahorse in the world (according to the IUCN Red Data lists). Its threatened status is due to habitat degradation in its extremely limited habitat and to mass mortalities in the Swartvlei estuary that were caused by artificial breaching of the estuary mouth.
- Perringuey's leaf-toed gecko (*Cryptactities peringuey*): this small gecko was rediscovered in 1992 after being 'lost' for 80 years. The only gecko in the world that lives in salt marshes, it is known only from the Kromme River estuary and a few sites near Port Elizabeth. As salt marshes disappear under bulldozers, so also will this unique gecko.
- White steenbras (*Lithognathus lithognathus*): the once abundant white steenbras is now severely depleted –



The Knysna seahorse (*Hippocampus capensis*) is endemic to Knysna and Swartvlei estuaries.

Photography: IMACES24.co.za / Beeld / Alan Murdoch

down to 5% of its original biomass – through over-fishing (because of its spawning aggregations, it was vulnerable to heavy fishing pressure and beach seine nets) and habitat degradation (its juvenile nurseries are estuary dependent). Severe fishing restrictions are now in place to save this valuable endemic.

- Estuarine pipefish (*Syngnathus watermeyer*): an Eastern Cape endemic, this fish was known only from the Bushmans, Kariega, and Kasuka estuaries, with the last known specimens in these estuaries collected in 1963. In 1996, a healthy population was discovered in the East Kleinemonde estuary, however, the only estuary where this species has again been found. Its precipitous decline is due to the absence of the required fresh water pulses into the estuaries, in catchments where upstream impoundments have inadequate environmental flow allocations.
- Burrowing prawn (*Callinassa sp.*): abundant in estuaries from Saldanha on the west coast to southern Mozambique, burrowing prawns are targeted by fishermen for bait. Nevertheless, their populations appear robust and they are more at risk from isolated events, such as salinity fluctuations and pollution.
- Eelgrass (*Zostera sp.*): eelgrass, present in many South African estuaries, binds sediments, shelters juveniles, and serves as a primary food producer. It is threatened by mismanaged catchments, pollution, and disturbance of estuaries. Eelgrass stands remain viable in smaller estuaries, but rehabilitation in larger systems is urgently needed.

Because of habitat degradation and increasing human pressures on estuaries, four South African estuarine fish species are listed as critically endangered on the IUCN Red Data List: doublesash butterflyfish (*Chaetodon marley*), Knysna seahorse (*Hippocampus capensis*), St Lucia mullet (*Liza luciae*), and estuarine pipefish (*Syngnathus watermeyer*).



Leatherback turtle. Photography: South African Tourism

5.4.5 Marine species

Some 10 000 species of marine plants and animals have been recorded in South Africa's marine environment⁸, that is, almost 15% of global marine species diversity. Some of these represent an important resource base for coastal subsistence communities, as well as for the millions of people who eat them. Little information exists on the status of marine species overall, and available data relate to particular species that are exploited for human use. Although many fisheries are stable and well managed, there are some alarming trends for species such as lobster, abalone, and linefish. One example is the Patagonian toothfish (*Dissostichus eleginoides*), a threatened species found in the waters of South Africa's EEZ around the Prince Edward Islands. Illegal fishing of the Patagonian toothfish in these waters, estimated at over 20 000 tons in 1996⁸¹, has decimated the stocks.

Five critically endangered, 15 endangered, and 26 vulnerable marine animal species have been recorded in South Africa⁸. These numbers are low and reflect the inadequacy of our information on marine species, mostly because collecting such information is difficult, given the limitations on time that can be spent under water. Valuable marine species are for the most part assessed in terms of their commercial status rather than their absolute abundance.

All five species of marine turtles occurring in South African waters are listed on the IUCN Red List as either vulnerable or endangered. Leatherback turtles (*Dermochelys coriacea*) are particularly susceptible to long-line fishing and trawling, but the use of turtle-excluder devices is now mandatory and has assisted in promoting the status of these turtles from critically endangered in 2001 to endangered in 2004. All leatherback turtle nesting sites in South Africa occur within the Greater St Lucia Wetland Park, which is a world heritage as well as a Ramsar site, thus

affording these nesting grounds the country's highest level of protection.

The status of the blue whale (*Balaenoptera musculus intermedia*) is classified as endangered and, although it is now fully protected in South African waters, populations are still struggling to recover from historic exploitation. Four other marine mammal species occurring in South African waters are considered to be vulnerable, namely, the Indian Ocean bottlenosed dolphin (*Tursiops aduncus*), the Indian Ocean humpback dolphin (*Sousa plumbea*), the sperm whale (*Physeter macrocephalus*), and Bryde's whale (*Balaenoptera bryde*).

Oceanic and coastal bird species are primarily threatened by long-line fishing activities, habitat loss, and disturbance while nesting. The bittern (*Botaurus stellaris*) is considered to be critically endangered due to loss of habitat in northern KwaZulu-Natal, and three tern species are listed as endangered, primarily due to habitat loss and disturbance. The Tristan albatross (*Diomedea dabbenena*) and spectacled petrel (*Procellaria sp.*) are listed as endangered and four further albatross species as vulnerable, mostly due to long-line-fishing-induced mortalities. These six species have become listed as 'endangered' or 'vulnerable' within the past decade.

On its Red List, the IUCN lists 53 species of coastal fish found in South African waters, but this is a global assessment and its pertinence to actual fish populations in this country has been questioned⁸². The most recent evaluations of South Africa's marine fish status indicates that up to 20 species of commercial and recreational marine fish are considered over-exploited and/or collapsed^{83, 84}. (See Chapter 7, section 7.5.)

The NSBA marine species analyses based on seaweeds, intertidal invertebrates, and fish demonstrated that, although many of these species may exist in marine protected areas (MPAs), their status is uncertain. Surveys of the relevant MPAs are required, as several gaps were



Black wattle infesting the banks of the Klein Brak River. Photography: Wilma Strydom

Some 10 000 species of marine plants and animals have been recorded in South Africa's marine environment, that is, almost 15% of global marine species diversity.



identified in terms of species protection in these areas. The study found that if the proposed Namaqualand MPA is proclaimed, it could protect a representative sample of all the species occurring along the Northern Cape coastline. Owing to the fact that the fish fauna are the most exploited and threatened component of marine life, the NSBA stressed that an accurate fish distribution database needs to be compiled, to allow these analyses to be repeated. (See Chapter 7, section 7.4.)

5.5 THE IMPACTS OF BIODIVERSITY LOSS

Destruction of ecosystems and loss of biodiversity can bring significant opportunity costs to social and economic systems through damage to the health, functions, and services that ecosystems provide. For example, according to the Working for Water programme, invasive alien plants use up 7% of South Africa's water resources; restrict and decrease the country's agricultural capacity, intensify flooding and fires, and are the cause of erosion, destruction of rivers, siltation of dams and estuaries, and poor water quality. They can also directly bring about the extinction of

indigenous plants and animals. Total economic losses of ecosystem services in the fynbos areas from alien plant invasion amount to almost R700 million per year, that is, an average annual 10% loss of economic opportunity, and growing⁸⁵. Global value of economic losses due to invasive alien species amount to almost 5% of the world economy, or some US\$1.4 trillion a year¹⁶. (See Box 5.2 for some of the opportunity costs of biodiversity loss in Durban.)

In the long term, over-exploitation of natural resources leads to dysfunctional ecosystems and deterioration in their productivity. This problem is compounded by lack of regulation and inadequate understanding of the impacts of over-exploitation. Adverse effects of over-exploitation include indirect effects on non-target species (for example, the killing of albatrosses caught in the by-catch of fishing industries using the long-line method⁸⁶).

5.6 RESPONDING TO BIODIVERSITY LOSS

Responses to the loss of biodiversity and of ecosystem health include measures that aim to conserve biodiversity

Destruction of ecosystems and loss of biodiversity can bring significant opportunity costs to social and economic systems through damage to the health, functions, and services that ecosystems provide.

Box 5.4 Transfrontier Parks and Transfrontier Conservation Areas (TFCAs)

One of the boldest and most exciting cross-border initiatives currently unfolding in southern Africa is the establishment, development, and management of Transfrontier Parks and Transfrontier Conservation Areas.

A Transfrontier Park comprises two areas, which border each other across international boundaries and whose primary focus is wildlife conservation. Authorities responsible for the respective areas formally agree to manage the areas as one integrated unit according to a streamlined management plan. The authorities also undertake to remove all human barriers within the Transfrontier Park so that animals can roam freely.

A Transfrontier Conservation Area (TFCA) is defined as a relatively large area, straddling frontiers between two or more countries and covering large-scale natural systems encompassing one or more protected areas. In a TFCA, different component sections have different forms of conservation status, such as national parks, private game reserves, communal natural resource management areas, and even hunting concession areas. Although fences, major highways, railway lines, and other forms of barrier may separate different sections, they nevertheless border each other and are managed jointly for long-term sustainable use. As distinct from

Transfrontier Parks, free movement of animals between the different parts that constitute a TFCA may not always be possible.

Although the establishment and development of Transfrontier Conservation Areas and Parks is a means for conservation and sustainable use of biological and cultural resources, they also aim to facilitate and promote regional peace, cooperation, and socio-economic development. It is envisaged that Transfrontier Parks and TFCAs will enable tourists to drive across international boundaries into adjoining conservation areas of participating countries with minimal obstacles and inconvenience. They are also expected to provide jobs and revenue generating opportunities for many local people.



San family in the Kgalagadi Transfrontier Park.
Photography: South African Tourism

South African National Parks and the Department of Environmental Affairs and Tourism have established a number of Transfrontier Conservation Areas and Parks that include the following:

- Kgalagadi Transfrontier Park – Botswana and South Africa signed a bilateral agreement in 1999
- Limpopo–Shashe Transfrontier Conservation Area – cooperation exists between Zimbabwe, Botswana, and South Africa
- Ai-Ais/Richtersveld Transfrontier Conservation Park – Namibia and South Africa signed a treaty in 2003
- Maloti–Drakensberg Transfrontier Conservation Area – Lesotho and South Africa signed a bilateral memorandum of understanding in 2001
- Lubombo Transfrontier Conservation Area – cooperation exists between South Africa, Mozambique, and Swaziland
- Great Limpopo Transfrontier Park and Resource Area – a joint agreement was signed in 2002 between South Africa, Zimbabwe, and Mozambique.

For further details see http://www.environment.gov.za/ProjProg/TFCAs/TFCA_contents.htm

Box 5.5 World Heritage Sites

UNESCO's World Heritage Convention recognizes and protects areas of outstanding natural, historical and/or cultural value to humanity. Regardless of the territory in which they are located, they belong to all the peoples of the world, and sites as diverse as the Great Barrier Reef in Australia and Egypt's Pyramids add to our global heritage in different ways.

Their value

Apart from being a source of inspiration and the means of learning about our ancestry and cultural diversity, heritage is also important in socio-economic development. World heritage sites attract many visitors and money spent on their maintenance and conservation are a key investment in tourism. Most visitors from abroad come to South Africa for its natural beauty and wildlife diversity. Many depart cherishing further memories of warm hospitality and rich cultural history. World heritage sites are monuments to our country's natural grandeur and our people's spirit.

Selection criteria

To achieve World Heritage Site status, an area or set of areas must satisfy a range of criteria. Cultural properties, for example, can represent a masterpiece of human creative genius or an important interchange of human values or exceptional architecture. Heritage is the sum total of sites of geological, zoological, botanical, archaeological, and historical importance, and includes national monuments; historic buildings and structures; works of art, literature and music; oral traditions; and museum collections and their documentation, all of which provide the basis for shared culture and creativity. Natural properties are expected to represent major stages in the Earth's history or noteworthy ongoing ecological and biological processes; sites such as the Greater St Lucia Wetlands Park or the Cape Floristic Region are areas of exceptional beauty and also contain important habitats for the conservation of biodiversity. Mixed properties (of which there are only 24 in the world) display characteristics of both cultural and natural value. Equally important, for both cultural and natural sites, is the authenticity of the area and the way in which it is managed and protected.

There are 812 world heritage sites in more than 130 countries around the globe. Since the inclusion of the Vredefort Dome, South Africa has seven sites:

- Robben Island
- Greater St. Lucia Wetland Park
- The Cradle of Humankind
- uKhahlamba Drakensberg Park
- Mapungubwe Cultural Landscape
- Cape Floristic Region
- The Vredefort Dome.



Sizing up Africa's baobab tree in the Mapungubwe National Park. *Photography: South African National Parks*

South Africa's most recent additions

South Africa's seventh world heritage site (and fourth natural heritage site), the Vredefort Dome, is the Earth's oldest and largest meteorite impact site, its 140-km diameter spanning parts of the Free State and the North West Province. It was created an estimated 2 billion years ago, when a giant meteorite hit the Earth, and thus represents an outstanding moment in the planet's history. The impact site offers virtually endless opportunities for geological research in the area. Apart from its scientific value, the Vredefort Dome site is also rich in ancient art forms, helping modern generations to explore and understand the traditional cultures of the Basotho, Batswana, and the Khoi-San.

As it celebrated the addition of the Vredefort Dome to the list of world heritage sites, the World Heritage Committee also added two extensions to the existing Cradle of Humankind site, namely the Taung Skull Fossil site and the Makapans Valley. Although not physically linked to Sterkfontein and its surroundings, these two sites share common features with the original hominid sites. The Makapans Valley in Limpopo has an unbroken record of early human occupation, dating from over three and a half million years ago. The Taung Fossil Site in the North West province is the place where the partial skull of a juvenile ape-man, representing *Australopithecus africanus*, was retrieved from a limestone quarry in 1924. The discovery of the Taung child led to the recognition of a new genus and species of hominid and a new field of scientific study, including African palaeoanthropology.

Sources: Department of Environmental Affairs & Tourism (2005). *Bojanala*, 11 (September/October). http://www.environment.gov.za/DOCUMENTS_UPLOAD/areasofinterest.aspx <http://whc.unesco.org/>

or to ensure the sustainable use and equitable sharing of natural resources. These strategies contribute to human well-being, as they conserve current and future ecosystem services and develop synergies and trade-offs with other sectoral needs (for example, agriculture and ecotourism). In South Africa, responses to biodiversity loss and degradation have surged with growing awareness of the importance of ecosystem services to human well-being. The country's responses range from the local to the global levels and are continuously developing. (For the legal framework and institutional arrangements for environmental management and protection, see Chapter 3.) A brief overview follows of the responses most applicable in the area of biodiversity.

5.6.1 International agreements and obligations

Political transformation in South Africa in 1994 brought significant policy changes, including those concerning the environment. Furthermore, South Africa played a leading regional and international role in the development and roll-out of the New Partnership for African Development (NEPAD), the World Summit on Sustainable Development (WSSD) in 2002, and the subsequent Johannesburg Plan of Implementation, and this role has been enhanced by the country's strengthening participation in international multilateral forums. There is international interest in the establishment of Trans-boundary Protected Areas (TBPAs), Transfrontier Conservation Areas (TFCAs), World Heritage Sites, contractual parks⁶, and a people-centred approach to conservation (see Box 5.4 and Box 5.5). South Africa is also a founding member of the Like-minded Group of Mega-Diverse Countries. At the time of going to press, a Regional Biodiversity Strategy and Action Plan is being finalized with other members of Southern African Development Community (SADC).

South Africa is signatory or party to almost 100 different multilateral environmental agreements (MEAs) ranging from broadly-focused agreements, such as the Convention on Biological Diversity (CBD), to those as specific as the Agreement on the Conservation of African–Eurasian Migratory Waterbirds. This involvement places significant obligations and burdens on South Africa to abide by the terms of each agreement, a challenge shared by the majority of participating countries.

Global concern for biodiversity loss led to the United Nations Conference on the Environment and Development (UNCED), that is, the Rio Earth Summit in 1992, from which the CBD emerged. It is founded on the principles that the well-being of the Earth and its biodiversity are inextricably linked and that human impacts on biodiversity directly affect human well-being. The convention has three main tenets: the conservation of biodiversity, the sustainable use of the

components of biodiversity, and the fair and equitable sharing of benefits arising from the commercial and other utilization of genetic resources. As one of its obligations as a party to the CBD, South Africa has developed a National Biodiversity Strategy and Action Plan (NBSAP), which has formed the basis of a National Biodiversity Framework (NBF). Since the CBD's inception in 1993, biodiversity loss has increased markedly, underlining the fact that political agreements mean little without the commitment of resources and the enforcement of legislation. To take the process further, the WSSD in Johannesburg succeeded in obtaining political commitment to "achieve by 2010 a significant reduction in the current rate of loss of biological diversity" – the so-called 2010 Biodiversity Target. It is generally recognised that achieving the Millennium Development Goals to ensure environmental sustainability and to halve global poverty is impossible without achieving this 2010 Biodiversity Target.

Other biodiversity related conventions include the Convention to Combat Desertification, the Convention on Migratory Species, and the Ramsar Convention on Wetlands of International Importance, which, amongst other things, promotes the wise use and conservation of all wetlands and the special protection of listed wetlands. In terms of its obligations to the Ramsar Convention, South Africa has declared 17 of its sites as Wetlands of International Importance.

International trade in wildlife and wildlife products is regulated through the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which accords varying degrees of protection to more than 30 000 species of animals and plants to ensure that trade does not threaten their survival⁷. South Africa ratified CITES in 1975 and is a significant importer and exporter of CITES-listed species. Social and economic incentives are increasingly being offered to local communities engaging in both legal and illegal utilization of natural resources, so as to promote the principles of sustainable use.

In evaluating responses, it is crucial to recognize that signing political agreements is not sufficient to address or eliminate threats to biodiversity and that significant outcomes depend on these agreements being implemented at both national and local levels.

5.6.2 National policy, legislation and institutions

Policy and legislation

South Africa's progressive constitutional framework enabled the development of innovative national environmental legislation. The Biodiversity White Paper of 1997 set out goals, strategies, and priorities for conservation, sustainable

South Africa is signatory or party to almost 100 different multilateral environmental agreements.

use, and equitable benefit-sharing. The National Environmental Management Act (Act 107 of 1998) (NEMA) introduced a new era of management of the environment, culminating in national legislation on biodiversity use and conservation (NEM: Biodiversity Act [NEMBA] and NEM: Protected Areas Act [NEMPA]). The Marine Living Resources Act (Act 18 of 1998) provides for the conservation, sustainable use and sharing of marine resources and ecosystems. With the impetus provided by the CBD, and if wisely used, these statutes, alongside the National Biodiversity Strategy and Action Plan and the National Biodiversity Framework, are invaluable tools for revolutionising the conservation, use, protection, and management of biodiversity in South Africa at large.

Spheres of government and departments

The Department of Environmental Affairs and Tourism (DEAT) holds the primary responsibility and authority for biodiversity conservation countrywide, but this responsibility is shared with other national departments including the Department of Water Affairs and Forestry and the Department of Agriculture. All spheres of government have responsibilities for environmental management and biodiversity conservation, as much of the implementation of central government policies is devolved to local government. (Certain environmental functions are mandated to local government, which then serves as lead

Box 5.6 Elephant management in the Kruger National Park – science versus ethics

The issue of whether or not culling elephants in the Kruger National Park should resume in order to protect biodiversity was a heated debate in 2005/2006. It is known that the scale and magnitude of the impacts by elephants on vegetation are far greater than for any other herbivore. As any visitor to Kruger will testify, damage to trees by elephants is widely evident. Aerial photographs show a decline in the abundance of tall trees over much of the park during the past few decades, although shrub cover has increased in places. Conservationists have deplored the destruction of woodlands that has taken place elsewhere in Africa where elephants increased to high densities, notably in Tsavo East in Kenya and Chobe in Botswana. The question therefore arose as to whether action should be taken to stop elephant numbers increasing to the point where damage could threaten the conservation objectives of the Kruger. The park's scientific services division proposed the resumption of culling in parts of the park. But

how should the judgements of scientists be balanced against the ethical issues involved: the killing of highly intelligent animals versus protecting other species and other aesthetic values from rampaging elephants?

A review process, which was one of the most comprehensive reviews of a wildlife management issue anywhere in the world, was started in late 2004. Many people and constituencies were either strongly for or strongly against the culling of elephants. An 'Elephant Science Roundtable' was convened in January 2006 to advise the Minister of Environmental Affairs and Tourism as to the necessity of culling, from a scientific perspective. The scientists who participated drew attention to the following points.

- Culling undertaken up to 1994 (about 400 animals every year) had not halted the declining density of big trees in the Kruger National Park.
- If elephant numbers are allowed to climb to the ecological carrying capacity (that is, to the maximum number that the vegetation can support), limited food and nutrition eventually slow the growth rate. With biochemical contraception being impractical in such a large population, this form of 'natural contraception' may be more logical.
- The destruction of woodlands elsewhere in Africa (such as that in Chobe and Hwange), with higher elephant numbers, did not result in threats to biodiversity.
- The distribution of elephants in the Kruger National Park, rather than the size of population,

will affect biodiversity. The installation of artificial watering points throughout the park has distributed the elephant population across the park. Trees far from rivers, which otherwise would have escaped elephant attention during the dry season, became the targets mainly of bull elephants. So removing the artificial points could limit the extent of damage to upland trees such as baobabs and marulas.

- Assessments of the local consequences of global warming suggest that many plant and animal species currently resident in the Kruger National Park will not find suitable habitat there within a few decades. If such species cannot be saved within isolated parks in the long term, killing elephants now is a futile response.

While scientists agreed that "there is no compelling evidence to suggest the need for immediate, large-scale reduction of elephant numbers in the Kruger National Park", and the Minister announced that culling will not be resumed, many questions remain. For example, should we increase the space available to relieve the local impacts on biodiversity, and if so, how does one address the issue that neighbouring people have inadequate land available to support their families? Does invoking the precautionary principle mean that elephant populations should be left unmanaged until some species have been demonstrably lost, or should we keep elephant numbers low until we are sure that no species are endangered from their impacts?

Source: Text compiled from information provided by Norman Owen-Smith, University of the Witwatersrand.



An elephant stripping bark off a tree in national park. *Photography: South African Tourism*

agent, for example for waste management and coastal development.) Problems of capacity and resources at local government level everywhere affect performance, however, to the extent that in some areas there has been an almost complete collapse of regulatory enforcement.

South African National Biodiversity Institute

In 2004, through the enactment of NEMBA, the previous National Botanical Institute was replaced by the South African National Biodiversity Institute (SANBI). For the first time, a technical body for centralized monitoring and reporting on the status of the country's biodiversity was formally established at national level.

SANBI's responsibilities now relate to the full diversity of South Africa's fauna and flora. It is mandated to act as a comprehensive national consultative and advisory body on the full spectrum of biodiversity issues, and its role includes communication. It operates on the basis of international best practice and research, with special emphasis on outreach programmes.

South African National Parks

South African National Parks (SANParks) was established in terms of the Protected Areas Act (No. 57 of 2003). Today it is South Africa's leading statutory conservation authority, responsible for over 3 750 000 ha of protected land in 21 national parks. The National Parks of South Africa have 3 spheres of focus:

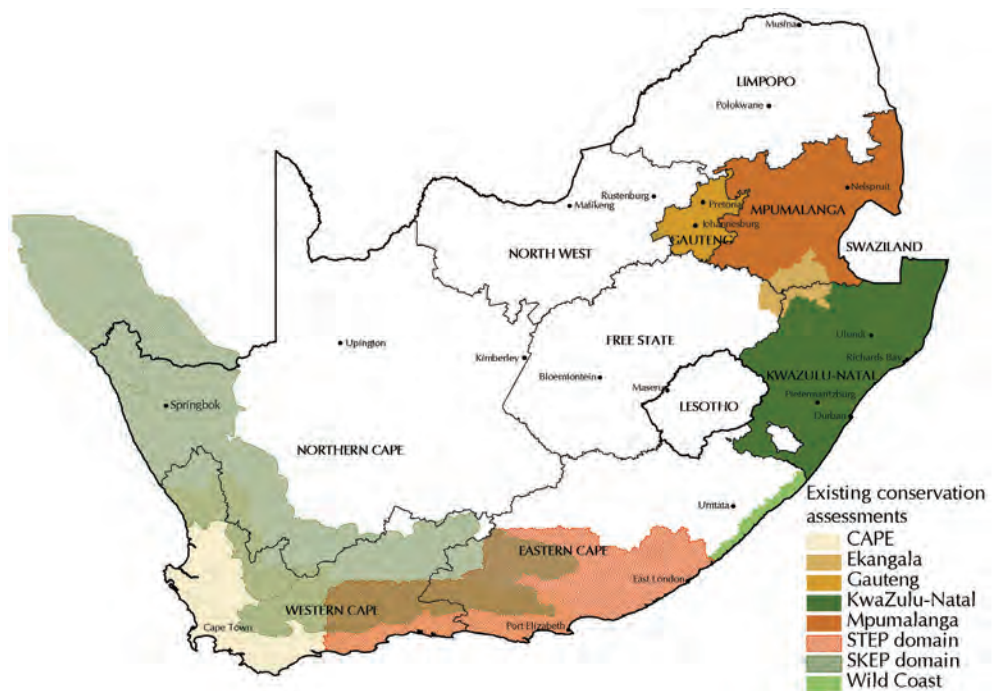
- The conservation of a representative sample of the biodiversity of the country
- To maintain a relationship of community upliftment and capacity building amongst people living in the areas in and around national parks
- To provide a recreational outlet to the public to experience and enjoy the wonders of national parks.

Since 1994, supported by the DEAT, SANParks has worked to make national parks more accessible to the public and tourists, both local and international, to ensure that conservation contributes to overall social and economic development; at the same time it has been maintaining high standards of research and management and has expanded the land under its protection by adding 176 931 ha. SANParks has recently been mandated to begin to generate a large proportion (75%) of its own operating revenue. Debate is raging, however, as to whether or not the country's natural assets should be sold off to concessionaires or remain protected as the last undisturbed examples of South Africa's natural heritage.

5.6.3 Control and rehabilitation programmes

South Africa's many control programmes aimed at conserving and rehabilitating ecosystems and their biodiversity often involve different governmental departments and organizations and contribute to education, community empowerment, capacity building, and employment (such as the measures employed to address the threats posed by invasive alien species). These programmes range from regulatory frameworks (such as the NEMBA) geared towards controlling the importation of potentially invasive species, and eradicating or controlling established invasive alien species. In 1999, for example, Olckers and Hill⁸⁷ reported on the success of biological control strategies involving the introduction of "natural pests or predators from the place of origin of the alien species" in combination with direct physical control measures as a way of preventing the proliferation of invasive alien species in South Africa.

Working for Water⁸⁸, with its substantial budget, has over 300 projects combating invasive aliens around the country in all the provinces, and is providing work and, to a lesser extent, training opportunities to some 21 000 people, mostly the poor and marginalized. The success of this programme is due to the innovative conjunction of a strategy to remove alien invasive plants from water catchments with a large-scale rural poverty alleviation and job creation initiative⁸⁹. The programme saw exceptional



Map 5.11: Existing conservation assessments in South Africa
National Spatial Biodiversity Assessment 2004⁷



budget increases – from R25 million in 1995/6 to R442 million in 2003/4. Although over one million hectares of land have been cleared of invasive alien plants during the past eight years⁸⁹, these species are still spreading and growing at a faster rate than the programme can clear them. Controlling them is currently costing South Africa an estimated R600 million a year. A similar investment will need to continue over the next 20 years to be successful. The establishment of the Secretariat for the Global Invasive Species Programme within South Africa has given a further boost to this cause.

Several aligned initiatives have grown out of the Working for Water programme.

- The Working on Fire programme^h is designed to limit the impact of large veld fires on the environment and on the poor communities exposed to them. In the process,

opportunities are created for skills development, capacity building, and jobs for affected communities (such as clearing invading alien plants, creating firebreaks, and reducing fuel-load). Its R20-million annual budget from Working for Water is supplemented by significant support from the private sector.

- The Working for Wetlands programme, a national wetland rehabilitation initiative, was launched in 2000 under the banner of the Working for Water programme, and also provides training and work opportunities in the rehabilitation of wetlands. It is a fine example of cooperative governance, as it works across three national departments (DEAT, DWAF, and the National Department of Agriculture [NDA]), provincial capacities, local government, and the private sector. The Mondli Wetlands Projectⁱ also addresses the conservation and rehabilitation of wetlands. To assist these efforts, the Water Research Commission (WRC) has produced Guidelines for Integrating the Protection, Conservation and Management of Wetlands into Catchment Management Planning⁶¹.

Box 5.7 Cooperation towards community resource management: The Makuleke Community

The Makuleke community is one of the many rural communities living on the borders of the Kruger National Park. In 1969, the Makuleke people were forcibly removed from the Pafuri triangle (26 500 hectares of land bordering Zimbabwe and Mozambique in the northeastern corner of South Africa) to allow the inclusion of their land within the borders of the Kruger National Park, and were relocated to 5 000 hectares (ha) of less desirable land 150 km south of the Pafuri region, outside the park boundaries.

In 1996, the Makuleke people initiated a land claim against South African National Parks (SANParks) under the Restitution of Land Rights Act (No. 22 of 1994), and in 1998 they regained ownership of their land. The Pafuri Triangle was renamed the 'Makuleke Region of the Kruger National Park', to be managed over a period of 25 years by a joint management board with equal representation from the Makuleke people and SANParks. The land remains within the boundaries of the Kruger National Park and, as such, SANParks is responsible for its day-to-day management. The Makuleke now have significant resource-use rights, however, through tourism development and the commercial use of natural resources through hunting and eco-tourism.

In the past four years, the community have conducted a park-friendly lodge business on their reclaimed land, working with the Johannesburg-based hotel group, The Mix, which currently owns the lodge. It is largely run by Makuleke residents, however, and will be handed over to the Makuleke community in 28 years' time. The community is paid 10% of the revenue generated, and has used this income to build the multipurpose centre in the heart of the village for tourists wishing to experience the Makuleke way of life. This centre includes a bed and breakfast facility, a crafts production unit, and an amphitheatre.

A development programme was established in 1996, funded by donor agencies and non-governmental organizations (NGOs), through which the Endangered Wildlife Trust (EWT) has been running the Makuleke Training Project. Working with people from the community, it gives training and opportunities for practical experience in nature conservation and business administration. Students are also prepared for the University of South Africa National Diploma in Nature Conservation and Business Administration and for the examinations of the Field Guides Association of Southern Africa. To date, it has produced five graduates and, by April 2005, 14 Makuleke students had entered the marketplace, most of them as professionals or at junior management level. The increase in income earned by each student before and after involvement in this project was in the region of 600%.

Sources: Van Zyl, A. (2005). *Personal communication. Project coordinator, Makuleke Training Project Information, Endangered Wildlife Trust.* Koro, E. (2005). *New Development Model Spurs Growth in South African Rural Community. World Resources Institute, 3(2).* <http://newsroomwri.org>

There is no formalized national assessment procedure to appraise/evaluate wetlands⁹⁰ and, although the DEAT is compiling a National Inventory of Wetlands for handing over to Working for Wetlands to carry forward, this inventory focuses more on mapping the locations of the wetlands than on describing their status, health, or level of conservation⁹¹. South Africa's wetlands need to be assessed and categorized so as to record their status, trends, and biological and resource value, and to allow systematic planning for their effective conservation.

The WRC's research programme under the theme 'Water-linked Ecosystems' is studying wetland processes, wetland rehabilitation, health and integrity, biodiversity restoration in wetlands, and the wise use of wetlands.

5.6.4 Bioregional plans and programmes

The NEMBA has given the legal basis to the DEAT's bioregional planning approach to conservation and protected area management. These plans are normally the outputs of a systematic spatial conservation assessment of the region, which identifies areas of conservation priority and constraints and opportunities for their implementation. The plans form part of multi-sectoral partnership programmes that aim to link biodiversity conservation with socio-economic development¹. Bioregional programmes include: the Cape Action for People and the Environment (CAPE); The Succulent Karoo Ecosystem Programme (SKEP); the Subtropical Thicket Ecosystem Planning Programme (STEP); Wild Coast Conservation and Sustainable Development Programme; Maloti-Drakensberg Transfrontier Project; National Grasslands Biodiversity Programme; and St Lucia World Heritage Site.



Such planning is essential, as it identifies what happens where in the landscape and enables an effective land-use system to be put in place that meets the needs of the development sectors without compromising the needs of the environment. South Africa has been at the forefront of bioregional planning internationally, with many planning initiatives linked to particular biomes/ecoregions in the country that incorporate conservation priorities into proactive planning guidelines for the efficient and suitable selection of sites for conservation management^{92, 93}. (See Map 5.11 for areas in South Africa where these plans are under way.) The coverage is impressive but has significant gaps, particularly in the Nama Karoo and savanna biomes. The National Grasslands Biodiversity Programme has been initiated⁹⁴ to fill the grassland biome gap.

5.6.5 Non-governmental organizations and the private sector

Civil society plays an important constructive watchdog role in the conservation of biodiversity in South Africa, and an increasingly strong sense of custodianship of the environment and its dynamic synergy with its social context informs the agenda of many organizations outside government, including non-governmental organizations (NGOs), conservancies, and Community Based Organizations (CBOs). Examples include the Wildlife and Environmental Society of Southern Africa (WESSA), the Endangered Wildlife Trust, BirdLife South Africa, the Botanical Society of South Africa, Environmental Justice Network, Resource Africa, the Wilderness Foundation, WWF-SA, Conservation International, and GroundWork.

5.6.6 Conservation on private and communal land

South Africa has some 9 000 privately owned game farms, which are expanding at a rate of approximately 300 000 ha per year. Nature areas that are managed privately or by the community represent capital investments of approximately R6 billion⁹⁵. Therefore, privately owned land (in the form of conservancies, game farms, private game reserves, and mixed game/livestock farms) contributes substantially to national conservation efforts, often creating sustainable employment opportunities that help in the socio-economic upliftment of rural areas⁵.

There are about 600 conservancies in South Africa⁹⁴ and their growth is gaining ever-increasing momentum and recognition as a vehicle for merging development and social issues with biodiversity conservation. Biosphere Reserves are also becoming more popular and four of them in South Africa have been registered with UNESCO (although this does not yet afford them any special local legal status).

The South African Natural Heritage Programme (NHP),

established in 1985, is being revitalized after a non-operational period. Supported by the NEMBA and NEMPA Act, it focuses on the participation of civil society and, in particular, private landowners, in conserving important privately- and publicly-owned naturally biodiverse areas and exceptional natural features. The revived programme will seek to provide landowners with tax benefits, potential funding, recognition, and other incentives to support their conservation efforts.

The remnants of apartheid continue to affect the way in which we protect and manage our biodiversity. Land restitution claims lodged by communities who still hold title to lands from which they were forcibly dislodged during the pre-1994 government's expansion of protected areas have led to the establishment of contractual parks involving government agencies and these communities. These agreements were flagged as 'world firsts' during the 5th World Parks Congress in 2003. Examples include contracts involving the Makuleke, Khomani San, and Mier communities.

5.6.7 Cross-cutting programmes and projects

The overall goal of the cross-cutting programmes and actions is to incorporate conservation and the sustainable use of biodiversity into relevant sectoral and cross-sectoral plans, programmes, and policies, as required by the Convention of Biological Diversity. Such mainstreaming of biodiversity involves situations where biodiversity can be achieved together with economic gain; others where biodiversity gains exceed biodiversity losses; the recognition that a sectoral activity depends on sustainable use of biodiversity; and the inclusion of biodiversity concerns in sectoral policies⁹⁶. The overall objective is the full-scale integration of conservation values, goals, and priorities into

Privately owned land (in the form of conservancies, game farms, private game reserves, and mixed game/livestock farms) contributes substantially to national conservation efforts, often creating sustainable employment opportunities that help in the socio-economic upliftment of rural areas.



Communities selling craft made with reeds from the Nahoon River near East London.

Photography: Wilma Strydom

Box 5.8 Genetically modified organisms

What are GMOs?

A genetically modified organism (GMO) is any living organism that contains genes not normally found in it. This genetic material will have been transferred into the organism using genetic modification technology. In 2004, the global area planted with biotech crops was 81 million hectares (ha) in 17 countries (this was a 20% increase over 2003). About 27 million ha are now being planted in 11 developing countries. However, more than 90% of the area planted globally with GMOs in 2004 is located in just four countries, with the United States planting 47 million ha (58%), followed by Argentina (16.2 million ha, or 20%), Canada (5.4 million ha, or 6.6%) and Brazil (5 million ha, or 6.1%). The most popular genetically modified (GM) crops are soybean, maize, cotton, and canola. GM crops currently available in South Africa include insect resistant yellow and white maize, herbicide tolerant soybean, and insect resistant cotton.

How do GMOs benefit us?

GM crops are developed to have certain specific traits, such as drought tolerance, insect resistance, herbicide tolerance, giving a higher yield, or being more tasty or nutritious. This translates into several direct and indirect benefits. For example, an independent survey of smallholder farmers in South Africa designed to explore the economic benefits of their adoption of genetically modified Bt (insect-resistant) cotton was conducted in November 2000. It indicated that, during the 1998/1999, season, farmers experienced an 18% per ha increase in yields compared to non-adopters, and a 13% reduction of pesticide costs compared to non-adopters. These results outweighed the increase in seed costs (100% per ha) to give a substantial increase of 11% in gross margins.

Having to use less insecticide benefits farm workers, farmers, consumers, and the environment. In China, for example, fewer farmers are dying from chemical poisoning since adopting Bt cotton, as it is sprayed 13 times less than is conventional cotton. Benefits to the environment are also significant. It was estimated that in 2000 pesticide usage was reduced by a total of 22.3 million kg of formulated product due to the use of GM crops.

Herbicide resistant GM crops also help to protect the environment in that farmers switch to zero or minimal tillage practices, which save fuel and labour and significantly reduce the loss of topsoil. No-till processes also make the breakdown of crop stubble by soil microorganisms occur more slowly, in this way also reducing carbon dioxide emissions. It has been predicted that herbicide-tolerant GM maize would dramatically lower the herbicide concentrations in vulnerable watersheds, thus diminishing the risks to human health brought about by contaminated drinking.

What are the main concerns regarding GMOs?

Despite the benefits of GM crops, concerns have been raised by scientific, environmental, and consumer groups. The main ones are:

- potential risks to human and animal health
- potential effects on biodiversity and the environment
- effects on developing economies.

Health concerns

Possibly the public's greatest concern is whether or not food from GM crops is safe to eat – whether it contains toxins or causes allergies; whether its nutritional composition or digestibility has been adversely changed; or whether there will be unexpected effects.

Before a GM product is approved for commercial release, the developer has to research such risks. Food safety assessment normally follows national guidelines, and these are typically based on international standards, such as those issued by the Codex Alimentarius Commission. In South Africa, biosafety assessments are carried out under the Genetically Modified Organisms Act (No. 15 of 1997), and, together with existing labelling legislation, they are designed to regulate the safe introduction of GMOs into South Africa. Products are only given a general release permit if they are deemed to be safe and of benefit to South Africa.

The issue of food safety has been investigated through many health studies. In 2005, the World Health Organisation (WHO) published an opinion on GM foods. Its 84-page report, *Modern food biotechnology, human health and development: an evidence-based study*, suggests that GM foods can contribute positively to human

health and development, but stresses the need for continued safety assessments prior to marketing, to prevent risks to health and the environment. The WHO claims that, so far, the consumption of GM foods has caused no known negative health effects, and that GM foods are more rigorously examined than conventional foods for potential health and environmental impacts.

Environmental concerns

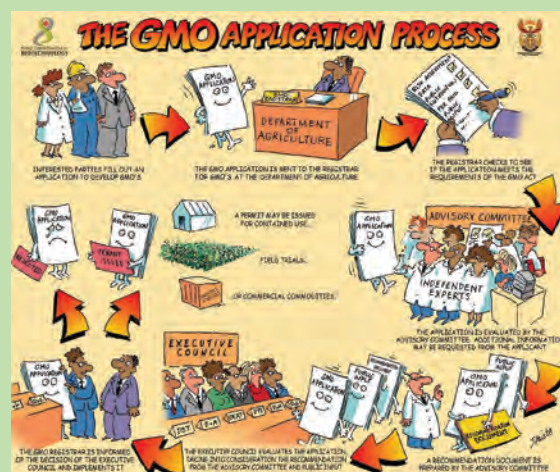
The concern has been raised that the introduction of herbicide tolerance in crops will lead to a misuse of herbicides, and that insect resistance in crops may result in a build-up of resistance in target insect populations. (This, however, is also true for most agro-chemicals used to control pests and diseases.) Another worry is the effect on non-target organisms, especially beneficial insects.

Concerns have also been raised that the inserted gene(s) in GM crops can pass into other species, especially weedy wild relatives. Highly domesticated species like maize and soybean are not normally competitive in the wild, however, and are therefore unlikely to become invasive. Less highly domesticated species, such as sorghum, pasture legumes, and cowpea may be more competitive in the wild and could pose a more serious threat of becoming invasive. In South Africa, impact assessments have to be carried out on all GMOs before commercialization is approved and it is expected that they will be monitored even after release. Several long-term studies are currently being conducted in South Africa on the environmental impacts of GM crops.

Socio-economic concerns

The effect of GM technology on developing countries, especially Africa, is often hotly debated. Those in favour of GMO technology have increasingly argued that GMOs can address the problems of malnutrition, hunger, and food insecurity. Several African countries, however, have been reluctant to adopt GMOs in their agricultural systems because of restrictions imposed by trading partners.

Most African food exports are to Europe and Asia, for instance, where GM foods are widely regarded as 'Frankenstein foods' and shunned by consumers. Some European countries request verification from exporting countries that their beef is not fed with genetically modified maize. This places the onus on exporting countries to develop an appropriate labelling and traceability system, and such a system is being developed in South Africa. Most other countries on the continent, however, do not have the legislation or the capacity to implement such a system. If GM foods are introduced into exporting countries without the required labelling and traceability support, grain and beef exports to Europe and Asia could be rejected, with dire potential economic consequences. In Africa, so far, only Kenya, Egypt, and South Africa have formally adopted the use of genetically modified crops.



Sources:

Agricultural Research Council: <http://www.arc.agric.za/main/biotech.htm>

Animal Feed Manufacturers Association: http://www.afma.co.za/AFMA_Template/1,2491,7105_1839,00.html

International Service for the Acquisition of Agri-biotech Applications (ASAAA):

<http://www.isaaa.org/> World Health Organisation (2005). *Modern food biotechnology, human health and development: an evidence-based study*. World Health Organization, Geneva.

Ismael, Y., Bennett, R., and Morse, S. (2001). *Farm level impact of Bt cotton in South Africa. Biotechnology and Development Monitor No. 48, 15-19*

the sectors responsible for ongoing biodiversity loss (that is, into economic sectors and development policies and programmes)⁹⁷.

One of the main incentives is the direct contribution of biodiversity to both economic and social development. Although mainstreaming initiatives may be catalysed by conservation agencies, they increasingly often originate within economic sectors, typically involving a wide range of people, and partnerships between NGOs, government, communities, industry, and small, medium, and micro enterprises⁹⁸.

The River Health Programme

The River Health Programme (RHP) was initiated in 1994 by the DWAF. Its overall goal is to expand the body of information on aquatic resources, so as to support their rational management in South Africa. Each province is responsible for the RHP activities within its borders. This programme uses numerous factors (indices) to determine the health of a river ecosystem. Its outputs take the form of simplified posters as well as reports that provide detailed analyses of the state of the country's rivers. Eight such state-of-rivers reports have been published and more are being planned. Because only a few rivers have been assessed to date, however, the existing reports are not suitable for use as a national indicator of the state of rivers in the country.

5.7 CONCLUSION

Priority areas

From the assessments available, it is clear that neither biodiversity nor the pressures that threaten it are evenly distributed across South Africa. Areas of high biodiversity, and which contain global biodiversity hotspots, are often also areas under greatest pressure. They include the South-western Cape region, the central grasslands, and the eastern coastal areas.

Although the northern and eastern parts of the country experience some of the greatest pressures, the established bioregional programmes are mostly focused in the southern region, but it is hoped that the newly established Grasslands Biome Programme, Mpumalanga Programme, and Wild Coast Conservation and Development Project will help to correct some of this bias. These parts of South Africa (particularly the Eastern Cape) are home to many poor and rural communities who, indirectly, are even more profoundly affected by the pressures of biodiversity loss, because they rely so heavily on the natural environment and its services. It is a matter of great urgency, therefore, to develop appropriate conservation responses for these important and threatened areas.

Reducing the rate of biodiversity loss (the 2010 Biodiversity Target)

In line with global trends, the decline of South Africa's biodiversity and ecosystem health has been most rapid in the past few decades^{99,100}. Despite the fact that biodiversity benefits many people, at least 60% of the ecosystem health and services that have been measured are declining rapidly worldwide, because of land-use change, climate change, invasions by alien species, and other direct drivers of environmental change. These pressures show no signs of decreasing: they are either constant or growing in strength and are projected to continue or to accelerate in the future¹⁰⁰.

The predictions that drivers of biodiversity change will remain stable or increase implies that for South Africa, as elsewhere on the planet, the goal of reducing the rates of biodiversity loss by 2010 will not be attained¹⁰⁰. The damaging consequences in terms of opportunity cost cannot be over-emphasized. Sub-components of this target may, however, be within our reach, as, for example, habitat loss is slowing down in some parts of the country. The Millennium Ecosystem Assessment states that "an unprecedented effort would be needed to achieve by 2010 a significant reduction in the rate of biodiversity loss at all levels". It recommends that longer-term goals and targets are also necessary (extending, for example, to 2050), as short-term goals and targets do not align with the characteristic longer response times of political, socio-economic, and ecological systems.

Despite the fact that biodiversity benefits many people, at least 60% of the ecosystem health and services that have been measured are declining rapidly worldwide, because of land-use change, climate change, invasions by alien species, and other direct drivers of environmental change.

Improving the information base

The indicators presented in this chapter give an overview of the status of South Africa's biodiversity. The validity of some of the indicators is questionable in terms of their age and comprehensiveness but they nevertheless represent an appropriate starting point for action and analysis. There remain some critical indicators for which we have no adequate data and without which our assessment of the current situation is incomplete. The most important of these include up-to-date land-cover information, as well as information at finer scales of the spatial distribution of habitat degradation and sensitive areas. There are, furthermore, several developing trends (such as the increased prevalence of genetically modified organisms (see Box 5.8), which might prove, in the future, to have adverse effects on biodiversity but for which we currently do not have reliable data.

Positive messages

Reporting on the state of biodiversity is often an exercise in 'doom and gloom', because of the pervasive and increasingly negative trends in biodiversity loss and decline in ecosystem health. South Africa has responded in various

ways, with varying degrees of success, as described in this chapter. Section 5.6 (above) highlights the many (often cutting-edge) responses that have put South Africa at the forefront of global biodiversity conservation. Their successful implementation will go some way towards achieving goals such as the 2010 target. The establishment of the SANBI, the completion of the first National Spatial Biodiversity Assessment, a robust National Biodiversity Strategy and Action Plan, and the extensive range of bioregional plans (well supported by legislation), attest to a growing awareness, in some sectors, of the importance of biodiversity to humans everywhere. The magnitude and the momentum of the drivers, however, will require a far greater commitment of resources and enforcement of legislation to turn this tide.

The involvement of an active civil society in South Africa in many environmental issues has helped significantly to improve the awareness of the state of the country's biodiversity. As highlighted in the Millennium Assessment, "less biodiversity would exist today had not communities, NGOs, governments, and, to a growing extent, business and industry taken actions to conserve biodiversity, mitigate its loss, and support its sustainable use". In terms of the involvement of business and industry in biodiversity conservation, South Africa is among the leaders in the field of 'mainstreaming'⁹⁶.

South Africa offers a wealth of further opportunities for biodiversity conservation and sustainable use. With large areas of natural habitat still remaining in many parts of the country (a situation that is not common in many other countries), conservation and biodiversity-friendly land uses (such as game ranching) have the chance to develop and flourish. Our tourism industry (the fastest-growing sector, and second only to manufacturing in its contribution to gross domestic product) provides an excellent incentive for better biodiversity management and for exploring the economic benefits that can result.

All the existing highly commendable policies, plans, and strategies, however, need to be fully entrenched and implemented on the ground to achieve the stated objectives of not only conserving biodiversity but also of achieving sound ecosystem health and functioning to underpin socio-economic development.

NOTES

- a. 'Biological diversity' or 'biodiversity' means the variability among living organisms from all sources including, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. It also includes diversity within species, between species, and of ecosystems.
- b. Terrestrial ecosystem status figures were calculated from the National Land Cover 2000 map provided by the CSIR.
- c. Biodiversity targets are also referred to as 'conservation targets'. They are quantifiable targets that indicate how much of each biodiversity feature should be conserved so as to maintain functioning landscapes and seascapes. These targets should be based on best available science rather than on arbitrarily defined thresholds. This chapter uses the biodiversity targets for representation as determined in the National Spatial Biodiversity Assessment, ranging from 16–36% of the ecosystem that should be conserved.
- d. Both the Orange River Mouth and Blesbokspruit Ramsar sites have been included in the Montreux Record. The Montreux Record is the principal tool of the Ramsar Convention for highlighting those sites where an adverse change in ecological character has occurred, is occurring, or is likely to occur, and which are therefore in need of priority conservation attention.
- e. A contractual park is defined as a park established through a contractual agreement between historically disadvantaged peoples (landowners) with land claims within proclaimed protected areas and the government institution responsible for the biodiversity management within such areas, whereby agreed benefits are accrued by such peoples, enabling their socio-economic development.
- f. Details about CITES are available at <http://www.cites.org>
- g. Information about the Working for Water programme is available at <http://www.dwaf.gov.za/wfw>
- h. Information about the Working on Fire programme is available at <http://www.workingonfire.org>
- i. Information about the Mondi Wetlands Project is available at <http://www.wetland.org.za>

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*The clearest way into the universe
is through a forest wilderness.*

John Muir

*We do not inherit this land
from our ancestors;
we borrow it from our children.*

Haida Indian saying

*Man is a complex being;
he makes the deserts bloom
and lakes die.*

Gil Stern





Chapter 6 Inland water

At a glance

This chapter discusses the state and quality of our water resources and the integrity of our aquatic ecosystems. Evidence provided here shows that a significant proportion of our usable water resources, including our river ecosystems, have been degraded, and that most of our exploitable water resources are being utilized at present. In many areas, current levels of water use make no allowance for the need to sustain the ecological viability of the resource. Furthermore, climate change is expected to alter hydrological systems and water supplies in southern Africa and to reduce the availability of water.

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Most fresh water resources in sub-Saharan Africa are located in transboundary watercourse systems and shared river basins.

6.1 INTRODUCTION

Fresh water is essential for the daily life of all aquatic and terrestrial organisms, including humans. Although water is normally a recyclable resource, it needs careful management and protection because of its vulnerability to over-exploitation and pollution. This is particularly so in South Africa where, in terms of a United Nations definition, we are water stressed^a, bordering on water scarce, with a water availability of only 1 100 m³/person/annum.

Most fresh water resources in sub-Saharan Africa are located in transboundary watercourse systems and shared river basins. Management and protection of these shared basins is required through a strong commitment to regional collaboration within the Southern African Development Community (SADC). Similarly, the environmental initiatives of the New Partnership for Africa's Development (NEPAD) include a framework for regional cooperation on water resources, as well as processes for the restoration of degraded ecosystem (including wetlands), the combating of desertification, drought relief, sustainable agricultural production, and biodiversity conservation. NEPAD's framework is thus a key initiative for improving water resource management for social, economic, and environmental security in Africa¹.

In addition to the direct use of water, aquatic resources can suffer from the way in which land is used, as well as through the impact of uncontrolled pollution from various

sources. The use of water resources affects the functioning of estuaries and coastal waters. Climate change is predicted to alter the amount and distribution of rainfall as well as evaporation rates. The complexity of all these interactions has to be taken into account in South Africa's water resource policy and requires an integrated approach to water management². Sustainable aquatic ecosystems rely on the availability of water of adequate quantity and quality. The ecosystem, as well as the water-user, needs to be considered when assessing the water requirements of South Africa and its neighbouring territories.

The Department of Water Affairs and Forestry (DWA) is the custodian of the nation's water resources, and the challenge is to manage these resources so as to promote equity, sustainability, and efficiency. The National Water Resource Strategy (NWRS) is an ambitious document that sets out the Department's plans. The NWRS will be legally binding, amendable to suit changing circumstances after periodic reviews at least every five years. Much of the information in this chapter is taken from the NWRS.

6.2 THE WATER SITUATION IN SOUTH AFRICA

The quantity of water available for direct human use or to support aquatic ecosystems depends on the availability and sustainability of the resource. Rainfall, surface flows, and groundwater recharge are intimately linked in the



Most of South Africa's water requirements are provided by rivers and dams. *Photography: South African Tourism*

hydrological cycle and need to be managed accordingly. As stated by the NWRS, one of its principal objectives "is to ensure an adequate supply of water to underpin the prosperity of the country and the well-being of its population."

6.2.1 Water resources

The average rainfall in South Africa is about 450 millimetres per year (mm/annum)³, that is, about half the world average of 860 mm/annum. Our rainfall has a water supply potential per capita of just over 1 100 cubic metres per year (m³/annum)⁴. The geographical distribution of rainfall, and subsequent availability for water supply, is highly variable, with the eastern and southern part of the country receiving significantly more rain than the northern and western regions. South Africa's inland water resources are the rivers, dams, lakes, wetlands, and subsurface aquifers, which together with natural processes (such as rainfall and evaporation) and anthropogenic influences (such as human-originated abstraction and discharges), form the hydrological cycle (see Figure 6.1) that controls the quality and quantity of our inland waters and the services they provide (see Box 6.1). Within the cycle, there are complex interactions between surface and ground water and between the water and the sediments, stream banks, animals, plants, and microbes in rivers, dams, and wetlands: all these have to be taken into account in water management. The chemical characteristics of water depend on the source of water, the local geology, local ecology, and the impact of local human activity.

Our water resources are currently allocated to 19 Water Management Areas (WMAs) covering the country and, because of the uneven distribution of water resources, a significant amount of water transfer needs to take place between WMAs, both nationally and internationally (Map 6.1). Substantial transfers take place from the Upper Orange to the Lower Orange (1 886 million m³/annum), the Upper Vaal to the Middle Vaal (790 million m³/annum), and from Lesotho into the Upper Vaal (600 million m³/annum) (see Table 6.3 for details of total transfers).

Most of South Africa's water requirements are provided by surface water supplies (rivers and dams). Generally, these surface water resources are highly developed over the country, with about 320 major dams having a total capacity of more than 32 400 million m³, which is some 66% of the total mean annual runoff of about 49 000m³/annum. This includes about 4 800 million m³/annum draining from Lesotho into South Africa and a further 500 million m³/annum draining from Swaziland to South Africa. A portion of this runoff (typically about 20%) needs to remain in rivers and estuaries to support the ecological component of the Reserve⁵. Only part of the remainder can be harnessed effectively as a usable yield. The usable yield may be further constrained by sources of pollution, such as irrigation return flows, urban drainage, and industrial and mining activities.

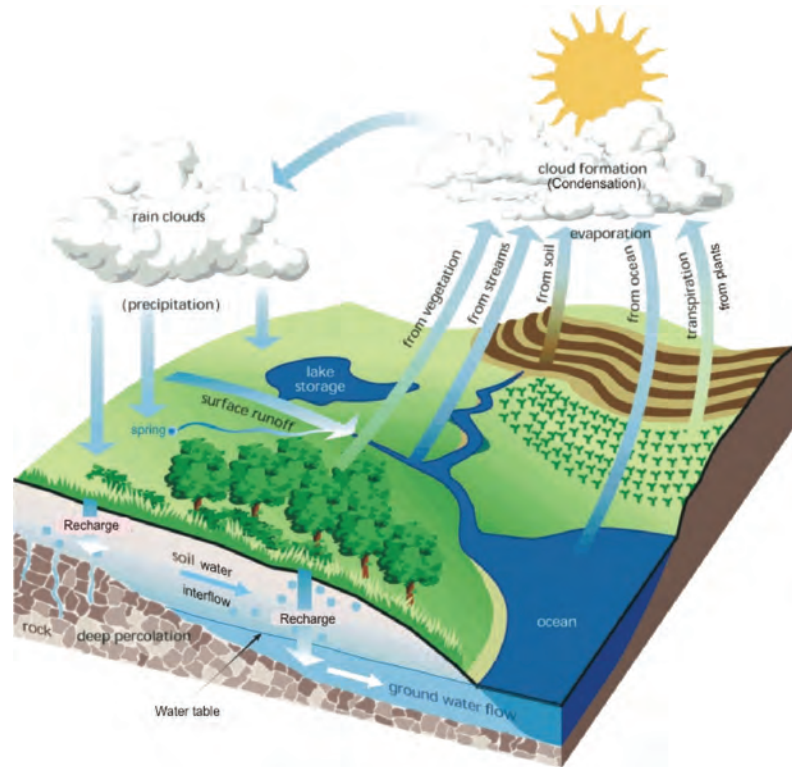
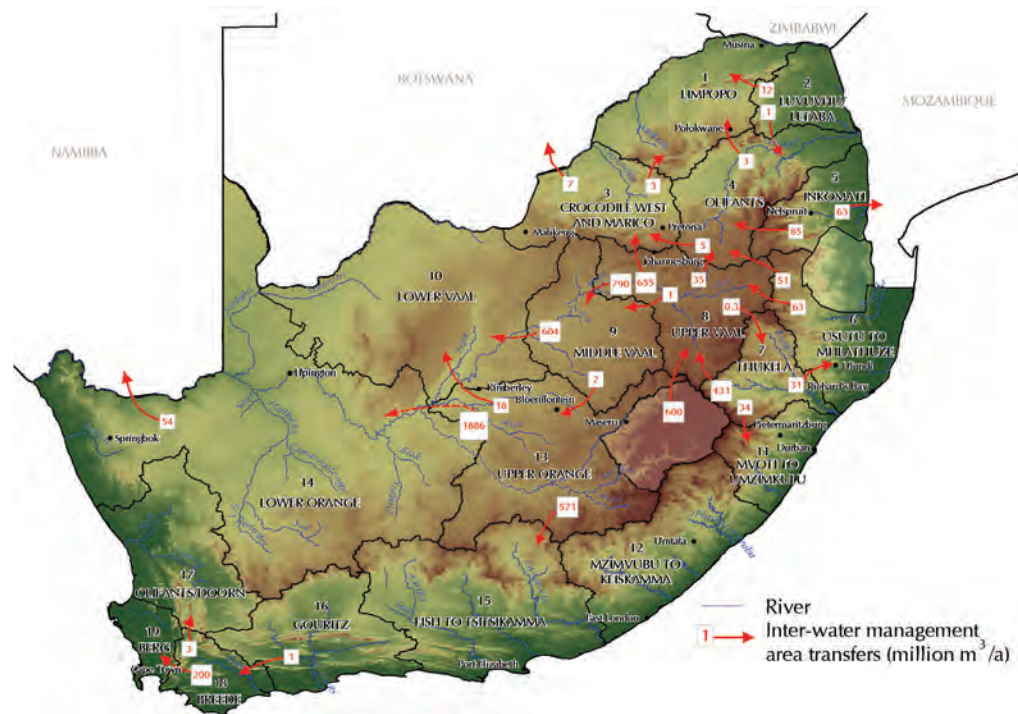


Figure 6.1: The hydrological cycle
Source: Adapted from WW2010 (2005)³ and Parsons (2004)⁶

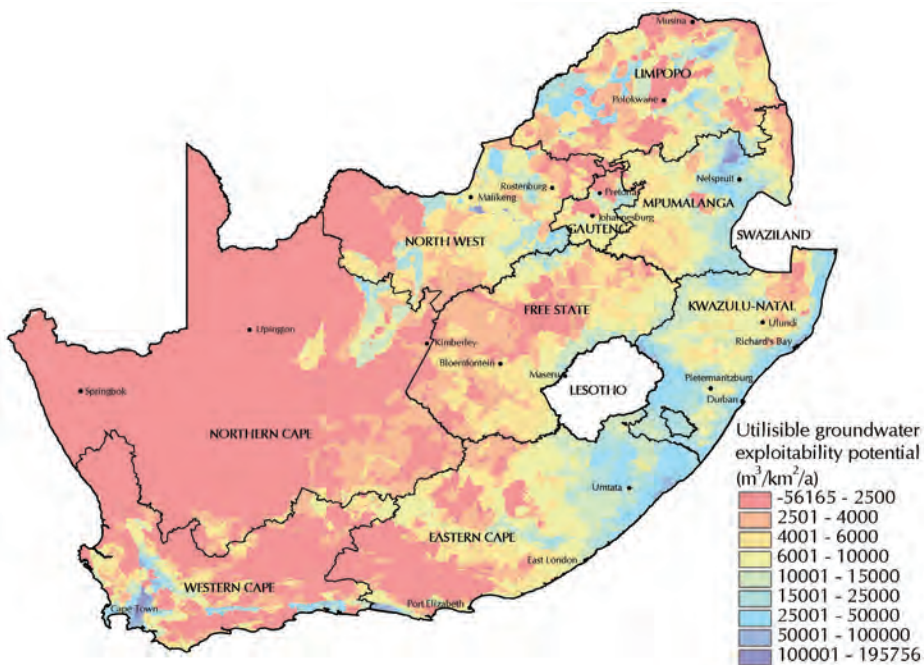


Map 6.1: Water management areas and inter-basin transfers
Source: Department of Water Affairs and Forestry (2004)³



Groundwater is used extensively, particularly in rural and arid areas where surface water is inadequate, as, for example, in the greater Orange River catchment⁵. This water source contributes significantly to baseflow in the perennial rivers along the eastern escarpment and wetter northeastern parts of the country, but groundwater resources tend to be limited in South Africa because much of the underlying geology is hard rock.

Groundwater is found in aquifers that range widely in depth, size, and capacity. Groundwater flow tends to follow surface topography and often interacts closely with surface waters. The six major aquifers in South Africa include the Dolomites, Table Mountain Group sandstones, coastal sand deposits, basement granites, Karoo dolerites, and alluvium along perennial rivers. Most exploitable groundwater occurs in the eastern and northeastern parts of the country and in the Western Cape, where aquifers are concentrated (see Map 6.2). Although the results of studies vary considerably as to the estimated quantity of groundwater in South Africa, the latest data indicate that of a total of 235 000 million m³/annum that is stored, between 10 000 million and 16 000 million m³/annum are available for use in an average rainfall year, and 7 000 million m³/annum in a drought year⁷. Significant constraints on increasing the abstraction of groundwater include inadequate water quality, which may fail to meet user requirements due to excessive concentration of chloride, nitrate, and other salts, all of which are costly to remove. Over-abstraction can also result in adverse impacts on groundwater-dependent ecosystems, including estuaries, wetlands, and springs.



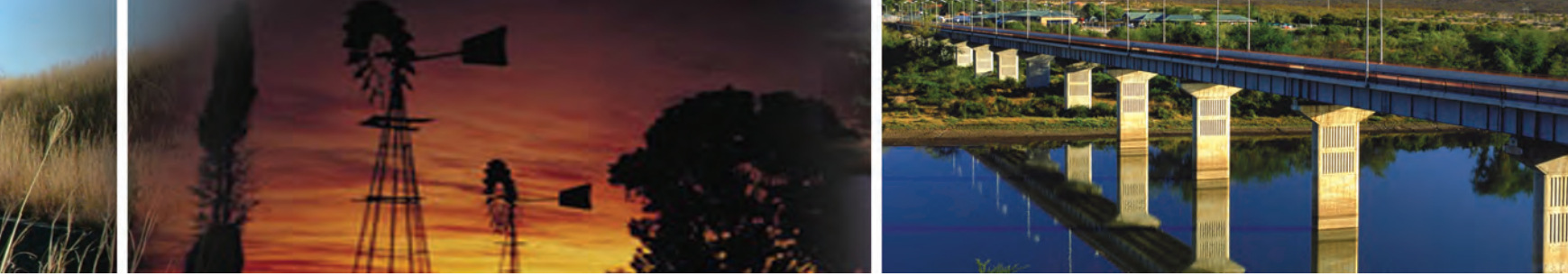
Map 6.2: Utilizable groundwater exploitation potential

Source: Department of Water Affairs and Forestry (2004)⁷

Box 6.1 Services provided by inland waters

- Essential for human life both directly (for drinking) and indirectly (for example, providing water for livestock and watering of dryland and irrigated crops; overall floral and faunal life).
- Crucial for maintaining ecosystem health (both terrestrial and aquatic) and biodiversity.
- Provides habitat for many flora and fauna both within the water itself and along the riparian corridors and wetlands associated with the water resource.
- Enables livelihoods (indirectly and directly, for example for fishermen, farmers, forestry, recreation, and those using reeds for thatching and basket-making).
- Facilitates power generation (for cooling in coal- and gas-fired stations and as the power source in hydroelectric power stations).
- Water is a key raw material for industry and mining.
- Transport and storage medium for raw water supply and removal of waste – these may be integrally linked in water-short areas such as Gauteng.
- Enables the movement of sediment by erosion and deposition with subsequent sculpting of the land, provision of sand to the coastal zone (such as beaches) and provision of rich silts onto floodplains.
- Wetlands and other aquatic ecosystems provide storage capacity, trap sediments, and opportunities for groundwater recharge and flood attenuation, as well as being able to assimilate some pollutants (including nutrient and toxic materials).
- Linked to these services are issues of health, poverty, climate change, afforestation, desertification, and changes in land use.

Table 6.1 indicates the relevant contributions of different water components (surface water, groundwater, and return flows) to the available yield⁶ in each of the water management areas. The local yield is calculated from the contribution of both natural resources and usable return flows (irrigation, urban, and mining/industrial). It should be noted that substantial volumes of water are returned to streams after use; they are then available for re-use, provided that the quality of the return flows satisfy the relevant user requirements⁵. In fact, the total usable return flows are close to twice the current yield from groundwater sources. The deficit in yields over time from surface water in the Middle Vaal, Lower Vaal, and Lower Orange water management areas indicate that river losses due to evaporation and seepage are greater than the additional yield contributed by local runoff in these areas.



Although the yield indicated in Table 6.1 takes account of the estimated allowance for protecting aquatic ecosystems (that is, the Ecological Reserve), not enough is known of the functioning and habitat requirements of these systems³. Catchments differ, and the estimates of requirements needed to sustain each aquatic ecosystem component of a Reserve vary from 12% of the total river flow in drier parts of the country to 30%. Estuarine requirements are also poorly understood³.

Opportunities for developing water resources

According to estimates of undeveloped resource potential, the yield from surface water can be increased by about 5 400 million m³/annum through further resource development. Such estimates exclude possible developments that are unlikely to have economic viability or sustainability. Substantial quantities of water can also be made available by increased re-use of return flows. Potential for this process exists at some coastal cities, where wastewater is currently discharged to the sea. There is also potential for further groundwater utilization, albeit on a smaller scale than the other options. Groundwater exploitation can also affect surface water availability and this possibility needs also to be held in consideration.

Desalination of seawater offers opportunities for coastal users. Although this water-treatment method is more expensive than developing and transferring further surface water resources, the technology is becoming more feasible as a result of advances in the field, particularly through the introduction of more cost-efficient membrane technologies. Desalination is practised on a large scale in many Middle Eastern countries and at arid isolated locations in South Africa, where small-scale desalination costs less than transporting potable water over long distances.

To augment water supplies in South Africa, consideration has in the past been given to other options and less conventional sources including long-distance importation of water from locations such as the Zambezi River, rainfall augmentation by cloud seeding, shipping fresh water from the mouths of large rivers, and towing icebergs to South Africa. Although all these options are technically feasible, there are various environmental, political, legal, and economic considerations attached to each. Current scientific understanding and costs preclude these options from being feasible compared to the options discussed under section 2.5 of the NWRS.

6.2.2 Water requirements

An appropriate understanding of water use requirements is essential for managing water resources judiciously. What complicates this understanding is the large variation in water requirements across the country, as different sectors

have different needs in terms of quantity, quality, temporal distribution, and assurance of supply. Also needing to be taken into account are the divergent social and economic values associated with water, the ability to pay, and priorities with regard to the provision of water.

Current water requirements

Estimated water requirements for the year 2000 for the different water use sectors are shown in Table 6.2. For ease of comparison with Table 6.1, the quantities are standardized at a 98% assurance of supply^d.

Comparison of the requirements (in Table 6.2) with return flows (in Table 6.1) shows that much of the water is used consumptively, with usable return flows estimated as follows: from the rural users (0%), irrigation (9%), urban (33%), and mining/bulk (34%). Agricultural irrigation accounts for about 62% of South Africa's total water requirement, with urban requirements needing about 23%. The remaining 15% is shared by the other four sectors. Only part of the water used non-consumptively becomes available for re-use, with large quantities of effluent return flows being discharged to the ocean, particularly from urban and bulk industrial users in coastal areas. Water use in the rural areas, as well as for irrigation and thermal power generation, is predominantly consumptive.

Although irrigated agriculture uses the major share of water in South Africa, its economic impact, per unit of water used, seems to be substantially lower than in other sectors. In other words, its economic contribution is small in relation to quantity of water used. A similar situation exists in mining.

Groundwater use has increased dramatically, from approximately 684 million m³ in 1950 to 1 770 million m³ in 2004⁸, mainly due to increased irrigation. Nationally,



Agricultural irrigation accounts for about 62% of South Africa's total water requirement. *Photography: Water Research Commission*

Table 6.1: Available yield in the year 2000 (million m³/annum)

Water management area		Natural resource		Usable return flow			Total local yield
		Surface water ¹	Ground water ²	Irrigation	Urban	Mining and bulk industrial	
1	Limpopo	160	98	8	15	0	281
2	Luvuvhu/Letaba	244	43	19	4	0	310
3	Crocodile West and Marico	203	146	44	282	41	716
4	Olifants	410	99	44	42	14	609
5	Inkomati	816	9	53	8	11	897
6	Usutu to Mhlatuze	1 019	39	42	9	1	1 110
7	Thukela	666	15	23	24	9	737
8	Upper Vaal	598	32	11	343	146	1 130
9	Middle Vaal	-67	54	16	29	18	50
10	Lower Vaal ¹	-54	126	52	0	2	126
11	Mvoti to Umzimkulu	433	6	21	57	6	523
12	Mzimvubu to Keiskamma	777	21	17	39	0	854
13	Upper Orange	4 311	65	34	37	0	4 447
14	Lower Orange ³	-1 083	24	96	1	0	-962
15	Fish to Tsitsikamma	260	36	103	19	0	418
16	Gouritz	191	64	8	6	6	275
17	Olifants/Doring	266	45	22	2	0	335
18	Breede	687	109	54	16	0	866
19	Berg	403	57	11	37	0	505
Total for South Africa		10 240	1 088	675	970	254	13 227

Notes:

Transfers into and out of water management areas are not included above but are covered in Table 6.3.

¹Yield from run-of-river and existing storage, after allowance for the impacts on yield of the ecological component of the reserve, river losses, alien vegetation, rain-fed sugar cane, and urban run-off.

²Estimated use from existing boreholes and springs. Total groundwater use may exceed this estimate as a result of development of groundwater for irrigation since the compilation of the database for the NWRS. Increase is due mainly to growth in irrigation water requirements, and therefore does not impact significantly on the overall water balances given in the NWRS.

³Negative figures under surface water arising from river losses being larger than the incremental runoff from within the water management area.

Source: Department of Water Affairs and Forestry (2004)³

irrigation comprises over 64% of groundwater use, while mining and domestic consumption in urban areas and in rural areas each use 8%. Groundwater is used for different purposes in various parts of the country, according to patterns of land use (see Map 6.3). Irrigation is obviously the largest user in many of the WMAs, but groundwater is

used for mining mainly over the highveld, while domestic use in rural areas occurs in the KwaZulu-Natal, Eastern Cape, Mpumalanga, and Limpopo provinces.

Table 6.3 provides a reconciliation of available water and total requirements for the year 2000, including transfers

Table 6.2: Water requirements for the year 2000 (million m³/annum)

Water management area	Irrigation	Urban ¹	Rural ¹	Mining and bulk industrial ²	Power generation ³	Afforestation ⁴	Total local requirements
1 Limpopo	238	34	28	14	7	1	322
2 Luvuvhu/Letaba	248	10	31	1	0	43	333
3 Crocodile West and Marico	445	547	37	127	28	0	1 184
4 Olifants	557	88	44	94	181	3	967
5 Inkomati	593	63	26	24	0	138	844
6 Usutu to Mhlathuze	432	50	40	91	0	104	717
7 Thukela	204	52	31	46	1	0	334
8 Upper Vaal	114	635	43	173	80	0	1 045
9 Middle Vaal	159	93	32	85	0	0	369
10 Lower Vaal	525	68	44	6	0	0	643
11 Mvoti to Umzimkulu	207	408	44	74	0	65	798
12 Mzimvubu to Keiskamma	190	99	39	0	0	46	374
13 Upper Orange	780	126	60	2	0	0	968
14 Lower Orange	977	25	17	9	0	0	1 028
15 Fish to Tsitsikamma	763	112	16	0	0	7	898
16 Gouritz	254	52	11	6	0	14	337
17 Olifants/Doring	356	7	6	3	0	1	373
18 Breede	577	39	11	0	0	6	633
19 Berg	301	389	14	0	0	0	704
Total for South Africa	7 920	2 897	574	755	297	428	12 871
	62%	23%	4%	6%	2%	3%	100%

Notes:

¹Includes the component of the reserve for basic human needs at 25 litres/person/day.

²Mining and bulk industrial that are not part of urban systems.

³Includes water for thermal power generation only, since water used for hydropower, which represents only a small portion of power generation in South Africa, remains available, unchanged, for further use. For ease of direct comparison with Eskom data, these numbers have not been adjusted for assurance of supply. The quantitative impact is not large.

⁴Quantities given refer to impact on yield only. The incremental water use in excess of that of natural vegetation is estimated at 1 460 million m³/annum.

Source: Department of Water Affairs and Forestry (2004)³

between water management areas and to neighbouring countries. Deficits exist in more than half of the water management areas, but there is a surplus for the country as a whole. This situation highlights the regional differences in the country and reveals the potential risks of generalization. Similarly, a surplus or a deficit shown in a specific water management area is unlikely to be representative of the entire area, and anomalies are most likely to occur in some

catchments or smaller areas within a larger water management area. Furthermore, the water availability and water balance figures are related to current water use patterns and the existing geographic occurrence of resources, abstractions, and return flows. Often it is not practical or economically feasible for water to be transferred from areas of surplus to areas of deficit. Imbalances within water management will be handled according to catchment

Nationally, irrigation comprises over 64% of groundwater use, while mining and domestic consumption in urban areas and in rural areas each use 8%.

management strategies to be formulated by the relevant catchment management agencies.

In many cases, the deficits shown do not necessarily imply that water use exceeds the amount that is available, but rather that the allowances made for implementing the ecological component of the Reserve cannot fully be met at current levels of use. The requirements for the Reserve are estimates at present, and further research is needed to understand the ecosystem requirements sufficiently. The Reserve has not yet been implemented. The planned approach is to phase it in, so as to diminish the likelihood of adverse effects on existing users. Nevertheless, in many areas, current levels of use make no allowance for the need to sustain the ecological viability of the resource, and substantial changes will be needed when the Reserve is implemented.

In summary, approximately 9 500 million m³/annum of the total requirements for water of 12 871 million m³/annum is abstracted from surface water resources. The remainder comes from groundwater, the re-use of return flows, and the interception of water by afforestation. Total requirements, therefore, represent approximately 20% of the total mean annual runoff of 49 040 million m³/annum. A further 8% is lost by evaporation from storage and conveyance along rivers, and 6% through land use. Country-wide, approximately 66% of the natural river flow (mean annual runoff) remains in the rivers. Typically, the temporal flow

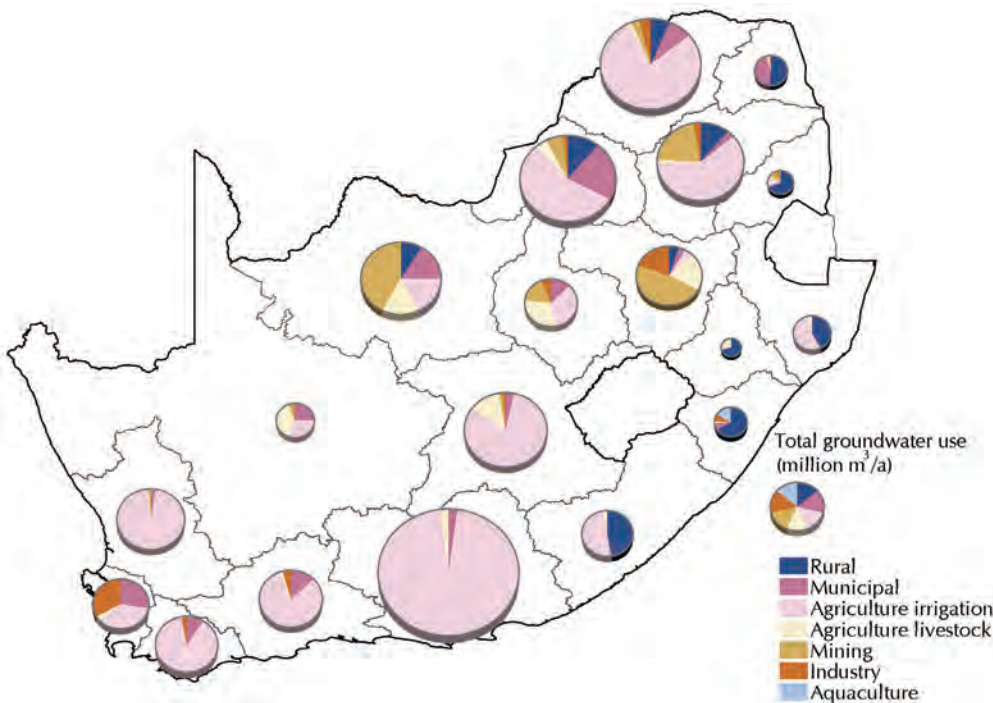
distribution of this remaining water has been significantly altered as a result of upstream regulation and use, and it no longer reflects the characteristics of the natural stream flow. It does however meet substantial requirements of the Reserve and fulfils downstream international commitments. Potential also exists for part of the remaining water to be abstracted for allocation to users, provided that sufficient infrastructure exists, or can be developed. Should the surface resources be developed to their full, but feasible potential, more than 50% of the mean annual runoff can still remain in the rivers. Serious questions that require attention include the consideration of what likely future escalation in water requirements should be provided for, and what strategies need to be developed to ensure that these future requirements can be met.

Future water requirements

Many factors, including climate, the nature of the economy, and standards of living, will influence South Africa's future water requirements. Changes in population and economic growth are regarded as the primary determinants of future water requirements.

Changes in national policies since 1994, and the influence of global economic trends on South Africa, have led to population migration into some areas and population loss from others. Urbanization and the adverse effects of HIV and AIDS are recognized as strong contributory factors. Scenarios developed for population growth up to 2025 have indicated a decline in general population growth towards the end of this period, with small to negative growth in the rural population. Similar scenarios have been developed for economic growth and its influence on future water requirements. Economic growth (and the growth in water requirements) is, not surprisingly, expected to be substantially higher in the larger urban and industrialized areas than in the rural areas. An upper scenario of average real growth in gross domestic product (GDP) of 4% per year has been seen as a conservative indicator, to forestall any likelihood of unexpected water shortages. This compares with a low growth scenario of about 1.5% per year. Both these scenarios have been used in the NWR5 for developing strategies to balance future water supply and demand.

Future growth in water demand is expected to occur in the economically more favourably located urban areas, given the general trends towards urbanization and continued economic growth. Relatively strong growth is also expected in the mining sector, with water demand for mineral exploitation concentrated in the country's northern regions. The base scenario⁶ comprises the high scenario of population growth, together with higher average levels of urban domestic water requirements (this occurs because demand and consumption increase as people become better off through more equitable distribution of wealth). The ratio of domestic to commercial, communal, and industrial water use in urban centres in the year 2000 is



Map 6.3: Sectoral groundwater use (million m³/annum) per water management area

Source: Department of Water Affairs and Forestry (2004)⁸

Table 6.3: Reconciliation of the requirements for and availability of water for year 2000 (million m³/annum)

Water management area	Reliable local yield	Transfers in ²	Local requirements	Transfers out ²	Balance ¹
1 Limpopo	281	18	322	0	-23
2 Luvuvhu/Letaba	310	0	333	13	-36
3 Crocodile West and Marico	716	519	1 184	10	41
4 Olifants	609	172	967	8	-194
5 Inkomati	897	0	844	311	-258
6 Usutu to Mhlataze	1 110	40	717	114	319
7 Thukela	737	0	334	506	-103
8 Upper Vaal	1 130	1 311	1 045	1 379	17
9 Middle Vaal	50	829	369	502	8
10 Lower Vaal	126	548	643	0	31
11 Mvoti to Umzimkulu	523	34	798	0	-241
12 Mzimvubu to Keiskamma	854	0	374	0	480
13 Upper Orange	4 447	2	968	3 149	332
14 Lower Orange	-962	2 035	1 028	54	-9
15 Fish to Tsitsikamma	418	575	898	0	95
16 Gouritz	275	0	337	1	-63
17 Olifants/Doring	335	3	373	0	-35
18 Breede	866	1	633	196	38
19 Berg	505	194	704	0	-5
Total for South Africa	13 227	0	12 871	170	186

¹Surpluses in the Vaal and Orange water management areas are shown in the most upstream water management area where they become available (namely, the Upper Vaal and Upper Orange water management areas).

²Transfers into and out of water management areas may include transfers between water management areas as well as to or from neighbouring countries. Yields transferred from one water management area to another may also not be numerically equivalent in the source and recipient water management area. For this reason, the total of transfers into and out of water management areas does not necessarily correspond to the country total. The transfer of water from Lesotho to South Africa is reflected in the tables as being from the Upper Orange water management area (refer to Appendix D 13 of NWRS).

Source: Department of Water Affairs and Forestry (2004)³

maintained in this scenario. The upper limit scenario is based on the same assumption of high population growth and the high standard of service provision that arises from rapid socio-economic development. These are combined with strong economic growth in which commercial, communal, and industrial water use increases in direct proportion to growth in GDP. The upper scenario serves as a conservative indicator, factoring in possible unexpected water shortages. (Figures for these scenarios are presented in section 6.2.3 below.)

6.2.3 Strategies to balance supply and demand

Tables 6.4 and 6.5 show the reconciliation of requirements and availability of water for the year 2025 for the base scenario (1.5% GDP growth rate per year) and high scenario (4% GDP growth rate per year). These scenarios provide for known and anticipated future developments in irrigation, mining, and bulk use, as well as Eskom's projections of future water requirements for power generation. Where



feasible, specific quantities rather than annual growth rates were allowed for in these sectors.

The base scenario, which is regarded as the more probable, does not show a pronounced deviation from the situation in the year 2000. Deficits will increase under both scenarios, while surpluses will diminish. Total deficits in water resources range between 234 million m³/annum for

the base scenario and 2 044 million m³/annum for the high scenario. It is expected that future growth in water requirements will be largely in the main metropolitan centres. Apart from catchments already under stress, particular attention will therefore have to be given to ensuring adequate future water supplies to these areas, as well as ensuring equitable access to existing supplies.

Table 6.4: Reconciliation of requirements for and availability of water for the year 2025 base scenario (million m³/annum)

Water management area	Reliable local yield ¹	Transfers in	Local requirements ²	Transfers out	Balance	Potential for development ³
1 Limpopo	281	18	347	0	-48	8
2 Luvuvhu/Letaba	404	0	349	13	42	102
3 Crocodile West and Marico	846	727	1 438	10	125	0
4 Olifants	630	210	1 075	7	-242	239
5 Inkomati	1 028	0	914	311	-197	104
6 Usutu to Mhlathuze	1 113	40	728	114	311	110
7 Thukela	742	0	347	506	-111	598
8 Upper Vaal	1 229	1 630	1 269	1 632	-42	50
9 Middle Vaal	55	838	381	503	9	0
10 Lower Vaal	127	571	641	0	57	0
11 Mvoti to Umzimkulu	555	34	1 012	0	-423	1 018
12 Mzimvubu to Keiskamma	872	0	413	0	459	1 500
13 Upper Orange	4 734	2	1 059	3 589	88	900
14 Lower Orange	-956	2 082	1 079	54	-7	150
15 Fish to Tsitsikamma	456	603	988	0	71	85
16 Gouritz	278	0	353	1	-76	110
17 Olifants/Doring	335	3	370	0	-32	185
18 Breede	869	1	638	196	36	124
19 Berg	568	194	829	0	-67	127
Total for South Africa	14 166	0	14 230	170	-234	5 410

¹Based on infrastructure in existence, and under construction, in the year 2000. Return flows resulting from a growth in requirements are included.

²The assumed growth in urban and rural water requirements results from the anticipated high population growth and current ratios of domestic to public and business water use. Allowance has been made for known developments in urban, industrial, and mining sectors only, with no general increase in irrigation.

³For more detail for each water management area, see the corresponding tables in Appendix D of the NWR5.

Source: Department of Water Affairs and Forestry (2004)³



Water that is potentially identified as available for supply (primarily through the construction of new storage dams and the use of groundwater) amounts to 5 410 million m³/annum. Water is thus not currently regarded as a limiting factor to economic growth³. Nonetheless, the discussed deficits could increase, taking account of the potential effects of climate change, and allowing also for the fact that allocations for the Ecological Reserve have not yet been fully implemented. In addition, it is questionable whether or not the further development of water resources will address imbalances, given unequal geographic distribution of water resources, the relevant technological requirements that are necessary for corrections, and the capacity constraints of the DWAF. Such development will need to be carefully managed to ensure protection of aquatic ecosystems and other habitats. Issues to be considered include: the implications of transferring water between areas and across catchments (for example, changes in flows, transfer of species, varying chemistry); variable rainfall across the country and over time; loss of land with agricultural potential; loss of areas of high biodiversity including aquatic systems; and climate change, which could exacerbate potential problems.

Reconciliation interventions

The main interventions for balancing the requirements and availability of water are summarized below. In practice, varying combinations of the intervention options outlined here may be employed, depending on suitability for each water management area.

- **Demand management.** This is a response to a situation in which the demand for water exceeds supply. Investment is made in resource development, often with increasing cost implications and environmental impacts. An effective alternative is the management of water demand, this having been applied with notable success to some users, particularly in selected areas of industry and agriculture. Compared with supply-side management, the management of water demand in South Africa is relatively unexploited. Investment in improving practices, technology, and capacity in water demand management is now a NWRS priority.
- **Water resource management.** Water resource deficits in more than half the water management areas in South Africa have made it necessary to develop more sophisticated systems of reservoir management and to use inter-catchment transfer to reduce risks of failure in supply. Scope now exists to improve the management of many of the smaller water resource systems; to revise operating strategies for the larger water resource systems to improve effectiveness; and to respond more constructively to any change.
- **Managing groundwater resources.** Under previous legislation, groundwater was deemed to be private

water. Consequently, there has been limited investment in the assessment and management of this resource. Recent investigation reveals the considerable potential for developing small-localized supplies of groundwater in most parts of South Africa, to assist in reconciling future demand and supply imbalances. These systems are often particularly attractive, because of a minimal investment requirement for developing and treating this supply.

- **Re-use of water.** Approximately 50% of urban and industrial drainage is returned for re-use in urban and industrial areas such as Tshwane and Johannesburg. Coastal cities such as Cape Town and Durban re-use only 5–15% of urban and industrial drainage. Opportunities may be available for increasing the source of water substantially through additional re-use, provided appropriate treatment technology and quality control is applied.
- **Control of invasive alien vegetation.** Provisional estimates quoted in the NWRS indicate that about 1 400 million m³/annum of surface runoff (about 3% of the national mean annual runoff) is intercepted by invasive alien vegetation. Without effective control, this impact is likely to increase. Typical catchment management strategies include the clearing of alien vegetation as part of the Working for Water Programme (for details, see Chapter 5).
- **Re-allocation of water.** Water should ideally be exploited to best advantage to achieve the greatest overall benefit for the country, from a social, economic, and environmental perspective. Re-allocation of water can be effective in achieving these aims. It includes the option of moving water from lower to high benefit uses through trading water use authorizations, while preserving priorities such as the maintenance of food security. Managing the process effectively is critically important but reallocation may not be practicable in certain locations. A major consideration is the quantity and quality of the return flow, which may render the source unfit for other legitimate uses.
- **Development of surface water resources.** Significant opportunities still exist in many parts of the country for developing surface water resources further. These would typically be capital-intensive projects, however, tending to have a long pay-back period that could diminish the economical viability of such an investment. In many cases, it may be more economically attractive to induce changes in water-use patterns and to re-allocate water among users.
- **Inter-catchment transfers.** The country's geographical imbalances in water availability and requirements make inter-catchment transfer necessary in South Africa. More than half of the water-management areas listed in Tables 6.4 and 6.5 rely on inter-catchment transfers to

avoid deficits in water supply. Figures for the year 2000 show that inter-catchment transfers of yield amounted to more than 3 000 million m³/annum, (out of a total surface water yield in the country of about 11 000 million m³/annum) and more water will inevitably need to be transferred in future.

- **Water-quality considerations.** Water quality is a fundamental consideration for all options, although it is

not in itself an intervention that reconciles the imbalances between water supply and requirements. It is essential for water to be of appropriate quality for the uses intended as well as for the Ecological Reserve. All interventions affect the water quality in some way and, in some cases, the blending of resources may be needed to maintain the quality that is fit for the intended use.

Table 6.5: Reconciliation of requirements for and availability of water for the year 2025 high scenario (million m³/annum)

Component/ Water management area	Reliable local yield ¹	Transfers in	Local requirements ²	Transfers out	Balance	Potential for development ³
1 Limpopo	295	23	379	0	-61	8
2 Luvuvhu/Letaba	405	0	351	13	41	102
3 Crocodile West and Marico	1 084	1 159	1 898	10	335	0
4 Olifants	665	210	1 143	13	-281	239
5 Inkomati	1 036	0	957	311	-232	104
6 Usutu to Mhlathuze	1 124	40	812	114	238	110
7 Thukela	776	0	420	506	-150	598
8 Upper Vaal	1 486	1 630	1 742	2 138	-764	50
9 Middle Vaal	67	911	415	557	6	0
10 Lower Vaal	127	646	703	0	70	0
11 Mvoti to Umzimkulu	614	34	1 436	0	-788	1 018
12 Mzimvubu to Keiskamma	886	0	449	0	437	1 500
13 Upper Orange	4 755	2	1 122	3 678	-43	900
14 Lower Orange	-956	2 100	1 102	54	-12	150
15 Fish to Tsitsikamma	452	653	1 053	0	52	85
16 Gouritz	288	0	444	1	-157	110
17 Olifants/Doring	337	3	380	0	-40	185
18 Breede	897	1	704	196	-2	124
19 Berg	602	194	1 304	0	-508	127
Total for South Africa	14 940	0	16 814	170	-2 044	5 410

¹Based on infrastructure in existence and under construction in the year 2000. Also includes return flows resulting from a growth in requirements.

²Urban and rural requirements based on high growth in water requirements as a result of population growth and the high impact of economic development. Allowance has been made for known developments in urban, industrial, and mining sectors only, with no general increase in irrigation.

³For more detail for each water management area, see the corresponding tables in Appendix D of NWRS.

Source: Department of Water Affairs and Forestry (2004)³

- **Environmental considerations.** As concerns water quality, all interventions on behalf of reconciliation need to take account of the potential impacts on the social and natural environment, and need to be assessed together with the technical and economic factors.

6.2.4 Other factors affecting availability and requirements

Land use

Changing patterns of land use (see Chapter 4) affect water flows and water availability in four main ways.

Firstly, urbanization results in an increase in impervious surfaces. These augment the volume of runoff entering surface waters and reduce the volume that recharges groundwater. Such runoff constitutes a new source of recharge, with further contributions from leaking water pipes or underground storage tanks, as well as from the over-irrigation of gardens and parks⁶.

Secondly, the hydrological patterns (flow rate and volume) are significantly altered by human activities including the construction of dams, weirs, and bridges; canalization or diversion of watercourses; and mining within watercourses.

Thirdly, the misuse of land (including overgrazing) results in erosion, with increased sediment loads entering watercourses. The material tends to settle where water flows slowly, such as at dams and in wide river sections, thereby degrading ecosystems through silting, reducing the storage capacity of these facilities, and changing the flow dynamics of rivers.

Finally, alien vegetation in South Africa tends to consume greater volumes of water than indigenous vegetation, creating the risk of reduced yields in affected areas. Alien vegetation in some areas has been estimated to reduce stream flows by up to 10%⁹. Alien vegetation removal in the North West and Limpopo provinces has resulted in a 20-m rise in the water table over a 30-year period⁶.

Policy and regulation

Some of the structures and devices required to regulate South Africa's water resources are in place, through the terms of the National Water Policy 1997, the National Water Act No. 36 of 1998 (NWA), and the Water Services Act No. 108 of 1997, amongst others (see Table 3.1 in Chapter 3). Historical lack of capacity and financial resources within the regulating bodies, however, have led to inconsistent management and a lack of widespread enforcement. Water-supply organizations should strive to supply water efficiently and effectively, minimize water losses (from reticulation leakage, for example) and promote water conservation and water demand management (WC/WDM) among their consumers³.

The NWA provides a key step in assisting the DWAF to identify and control water abstraction. All existing water users are required to be registered. The time-period for registration has lapsed, so all users that are not covered by Schedule 1 of the Act, or by a General Authorization, or by DWAF registration/licence, are drawing water illegally. The DWAF is in the process of issuing all the registered users with a water-use licence, based on the priority of the water-stressed nature of the WMAs, which stipulates the volumes to be abstracted and the conditions that apply to the abstractor. Allocation of water not already in use, as well as re-allocation of water to achieve equity and beneficial use, will form part of the licensing process. Guidelines have been drawn up to facilitate the equitable allocation and re-allocation of water¹⁰. It is imperative for DWAF to take strong action against illegal abstractors.

Climate change

Climate change has the potential to make a significant impact on both the availability of and requirements for water in South Africa. The 2003 South African study on water resource management and climate change¹¹ indicates that climate change is expected to alter hydrological systems and water resources in southern Africa and reduce the availability of water (see Chapter 8).

Rising temperatures and increasing variability of rainfall will generally affect surface waters, increasing drought in some regions and causing floods in others, as well as influencing groundwater recharge. There is likely to be a general decrease of 5–10% of present rainfall¹¹, with longer dry spells in the interior and northeastern areas of the country coupled with more frequent and severe flood events. The probable effect is greater evapo-transpiration and more stress on arid and marginal zones.

Recent models, using a local scale response to climate change, indicate more wetting in the east than other global models¹². Wetting is generally expected over the eastern half of the country, particularly in the east coast regions, where topography plays a significant role. Portions of the Eastern Cape interior may experience increased late summer rainfall. Drying is expected in the west of the country, particularly around the Western Cape, which seems to be facing a shorter rainfall season, and in the far northern area of the country in Limpopo province.

Runoff is highly dependent upon changes in rainfall, and groundwater recharge even more so. Parts of South Africa could experience reductions in runoff and/or stream flow of up to 10%, which could be evident in the western parts of the country as soon as 2015¹¹. The decrease in runoff would move progressively from west to east, and could be expected to reach the east coast by 2060. Even if the average rainfall were to remain the same, increased variability of stream flow would result in reduced natural yields and reliability, and an increase in the unit cost of

Climate change has the potential to make a significant impact on both the availability of and requirements for water in South Africa. The 2003 South African study on water resource management and climate change indicates that climate change is expected to alter hydrological systems and water resources in southern Africa and reduce the availability of water.



No development or investment decisions should be made that neglect to take into account the actual or potential effects of climate change on water resources.

water from dams. Should warmer climatic conditions prevail, the water requirements of plants, and therefore irrigation requirements, would also increase. A decrease in water availability will also affect water quality, further limiting the extent to which water may be used and developed.

Interaction is needed among all water-dependent sectors to ensure that all available measures are considered, so as to adapt to changing circumstances and reduce vulnerability. No development or investment decisions should be made that neglect to take into account the actual or potential effects of climate change on water resources.

Impacts of water resources management

Reductions in flow that arise from some of the pressures indicated above can result in increasingly variable availability of water, reducing assurance of supply, and increasing cost of water to downstream users. The demand for scarce resources can lead to conflicts among different users. The various users in the Mpumalanga Olifants River WMA are an example, with a deficit of 194 million m³/annum (see Table 6.3) covering plantations, irrigated farmlands, domestic use, and mining. The consequence is a significant stream-flow reduction. This has had negative effects on downstream aquatic ecosystems (many of which are found in conservation areas such as the Kruger National Park) and neighbouring countries (Mozambique and Swaziland).

Over-abstraction of groundwater (where abstraction exceeds recharge) by particular users, especially where recharge rates are low, such as in the North West province, can lower the groundwater to a point that renders it unavailable to other users¹³. Even if over-abstraction is curtailed, it can take many years to re-establish natural levels.

Infrequent severe events, such as prolonged droughts and heavy floods, can reduce the availability of clean water, cause significant damage to infrastructure (for example bridges, weirs, and dams) and lead to a loss of crops and livestock. The effects of these major events often last for several years, increasing the risk of people moving away from their traditional homes (see Chapters 4, 9, and 10). Climate change is likely to increase the risk of such severe events.

Further development of currently under-developed water resources for water supply (for example in WMA 11 Mvoti to Umzimkulu, 12 Mzimvubu to Keiskamma, and 13 Upper Orange) could result in the future³ availability of about 5 400 million m³/annum. The implications are significant: they include economic implications (dams and pipelines are capitally expensive), social implications (in terms of loss of land and livelihoods), and environmental implications (such as loss of habitat and changes to aquatic ecosystems). Each option will need to be investigated intensively, with

environmental and socio-economic impact assessments being conducted to ensure long-term benefits to all stakeholders. This kind of investigation is currently under way for the Olifants River Water Resources Development Project, which includes upgrades to the Flag Boshelo Dam and the proposed construction of the De Hoop Dam¹⁴.

6.2.5 Current management of water resources

The Minister of Water Affairs and Forestry, as the public trustee of the nation's water resources, has overall responsibility for all aspects of water resource management. The Minister has delegated many of her powers to the relevant water management institutions identified below:

- Catchment Management Agencies (expected to be in place countrywide by 2011), which will manage water resources within specific WMAs and coordinate water-related activities of the water users and of other water management institutions
- Water-User Associations, as cooperative associations of individual users (for example, irrigation boards)
- International institutions for managing international obligations. Several bilateral and multilateral commissions with overall co-operation are taking place within the framework of the SADC Protocol on Shared Water Courses (which came into force in September 2003) including:
 - Botswana/RSA Joint Permanent Technical Water Committee
 - Lesotho Highlands Water Commission
 - Limpopo Basin Permanent Technical Committee
 - Mozambique/RSA Joint Water Commission
 - Orange/Senqu River Basin Commission
 - Permanent Water Commission
 - Swaziland/RSA Joint Water Commission
 - Swaziland/Mozambique/RSA Tripartite Permanent Technical Committee.

The establishment of these institutions often involve extensive stakeholder consultation. Although this is essential in ensuring that all views are considered, it has contributed to delays in getting the necessary systems in place. Other responses to managing water resources are discussed below.

National Water Resource Strategy

Several management mechanisms have been identified and adopted by the DWAF as part of its NWRS (see Chapter 3). They are described below, but apply equally to the



sections on fitness for use and aquatic ecosystems (section 6.3 and section 6.4, respectively). The NWR5 also indicates the need for water-related disaster management (floods, drought, dam-failure, and pollution incidents) to be incorporated into the overall framework required by the National Disaster Management Act (No. 57 of 2002).

The proposed strategies are broadly divided into 'resource-' and 'source-directed' controls. Resource-directed measures focus on the overall health or condition of an aquatic ecosystem that provides the abstracted water, and they assess its ecological status. The key parameter is the grouping of water resources in terms of the national water resources classification system. This system indicates the extent to which the resource is being modified, with each class representing a different level of protection as well as the Reserve' and resource quality objectives, (which take into account the user requirements and the biological, chemical, and physical attributes of the resource).

Specific actions in terms of resource-directed measures requiring attention at national level in respect of water quality management include the following:

- Formulating objectives for managing sources of pollution and associated single-source interventions
- Benchmarking water-resource quality
- Identifying emerging threats to the water resource and prioritizing action
- Establishing priorities in relation to issues such as the remediation of water resources and degraded land, as a focus for regulation using source-directed controls.

Source-directed controls focus on the use of the water resource and are intended to achieve the desired level of protection (as required by resource-directed measures). These can be further broken down into controls relating to:

- Water use – licensing, water user associations, and specific regulations (for example, the protection of water resources from mining activities, specified in Regulation GN704).
- Water conservation and demand management – benchmarking for efficient water use, sector-specific plans, and control of invasive alien vegetation as, for example, through the Working for Water programme, which has the added benefit of job creation (see Chapter 5, section 5.6.3). Issues also include communication, community awareness, and education plans.
- Water pricing – water-use charges, combined with financial assistance where necessary.

Data and information availability

The availability of reliable data and information is critical for planning purposes. Monitoring and information systems

that are in place, or have been proposed, include the following:

- **Flow monitoring** at 800 stations: this translates into one station per 1 500 km². Some of them are combined with off-takes or outlets, reservoir water level recording, and meteorological stations. The target that has been set by the World Meteorological Organization is one station per 1 000 km². The DWAF, in response, is planning for another 500–1 000 stations to be developed over the next 20–25 years.
- **Surface water quality**, with additional emphasis on microbial, toxicological, and radioactivity monitoring (physico-chemical, biological, and estuary monitoring, including eutrophication, are fairly well established).
- **Groundwater monitoring**. Because of groundwater's historical 'private' status, past monitoring has been incomplete. Plans now include the monitoring of water levels, as well as the water's physical, chemical, and biological characteristics. Initially, only physical and chemical data will be collected, but eventual monitoring will expand to include microbial, toxicological, and radioactivity data.
- Preparation of a **national scale map**, indicating river reaches that depend on groundwater recharge. The quantification of groundwater use has also been recommended.
- **Water-use registration and authorizations** to control the registration/application process and invoicing, and the links to other databases.

Water Resources of South Africa 2005 Project

The Water Research Commission (WRC), which is the major freshwater research organization in South Africa, has funded research and published reports on many aspects of water resource management. It has ongoing projects in five key strategic areas¹⁵. The first, Water Resource Management, includes the key Water Resources of South Africa 2005 Project, in which hydrological, meteorological, geohydrological (groundwater), and some water chemical data are being updated for catchments in South Africa. This updated database, expected to be completed in March 2007, will form a baseline for future national water availability studies. Other key strategic areas are Water Utilization in Agriculture, Water Use and Waste Management, Water-Centred Knowledge and Water-Linked Ecosystems¹⁵.

6.3 FITNESS FOR USE: WATER QUALITY

The fitness for use of water by either humans or aquatic organisms depends not only on availability but also on the



President Thabo Mbeki and former Water Affairs Minister Ronnie Kasrils help clean up the polluted Vygieskraal River on the Cape Flats to mark the start of National Water Week.

Photography: Cape Times

physical and chemical nature of the water. Various users and ecosystems have differing water-quality requirements, which can be affected by natural processes, diffuse and point-source discharges, or by the diversion, storage, or inter-catchment transfer of water.

The physico-chemical requirements of some users, including domestic, irrigation, livestock watering, recreation, and aquatic ecosystems, have been defined in the Water Quality Guidelines issued by the DWAF (1996)¹⁶. The Reserve Determination Process being undertaken by the DWAF for each water resource indicates basic requirements for human needs, aquatic ecosystem maintenance, and international obligations. The Reserve specifies a required flow for each resource, as well as required physico-chemical (ground and surface water) and biological (surface waters only) qualities.

Diminished fitness for use is generally associated with the activities of humans but can also arise from natural causes, such as underlying geology (higher mineral content), biological phenomena (evapo-transpiration or pH shift and anoxia associated with the breakdown of organic matter), atmospheric deposition and evaporative loss, with consequent increase in dissolved solid content, particularly salts. Pollution of a resource takes place when an excess of an unwanted or harmful substance is assimilated by it. This diminishes the residual natural assimilative capacity of the resource, reducing its fitness for subsequent use⁴. Water used by industry or in urban areas is often returned to the resource for re-use by others. Its state is often degraded during this process, however, and can become unfit for further use.

Pollution of water resources occurs either in the form of point-source releases (for example, discharges from sewage works and industrial activities) or from diffuse inputs via air, land, or surface runoff. On-site sanitation, for example, can lead to distributed high levels of nitrogenous pollution in groundwater. Accidental spillage or waste release is also a



The unsettling sight of a polluted river.

Photography: IMAGES24.co.za / Beeld / Daryl Hammond

potential problem. Examples include littering in urban areas and spills of hazardous material during transport, improper storage, or misuse. (See Box 6.2 for the common pollutants found in South Africa and their impacts on fitness for use.) Pollution of surface waters is more obvious than groundwater pollution, the latter being more difficult to detect and to remedy than surface water³. Contamination of aquifers and surface-water bodies by fouled subsurface discharge is recognized as a problem. Irrigation, including over-irrigation of naturally saline soils and underlying rocks, has contaminated the Breede⁶.

6.3.1 State of water quality in South Africa

Numerous water-monitoring programmes are being undertaken by the different spheres of government. Examples include the DWAF's national water quality and microbial monitoring programmes, the River Health Programme (see section 6.4.1), and monitoring by local authorities and service providers. The WRC has funded several research initiatives to collate information from these different sources into the DWAF's Water Management System (WMS) database. The Water Resources of South Africa 2005 Project described in section 6.2.5 is one such initiative.

Water samples from about 1 600 surface water sites and 450 groundwater sites across the country are currently being collected and analysed, and the results are being added to the WMS. The DWAF published a National Water Resource Quality Status Report¹⁷ in 2002. This study used data from over 150 representative sites (selected from the WMS) to determine the suitability (from a physico-chemical perspective) of surface-water resources for domestic, irrigation, and recreational uses. Other than for aquatic ecology, the criteria for these uses are the most stringent. The results were based on data collected between 1996 and 2000, so they are now out of date. The report will probably be updated in 2006/2007, however, using data from 2001 to 2005¹⁸.

The restriction on the fitness for use imposed by the physico-chemical water quality standards of the different WMAs regarding domestic, irrigation, and recreational use is given in Table 6.6. The data are consolidated for each WMA and conceal the inherent vulnerability that exists within these large areas. The table also includes the conservation status, as determined by the National Spatial Biodiversity Assessment¹⁹.

6.3.2 Water quality trends

The results discussed in the previous section provide an indication of the spatial variation in water quality of surface-water resources. Median values from the WMS for the years 2000–2004 were assessed to highlight temporal

changes, especially the temporal trends of nitrate/nitrite content (an indicator of nutrient status) and total dissolved solids (an indicator of salinity).

The results indicate that nitrate levels tend to be stable or are improving, with an indication of deterioration evident at only 10% of the sites (see Map 6.4). Nitrate concentrations link to organic matter content in water, influencing dissolved oxygen content and pH, so a definitive conclusion cannot be drawn without a detailed assessment of all these factors. In contrast, salinity levels tend to be variable. There is an increase (a deteriorating trend) in the case of 46% and a decrease (improvement) in only 17% of the sites (see Map 6.5).

Existing groundwater data are difficult to interpret because, unlike surface-water data, groundwater information is spatially discontinuous. Furthermore, poor data density means that valid statistical analyses cannot reliably be drawn. Specific locations and geohydrological settings of the sampling points are not always available, and unsystematic data collection is an additional problem.

Estimates of the load of pollutants contributed by point-source discharges to water resources are generally unavailable. This is because not all water users have been registered or licensed and where they have been, the volume and quality indicated generally represents the total allowed rather than actual quantities being released. Volume and quality information of these dischargers will, in time, be incorporated into the WMS. Estimation of loads from diffuse sources is even more difficult as numerous factors need to be taken into account, including rainfall volumes, runoff, permeability values, and the nature of the pollutant, though some catchment-based investigations have successfully been undertaken (for example, the Upper Vaal).

6.3.3 Effects of human activities

The pressures exerted by human activities on water resource quality are summarized from the NWR5 and miscellaneous other sources.

- **Industry and mining.** Mining can result in change of pH (acidity of the water), increased salinity, increased metal content, and increased sediment load. Industrial contributions are more varied, depending on the industrial process, but can include poisonous and hazardous chemicals, nutrients, elevated salinity, and increased sediments.
- **Increased urbanization and deteriorating standards in wastewater management.** Little or no treatment of wastewater takes place in some circumstances, such as at informal settlements. Where treatment is available, sewer reticulation can be inadequate or poorly maintained, resulting in uncontrolled releases such as leakage and overflow to the natural

Box 6.2 Water quality problems in South Africa

- **Salinity** refers to the quantity of total dissolved inorganic solids or salts in the water. Increased salinity can lead to salinization of irrigated soils, diminished crop yields, increased scale formation and corrosion in domestic and industrial water pipes, and changes in the biotic communities. Salinity can arise naturally or from activities such as mining, industry, and agriculture. Humans can generally tolerate moderate salinity (less than 1 000 milligrams per litre (mg/l)), though the taste can become too salty. High salinity (exceeding 3 000 mg/l) can cause fatal intestinal and renal damage. Salinity is often the major limiting factor in determining fitness for use, compared with wetter countries, where an option of dilution is available to them.
- **Water-borne diseases** such as diarrhoea, dysentery, skin infections, intestinal worms, cholera, trachoma, and schistosomiasis (bilharzia) arise from bacteria or parasites. These are attributable to poor sanitation practices.
- **Low oxygen levels** occur when bacteria in the water decompose organic matter, using oxygen, which is also required by other biotic components of the aquatic ecosystem. Elevated concentrations of organic matter in water, arising from animals, humans, or plants can occur naturally as well as from poor waste-disposal practices.
- **Eutrophication** is due to an accumulation of nutrients (mostly nitrogen and phosphorus compounds) in water. The nitrogen:phosphate ratio, at higher proportions of phosphorus, will promote growth of potentially toxic cyanobacteria. Anthropogenic sources of nutrients in water commonly arise from domestic waste treatment, over-application of fertilizers, and certain industrial and mining processes. Nutrients such as ammonia and nitrate present a fatally toxic hazard to aquatic fauna, particularly fish, and can lead to excessive plant and algal production, as was the case with the water hyacinth problem in Hartbeespoort Dam in the 1970s and 1980s. The consequence is further depletion of oxygen in the water, compounded by mass mortality of the aqueous biota that require oxygen. Cell rupture of dying cyanobacteria releases their toxin content into the water.
- **Suspended solids** are insoluble sediments carried by the water, and arise from excessive erosion, destruction of riparian vegetation, construction activities, over-grazing, and industrial or domestic discharges. Large quantities of solids, either suspended in the water, or as deposited sediment, can alter the habitat of some aquatic organisms, with consequent change in the composition of the stream-bed community. Change in the stream-bed characteristics can impair the feeding efficiency of fish (impaired visibility, burial of food in silt), compromise breeding, impair their respiratory functions, and impede gaseous exchange that is essential for the life of all aquatic fauna and flora. Lack of light prevents photosynthesis.
- **Hydrocarbons** can have toxic effects. Oil films block or smother animal respiratory organs. Hydrocarbons include petrochemicals, such as lubricating oil, petrol, paraffin, diesel, greases and tar, synthetic organic solvents (not necessarily classified as hydrocarbons), and the oils and fats of biological origin from food processes (which are also not true hydrocarbons).
- **Acidification** occurs when the pH of the water is lowered as a result of mining, industry, acid rain, waste disposal, or certain natural biological processes (such as the decomposition of fynbos in the South West Cape). Lowering of the pH can mobilize metals such as cadmium and lead, which in turn can have an adverse impact on aquatic ecosystems and water users.
- **Solid litter** takes many forms, both non-biogenic (plastics, cans) and biogenic (vegetation, cellulose-based paper). Besides being unsightly, they can degrade to release hazardous substances, deplete oxygen, and obstruct watercourses, causing flooding upstream and draining downstream.
- **Other quality problems** that are being recognized as important but that still require further investigation include bioactive materials such as endocrine disruptors, environmentally stable products such as herbicides and pesticides, trace elements (essential and adverse), and radioactive contamination.

Table 6.6: Physico-chemical restrictions on fitness for use in the different Water Management Areas (WMAs)

WMA	Domestic Use	Irrigation ¹				Recreation ²	Conservation status ³	
		SAR	EC	pH	Cl			
1	Limpopo	No restrictions					3	
2	Luvuvhu/Letaba	No restrictions		(+)			3	
3	Crocodile West/ Marico	No restrictions		(+)		X	2	
4	Olifants	Fluoride		L	(+)	X	2	
5	Inkomati	No restrictions					3	
6	Usutu to Mhlatuze	Chloride		L	(+)	L	5	
7	Thukela	No restrictions				X	5	
8	Upper Vaal	Sulphates				X	1	
9	Middle Vaal	No restrictions				X	1	
10	Lower Vaal	No restrictions				X	4	
11	Mvoti to Umzimkulu	No restrictions				X	4	
12	Mzimvubu to Keiskamma	No restrictions		(+)		X	1	
13	Upper Orange	Total dissolved salts (TDS), sodium		(+)			3	
14	Lower Orange	TDS, sodium	L	L	(+)	M	X	4
15	Fish to Tsitsikamma	TDS, calcium, sulphates, chloride, sodium	L	LMH	(-) (+)	LMH	X	2
16	Gouritz	TDS, calcium, sulphates, magnesium, chloride, sodium, potassium	LM	H	(-)	H		1
17	Olifants/Doring	No restrictions					2	
18	Breede	Chloride		L		L	X	1
19	Berg	No restrictions					1	

Notes:

The data are based on 156 sites for the period 1996–2000 and the median concentration for each variable.

¹Irrigation use: a symbol indicates that the water quality indicator is outside the target water quality range for irrigation use at some locations in the WMA. L, M and H means Low, Medium, or High risk, (+) = alkaline and (-) = acidic. SAR = Sodium Absorption Ratio; EC = Electrical Conductivity; pH = acid-base scale; Cl = chloride (note that as there are multiple sites within the WMA, the risk may vary from stretch to stretch).

²Recreational use: X indicates that the water quality indicator is occasionally outside the acceptable levels for recreational use at some locations due to toxigenic cyanobacteria having been found. Microbial contamination may also limit use, but insufficient valid data precludes meaningful comment on this at a catchment scale. Cyanobacteria or 'blue-green algae' are natural inhabitants of many inland waters, estuaries and the sea. In still waters, such as lakes, ponds, canals, and reservoirs, they may multiply sufficiently in summer months to discolour the water so that it appears green, blue-green, or greenish brown. The toxic variants of these algae pose a health hazard to humans and livestock.

³Conservation status: 1 indicates an urgent need for conservation attention from a biodiversity perspective; 5 indicates lowest need.

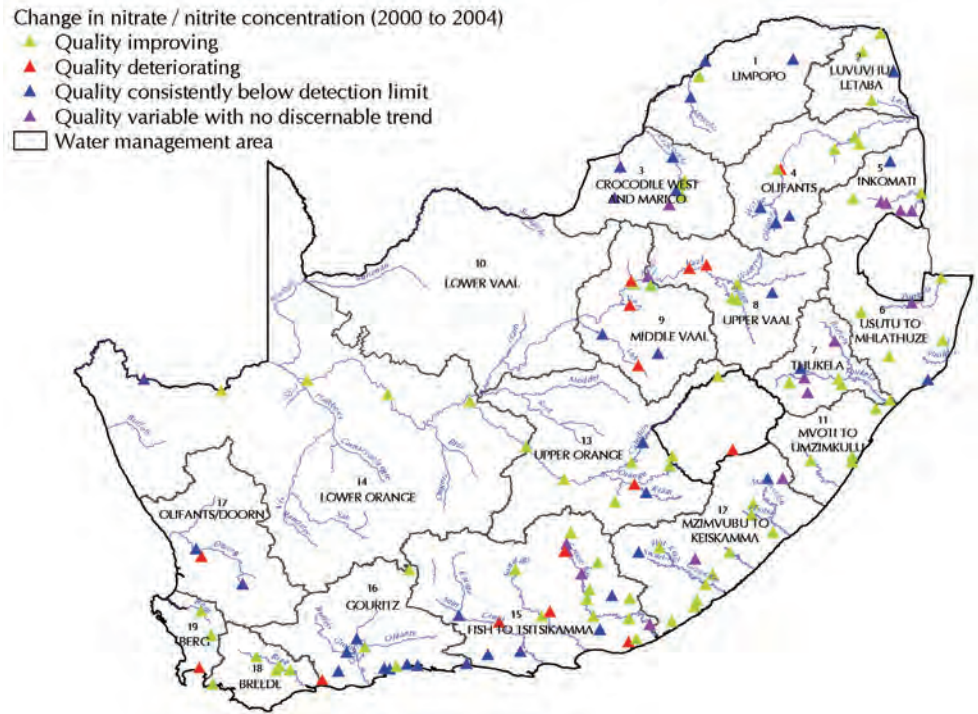
Source: Adapted from Department of Water Affairs and Forestry (2004)³

environment. Urban runoff can contain high organic and nutrient loads that contribute to problems in urban streams and impoundments. The consequence is increased nutrient and organic load, plus microbial contamination. An urgent need exists for adequate and improved urban wastewater treatment, to minimize the negative impact, including the cost of damage to our critical inland water resources.

- **Agricultural drainage.** This includes irrigation return flows and seepage, which may contain salts that include nutrients (fertilizers), other agro-chemicals (including herbicides and pesticides), and runoff or effluent from animal husbandry locations such as feedlots, piggeries, dairies, or chicken farms, which also contribute to contamination.
- **Waste disposal.** Industry, mining, and urban development result in increased production of waste, creating a need for additional and improved waste-management facilities (see Chapter 9). Although techniques for containing waste are available, and are being applied to new facilities, older waste repositories (industry and mining) and landfill sites (domestic) had no structured lining systems, and they have released contaminated leachate into adjacent water resources.
- **Land use.** Increase in the laying of impervious surfaces in urban areas diminishes rainwater recharge to groundwater. Lack of the dilution effect that would otherwise take place can lead to a rise in solute concentrations of the existing underlying aquifers. Overgrazing and clearance of natural vegetation increases the risk of erosion and the entry of sediment into surface waters.
- **Delays in classifying water resources.** Each resource needs to be adequately classified from a quality perspective. A shortfall in reliable monitoring data, from which valid statistical results can be drawn, together with a lack of capacity, has delayed this process, creating problems with the issue of water-use licences, or the granting of licences with inappropriate conditions.

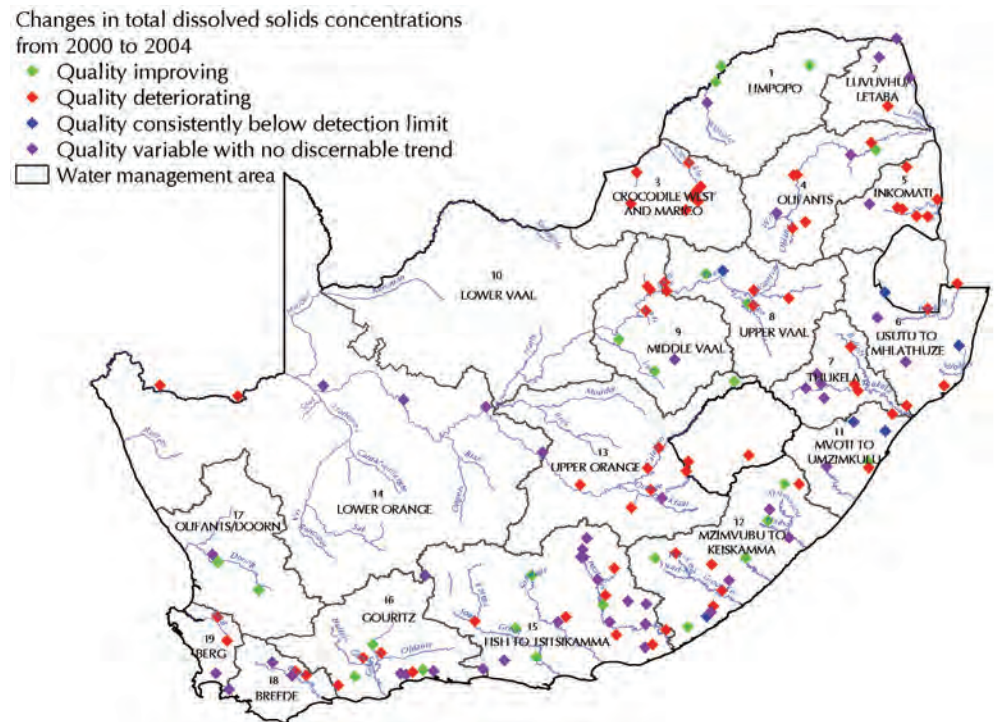
6.3.4 Consequences of poor quality

Pollution of water resources results in reduced fitness for use. This affects the resource directly by making the water less acceptable for consumption (either for food production or any other identified use), depending on the extent, severity, and temporal nature of the pollution. It can also affect the resource indirectly by curtailing recreational activities in badly affected water bodies. Overall, the services described in Box 6.1 will be limited by the quality of the water in the system under consideration. The nature of these direct and indirect



Map 6.4: Surface water quality trends for nitrate at 150 Water Management System sampling sites

Source: Brendan Hohls, Department of Water Affairs and Forestry



Map 6.5: Surface water quality trends for salinity at 150 Water Management System sampling sites

Source: Brendan Hohls, Department of Water Affairs and Forestry



impacts on humans and on the aquatic ecosystems are described in Box 6.2.

A consequence of these impacts is that water may need to be processed before it can be used. This increases water-supply cost, particularly if the process is technically complex and expensive. This is particularly relevant for saline water, common to mine wastewater discharge. Any desalination process, itself, generates a salt-enriched and aggressive waste liquor, that presents its own disposal problems and costs.

Eutrophication is an impact that is directly associated with nutrient loading (see Box 6.2). It can take millenia to occur naturally, but can appear quickly as a consequence of human activity. Classification of a trophic status of dams and lakes is given in Table 6.7. The number of dams within each trophic status, as monitored by the DWAF (a total of 76 dams and lakes are currently monitored), is also given. Where possible, a comparison has been made between the trophic status of the dams during the period 1990–2000²⁰. Of the 34 dams, 18 improved in status (became less eutrophic), 11 remained unchanged, and 5 deteriorated (the paucity of data could invalidate this comparison). The dams and lakes with higher trophic status are generally located near urban areas such as Gauteng, Durban, and Bloemfontein, or on highly exploited rivers (such as Crocodile West, Vaal, and Umgeni).

The responses covered by the NWRS and organizations such as the WRC are discussed in section 6.2.5. Many of these responses are equally relevant for ensuring that water quality is appropriate for its intended use. The water-use licensing process is critical for point-source pollution risks. The NWA classifies both discharges and waste disposal as water uses that require regulation. The DWAF is in the process of registering and licensing all such water uses. The water-use licence or general authorization will specify the conditions with which the user must comply.

6.3.5 Industrial and research initiatives for managing water resources

Many initiatives from an industry-specific perspective have been developed to minimize risks to the quality of water resources. The following are a few examples:

- Environmental management systems have been implemented (such as ISO14001), which seek continuous improvement in environmental management
- Guidelines for implementing Clean Technologies have been developed, amongst other things for the textile, metal finishing, food, and fishing industries
- The Chemical and Allied Industries Association’s Responsible Care Programme is a commitment from the chemical industry to responsible cradle-to-the-grave management of chemical products, to avoid harm to people and the environment
- Water and wastewater benchmarking by several industries forms part of the WRC’s NATSURV project²¹.

Research organizations such as the WRC are funding projects aimed at developing appropriate technologies for treating and managing wastewaters. Significant progress has been made on the use of biological processes to reduce sulphate concentrations in mine-contaminated waters and to remove nutrients from treated domestic wastewater.

6.4 AQUATIC ECOSYSTEM INTEGRITY

The integrity of aquatic ecosystems depends both on the availability of surface, subsurface (soil water interflow), and

Table 6.7: Trophic status of South African dams, October 2002–September 2003

Trophic status	Description	Number of dams or lakes
Oligotrophic	Low in nutrients and not productive in terms of aquatic animal and plant life.	40
Mesotrophic	Intermediate levels of nutrients, fairly productive in terms of aquatic animal and plant life, and showing emerging signs of water quality problems.	18
Eutrophic	Rich in nutrients, very productive in terms of aquatic animal and plant life and showing increasing signs of water quality problems.	9
Hypertrophic	Very high nutrient concentrations where plant growth is determined by physical factors. Water quality problems are serious and can be continuous, with consequent constraints on biological activity.	9

Source: Department of Water Affairs and Forestry (2003)²⁰



groundwater resources, and on the quality of those resources, as well as on all the other activities in the catchment. Riparian zones create a buffer between terrestrial and aquatic ecosystems, stabilizing river banks and assisting in protecting rivers from the effects of activities in the catchment. These zones are typically sustained by both surface and subsurface water, with groundwater playing a critical role during dry periods. Fish survive during summer in groundwater-fed pools, for example, when surface flow ceases in the Doring River⁶. Less disturbed ecosystems are generally found in many of the smaller tributaries of perennial rivers. The NWA has ascribed equal status to aquatic ecosystem integrity and to the requirements of basic human needs. This recognizes the essential benefits that are provided by these ecosystems for human well-being.

6.4.1 River health

Previous sections (section 6.2 and section 6.3) indicate that the quantity and quality of available water are fairly well established, but even if there is flow, and the quality appears acceptable, the aquatic ecosystems can be adversely affected. In 1994, the DWAF initiated the River Health Programme to enable a better understanding of these systems. A model of shared ownership was advocated during the design phases of the programme, to ensure the achievement of a critical level of institutional participation. Subsequently, the Department of Environmental Affairs and Tourism and the WRC, together with the DWAF, became joint national custodians of the programme. Provincial champions and provincial implementation teams are responsible for implementation initiatives at provincial and local levels.



One of the State-of-Rivers Reports published as part of the River Health Programme.

The suite of tools and methods used to provide a picture of individual river health include the following:

- **The Index of Habitat Integrity.** This assesses the impact of disturbance such as water abstraction, flow regulation, and river channel modification on the riparian zone and in-stream habitats.
- **The Geomorphological Index.** This assesses river-channel conditions and channel stability. (Channel conditions are based on physical structure such as weirs, bridges, or dams, and the type of channel such as bedrock or alluvial. Channel stability is based on the potential for erosion.)
- **The Riparian Vegetation Index.** This determines the status of riparian vegetation, based on a number of criteria including specific composition, structure and extent of cover, presence of juvenile indigenous species, cover of invasive alien species, and human influences.
- **The South African Scoring System (SASS).** This is based on the presence of families of aquatic invertebrate fauna and their sensitivity to water-quality changes.
- **The Fish Assemblage Integrity Index (FAII).** This assesses fish assemblages in homogenous fish habitat segments, with the results expressed as a ratio of observed conditions to the theoretical near-natural conditions.

The River Health Programme is continuous and rivers that have been assessed include the Buffalo and Berg Rivers, the Vaal and Orange (in the Free State), and the Diep, Hout Bay, Lourens, Palmiet, Hartenbos, Klein Brak (in the Western Cape), Umgeni (in KwaZulu-Natal), Letaba Luvuvhu, Crocodile, Sabie, Sand, and Olifants Rivers (in Mpumalanga). The systems that have been assessed indicate a generally good to fair condition in the upper reaches and tributaries, and fair to poor conditions in the lower reaches, with most rivers in highly urbanized areas, such as Gauteng, being in poor condition. The assessments include many of the tributaries, resulting in a highly variable status within individual catchments. Multiple indicators make it a complex task to create an overall picture of the state of South Africa's rivers. River health is therefore best portrayed per river system, and an example is given in Figure 6.2 for the Buffalo River. Results for other river systems and further information can be obtained from the River Health Programme web site (<http://www.csir.co.za/rhp/>). An assessment of the integrity and conservation status of rivers is presented in Chapter 5.

6.4.2 Wetlands

Wetlands are defined in the NWA as "land which is 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 or would support vegetation typically adapted to life in saturated soils".

Riparian zones create a buffer between terrestrial and aquatic ecosystems, stabilizing river banks and assisting in protecting rivers from the effects of activities in the catchment.

the Great Fish River from the Orange River: the smallmouth yellowfish, the Orange River mudfish, the sharptooth catfish, and the rock barbel²³. These species are putting severe competitive pressure on endemic fish species.

Organisms in many aquatic ecosystems are widely adapted to the highly variable flows and, in some cases, the variable water quality of South African systems. But with the increased control of flows by means of dams, habitat change, and increasing pollution loads, the natural cycles have been dramatically altered, with a resultant loss of biodiversity and the introduction and proliferation of invasive species. Degradation of aquatic ecosystems has implications for food security and associated economic activity.

The disturbance to and loss of wetlands and the over-abstraction of groundwater reduces storage capacity and natural water purification capacity and reduces the fish and wildlife habitats provided by these systems. The loss of storage capacity and of the buffering effect on flow results in greater peak flows (floods) and extended low or no-flow periods. There are serious cost implications arising from resultant flood damage and from the unavailability of water in dry seasons.

6.4.4 Management of aquatic ecosystems

The responses reported for water availability and fitness for use (section 6.2.5 and section 6.3.5) will assist in addressing the problems of aquatic ecosystem integrity. For maximum value as a water management tool, the

Box 6.3 Inland water resources: priorities for action

The quality, quantity, and sustainability of water resources are fully dependent on good land management practices within catchments. The fate of the country's water resources, therefore, relies on an integrated approach to managing water and land, to achieve ecological and socio-economic sustainability. The National Spatial Biodiversity Assessment (2004) has indicated a number of priority actions, including the following:

1. Integrate land and water policy and management, as a basis for integrated management strategies.
2. Feed information from all relevant assessments into the Department of Water Affairs and Forestry's Water Resource Classification System and Catchment Management Strategies, to determine how many and which rivers need to be managed in a natural or moderately impacted state.
3. For main streams that are heavily impacted, determine, implement, and monitor ecological reserves.
4. Integrate rivers into bioregional plans and programmes, and fine-scale biodiversity assessments.

Source: Adapted from Driver et al. (2005)²⁴

results of the River Health Programme and the further development of the Spatial Biodiversity Assessment need to be coordinated to cover the whole of the country.

In particular, to ensure that conservation status can be sustained or improved, attention needs to be paid to maintaining the status of the tributaries, as they provide refuges for biodiversity. This would enable areas subject to mass mortality events to be successfully recolonized.

Box 6.4 Opportunities for improved water resource management

- Potential alternative resource supplementation for consideration in future (such as desalinating seawater, importing water, cloud seeding, shipping fresh water from river mouths, and towing icebergs) is not in all cases economical. In the short term, the emphasis needs to be placed on water conservation and water demand management (WC/WDM) and the re-use by industry of water recovered from sewage treatment or from mines. This will be more cost-effective in the short to medium term.
- There is a need for improved agricultural and land management practices, which will require input from the different government bodies as well as from stakeholders involved in farming and managing the land. Two good examples already exist.
 - The Working for Water Programme aims to increase water availability whilst also
 - providing benefits to biodiversity, land use management, and social upliftment.
 - Although irrigated areas have increased, the demand for irrigation water has remained constant. This appears to be the result of better consultation within the agricultural sector, better irrigation practices and scheduling, gradual increase in tariffs (with associated reduction in subsidies), introduction of compulsory licensing, and better training of irrigators.
- Of the 6 000 million m³/annum of groundwater potentially available as a resource, only about 1 100 million m³/annum is currently being utilized. This implies an opportunity for further extraction, particularly in the rural areas previously not supplied. According to the National Water Resource Strategy (NWRS), optimal management and utilization of groundwater will benefit from improved capacity to assess potential and monitor trends and form a better understanding of the interactions between surface water and ecological functions.
- A range of institutions throughout South Africa (including the Department of Water Affairs and Forestry, local municipalities, research organizations, and industry) are undertaking water-quality monitoring. There has been a historical lack of coordination between such institutions, resulting in over-assessment in some areas and inadequate data in others. Opportunities exist to ensure that the data are collected in a consistent manner, suitable for incorporation into a single national database.
- Although some clean technology and water conservation/demand management programmes for specific sectors are in place, there is opportunity for much greater programme development by other sectors.

Box 6.5 What are some of the things you, as an individual, can do to protect South Africa's inland waters?

- Do not discard waste (for example oil, paint, rubbish) into sewer or storm water systems.
- Do not dispose of waste into streams, rivers, or dams.
- If you observe unlawful discharge of any waste by industry, report it to your local authority or to the Department of Water Affairs and Forestry.
- Report water leaks (from broken taps or pipes) or sewer pipes to your local authority.
- Use rain water for domestic and garden purposes by catching and storing run-off.
- Use water from your household activities (cleaning of eating utensils or bathing) to water the garden.
- Water your garden early in the morning or late in the afternoon to minimize evaporation; planting a water-friendly indigenous garden will conserve water.
- Repair dripping taps; take care to shut them properly after use.
- Take a short shower rather than a bath.
- Support water saving practices at work (for example, do not leave taps or hosepipes running).
- Adhere to water saving programmes in your area.
- Participate in environmental programmes in your area (for example, Working for Water).
- Spread the idea of water conservation!

For information about water-wise initiatives and practices visit <http://www.randwater.co.za>

Source: Adapted from Mogale City Local Municipality, State of the Environment Report 2003 (Mogale City 2003)²⁵

Special attention also needs to be paid to the riparian corridors between the tributaries, as linear linkages maintained via the main stem rivers allow migration of both aquatic and terrestrial fauna. The River Health Programme has identified management priorities for each river system that has been assessed, and it is the responsibility of the provincial implementation teams to schedule and implement actions to deal with these priorities (see Box 6.3).

Where aquatic ecosystems depend on groundwater, mechanisms need to be put in place to ensure that groundwater abstraction does not unduly undermine the benefits offered by those ecosystems. Extensive investigations into the feasibility of such mechanisms need to be undertaken, to minimize any negative enviro-economic consequences that could arise from the transfer and mixing of previously isolated biota during inter-basin transfers (see Box 6.4).

6.5 CONCLUSION

The demand on South Africa's scarce water resources is increasing, and a deficit in available water is projected by 2025, if not earlier. The water quality of the resources appears to be variable, with an overall deterioration. These, and other issues, have increased the stress on South Africa's aquatic ecosystems, including wetlands. The multitude of demands – ecological, domestic, industrial, and agricultural – needs to be balanced equitably, and the release of the NWRS in 2004 is seen by the DWAF as the main driver for ensuring that the balance can be achieved.

The DWAF states that there should be sufficient water of suitable quality to meet South Africa's expectations of

maintaining a strong economy, improving social standards, and sustaining healthy aquatic ecosystems for the near future³. This is possible, provided the resources are wisely allocated and responsibly managed, in line with the NWRS. All water-use sectors need to focus on the water and waste management hierarchy, which states that minimization at source is the first priority, followed by maximized re-use or recycling, as far as possible; treating to a suitable standard; and disposing or discharging to the environment only where no techno-economically feasible alternative exists.

All stakeholders have a role to play, and what every South African can do to protect this valuable resource is highlighted in Box 6.5. Educational materials and posters and further information can be sourced from sites such as Randwater <http://www.randwater.co.za> and Wildlife Society <http://www.wildlifesociety.org.za>.

The final question that remains is whether or not the government and other stakeholders, including the general public, will be able and willing to implement the strategies and policies that have recently been introduced. Financial resources, institutional capacity, and stakeholder willingness will all be crucial in ensuring that the general downward trends in the availability and quality of our water resources are reversed. A concerted move to water-use reduction and conservation is required, and adequate resources need to be mobilized to fund relevant public awareness and education programmes.

NOTES

- a. Water availability of less than 1 700 m³/person/annum constitutes water stress, with values below 1 000 m³/person/annum classified as water scarce.
- b. The Reserve is the volume and quality of water required for satisfying basic human needs and for maintaining aquatic ecosystems.
- c. The yield is the volume of water that can be abstracted at a certain rate over a specified period of time for supply purposes.
- d. The amount of water that can be abstracted for 98 out of 100 years on average is referred to as “the yield at a 98 per cent assurance of supply”.
- e. The Base Scenario is a scenario used in the National Water Resources Strategy to estimate the most likely future water requirements.
- f. The Reserve is the volume and quality of water required for basic human needs and maintenance of aquatic ecosystems.
- g. The NWA definition focuses on reduced fitness for use and does not take into account the assimilative capacity of the water resource.

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Chapter 7 Marine and coastal resources

At a glance

This chapter focuses on the contribution by the marine sector to the national economy and the livelihoods of South Africans. At the same time it deals with over-exploitation and its associated costs, degradation, and loss of the resource. Improved protection measures need to be enforced to protect the resource base, to ensure beneficial opportunities through sustainable management and equitable benefit-sharing. A significant proportion of the resource base has been lost owing to rapid and uncontrolled coastal development and poorly managed fish stocks through over-fishing, causing depletion and collapse. Increases in effluent discharges and pollution have added to these losses. Climate change and decreased quality of fresh water flow to estuaries contribute to large-scale changes. Continued resource losses affect the livelihoods of coastal communities dependent on coastal resources, with the added impact of health risks due to water quality. Enforced legislation can reverse unsustainable trends with resultant socio-economic benefits and opportunities.

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7.1 INTRODUCTION

The marine and coastal resources of South Africa are a rich and diverse national asset, providing important economic and social opportunities for the human population, which, in turn, has developed a strong reliance on these resources for commercial opportunity and gain, food, recreation, and transport. These resources have facilitated job creation and general economic upliftment in coastal regions. Increasing human and environmental pressure on the country's marine and coastal ecosystems, however, has changed the functioning and structure of many of their components, and uncontrolled or mismanaged use has led to over-exploitation, degradation, and resource loss¹.

These pressures have driven an overall decline in marine productivity, creating significant socio-economic opportunity costs. Direct impacts by humans are exacerbated by the fact that sea water links and disperses marine populations over vast areas, easily spreading invasive alien species and pollutants. Climate change is also predicted increasingly to damage our marine and coastal resources. Our understanding of these effects remains speculative, but they could be as severe as those of the uncontrolled human exploitation that has taken place to date².

The general South African public, however, especially coastal stakeholders, appears to be increasingly aware of the value of our seas and coast and of the importance of effective management. Protection, in the form of marine protected areas and improved management, has most recently been receiving high priority at national and international levels, and several of the acts, policies, and protocols used to govern South Africa's marine and coastal environment are either under review or have recently been revised to promote improvement. It is still too early to measure their effectiveness, but dramatic change for the

better is required if the country is to benefit from the opportunities available and reverse the current negative trends.

7.2 ECONOMIC AND SOCIAL VALUE

7.2.1 Economics

The marine and coastal environment and its associated resources contribute considerably to the South African economy in terms of employment, recreation, and tourism. Since the 1980s, the four major coastal cities of Cape Town, Port Elizabeth, East London, and Durban have shown the fastest economic growth of all cities in the country. In 2000, the estimated value of the direct benefits derived from all coastal goods and services in South Africa was approximately R168 billion, with indirect benefits contributing a further R134 billion (according to the *White Paper on Sustainable Coastal Development* of 2000).

The coastal contribution to the national economy is most frequently measured as the total annual gross domestic product (GDP) emanating from the coastal provinces (even though not all economic activity in these provinces depends on marine and coastal resources). The

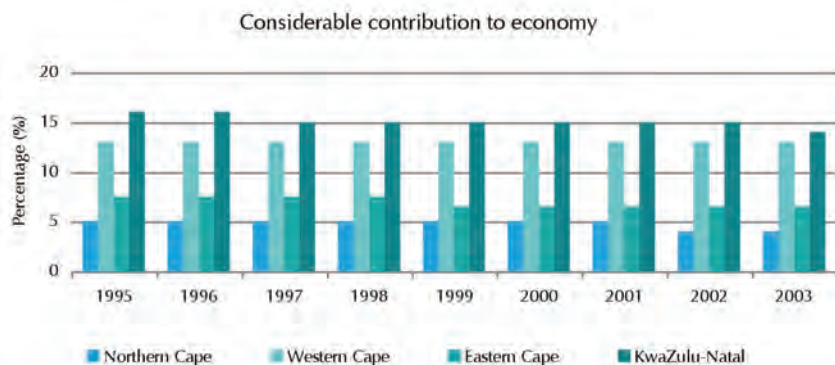


Figure 7.1: Annual gross domestic product (GDP) proportional contribution by coastal provinces of South Africa, 1995–2003 (at constant 2000 prices)

Source: Statistics South Africa (2005)³; Department of Environmental Affairs and Tourism and Council for Scientific and Industrial Research (2005)⁴



Packing frozen rock lobster tails: marine resources contribute to the economy. Photography: Tony van Dalsen



overall GDP contribution from the four coastal provinces in 1995 was R322 277 million and increased steadily to R401 674 million in 2003 (at constant 2000 prices). Their proportional contribution to South Africa's national average GDP, however, decreased from 42.5% in 1995 to 38% in 2003 (see Figure 7.1). KwaZulu-Natal has contributed the greatest proportion to GDP since 1995, followed by the Western Cape, Eastern Cape, and Northern Cape, respectively. The overall contribution from the Western Cape has remained at approximately 13%, while that of the other three provinces has declined over time³.

7.2.2 Employment

The primary, secondary, and tertiary aspects of the fishing industry are important sources of direct employment for nearly 28 000 people living at or near the coast. Compared with other employment sectors, fishing provides high-quality employment, generating substantial individual incomes. Fishers earn on average R36 000 per year, although gross earnings vary among different skills groups (that is, among unskilled and semi-skilled workers and managers). The earnings from South African commercial fisheries in 2000 totalled approximately R1 billion. Commercial fisheries employing the highest number of people are the line, squid, hake trawl, and west coast rock-



Yellowtail catch for sale in the Kalk Bay harbour.

Photography: Tony van Dalsen

lobster fisheries (see Figure 7.2). In terms of earnings, however, the deep-sea hake fishery pays the highest wages, followed by squid, linefish, and pelagic fisheries (see Figure 7.3). The Western Cape employs some 83.2% of the workers in the fishing industry, followed by the Eastern Cape (13.6%), KwaZulu-Natal (2.3%), and the Northern Cape (0.9%).

7.2.3 Transformation

Following the introduction of democracy in South Africa in 1994, the fishing industry has undergone dramatic changes, mostly facilitated by the new fisheries policy, the Marine Living Resources Act (No. 18 of 1998, amended as No. 68 of 2000) (MLRA)⁶. This act, amongst other requirements,

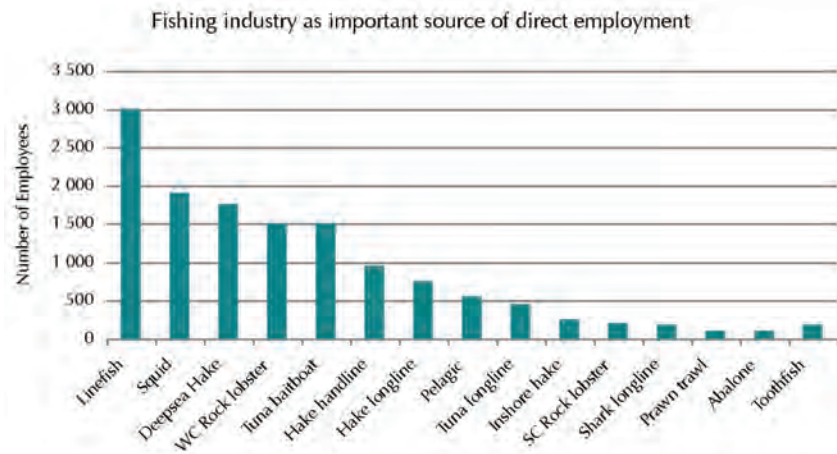


Figure 7.2: Number of people employed per commercial fishing sector, 2000

Source: Fishing Industry Handbook (2004)⁵

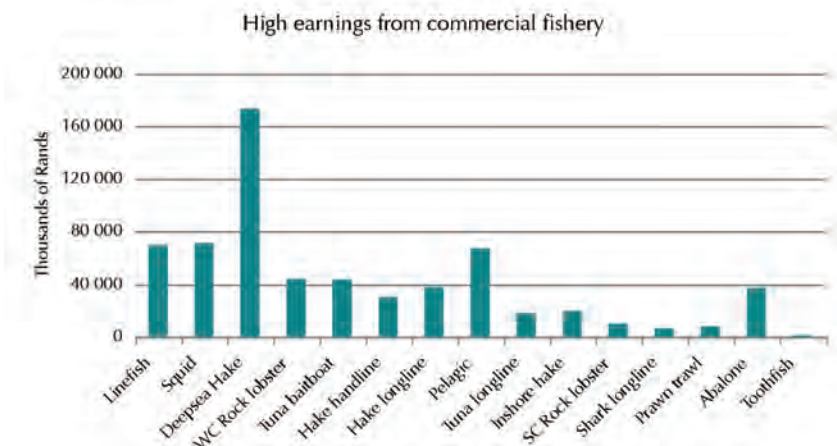


Figure 7.3: Total annual earnings for each commercial fishery, 2000

Source: Fishing Industry Handbook (2004)⁵

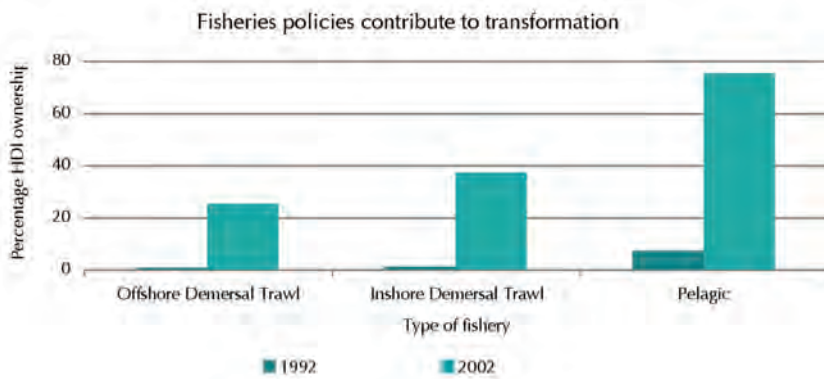


Figure 7.4: Proportion of historically disadvantaged ownership in the three largest commercial fisheries of South Africa, in 1992 and 2002

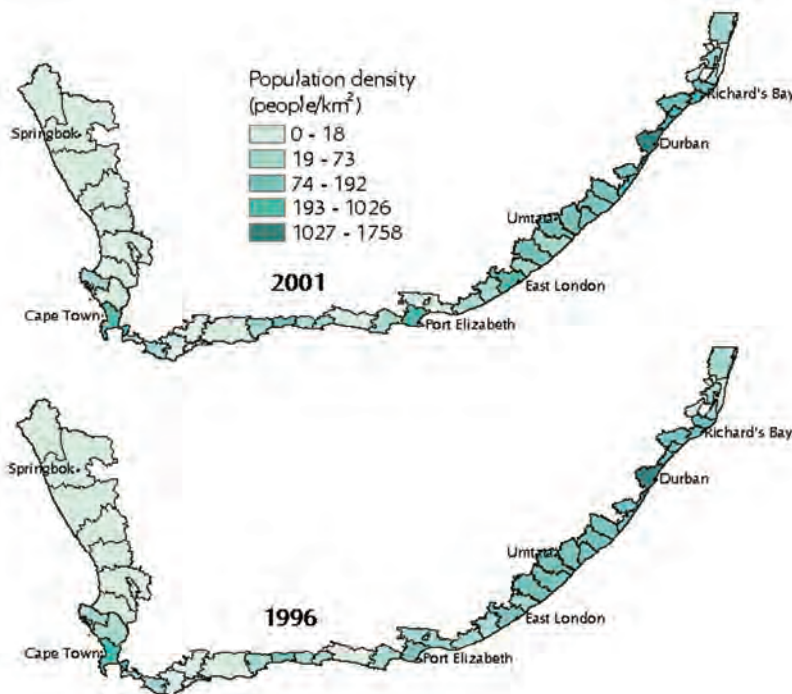
Source: Department of Environmental Affairs and Tourism and Council for Scientific and Industrial Research (2005)⁴

specifies the “need to restructure the fishing industry to address historical imbalances, to achieve equity”.

Transformation of the fishing industry is being addressed from three angles. First, fishing rights have been redistributed from a small number of mainly white-owned companies (less than 300) to a larger number (almost 6 000) of smaller companies owned by historically disadvantaged individuals (HDIs). Second, established companies have undergone internal transformation that includes improved

employee rights and minimum wages. Finally, subsistence fishers have been formally recognized and management structures are being developed to improve allocations and maintain sustainability through commercial, recreational, and subsistence fishing⁶. The Department of Environmental Affairs and Tourism (DEAT) has estimated that by 2003 at least 60% of commercial fishing rights had been allocated to HDIs or HDI-owned and -managed companies⁷. Small-scale fisheries, such as those of abalone (which require minimal infrastructural resources), have been most successful at transformation (that is, 88% of the rights of small companies are HDI-owned and 84% of Total Allowable Catch [TAC] is located in HDI-owned companies). The larger, more capital-intensive fisheries, such as those of deep-sea hake, have transformed to a lesser extent (with 74% of their rights HDI-owned and 25% of total allowable catches located in HDI-owned companies). As shown in Figure 7.4, the proportion of deep-sea hake fishery HDI-ownership increased from 0.5% in 1992 to 25% in 2002; that of inshore demersal trawl from 1% to 37% HDI during the same period; and that of pelagic fishery from 7% to an impressive 75% HDI.

The fishing industry is one of South Africa’s top three industries in terms of transformation⁷, but this success has not been achieved easily. Following the passing of the MLRA in 1998, annual allocation of fishing rights was introduced in an attempt to initiate transformation. The dramatic increase in the number of rights applications (from <300 in 1990 to 12 000 in 1999) had been underestimated, however, resulting in long delays in the issuing of rights, accompanied by numerous legal challenges. Furthermore, short-term (annual) rights allocations led to financial insecurity, lack of a sense of ownership, increased poaching, and the destabilization of the fishing industry. Various procedures were introduced to address these consequences, including a Rights Verification Unit, an Appeals Committee, and the allocation of medium-term fishing rights (for the four years 2002–2005). With these measures in place, applications decreased by 50%, medium-term rights have been allocated to most commercial fisheries, litigation has almost ceased, and stability has largely been restored⁸. On 1 March 2005, the Minister of Environmental Affairs and Tourism announced the intention to issue long-term (8–15-year) fishing rights, to provide greater security and further stability in the country’s fishing industry.



Map 7.1: Population density (people/km²) in South African coastal municipalities, in 1996 and 2001

Source: Department of Environmental Affairs and Tourism and Council for Scientific and Industrial Research (2005)⁴

7.3 MODIFICATION, DEGRADATION AND LOSS OF RESOURCES

Marine and coastal resources in South Africa are displaying signs of modification and degradation and, in some instances, destruction. The section that follows highlights some of the key factors contributing to these damaging processes.

7.3.1 Population pressure

Coastal cities around the world have grown dramatically over the past 50 years and are predicted to continue doing so for the near future. The main reasons for this increase are the appeal of living near the coast, increased tourism, sufficient wealth for coastal retirement opportunities, an increase in coastal holiday-home purchases, and the quest for employment and basic livelihoods⁸. As much as 40% of South Africa's population lives within 100 km of the coast, resulting in substantial development pressure for infrastructure such as housing and roads.

The 1996 and 2001 South African census data reflect a relatively small change in population densities within coastal provinces at a municipal level (see Map 7.1). A closer look shows a more dynamic picture: whereas population density decreases have occurred in the region between Cape Town and Saldanha Bay in the Western Cape, there have been noticeable population increases in the Eastern Cape's Nelson Mandela Metropole. Overall population growth and increased development thus continue to pose severe threats to resources of the coastal zone as reported in the 1999 National State of the Environment Report.

7.3.2 Coastal land use

The coastal land in South Africa has been classified as natural, degraded, urban, and agricultural⁹. Most urban land use occurs in the three largest coastal metropolises: Cape Town (25%), eThekweni (27%), and Nelson Mandela (12%) (see Table 7.1). Cape Town, eThekweni, and iLembe are the municipal areas that have been most transformed from their natural state. Not surprisingly, the sparsely populated Namaqua region has the highest proportion of natural land cover (98%), followed by Cacadu (92%), Eden (76%), Amatole (75%), and Nelson Mandela (74%).



Durban's small craft harbour.

Photography: South African Tourism

Urban development

The areas of natural or undeveloped coastal land in South Africa are increasingly under threat from large-scale urban developments, mostly residential or recreational estates (such as golf estates). Many are currently being planned or already being developed in the Western and Eastern Cape in particular, with the Saldanha Bay and George local municipalities showing the highest rates of development. Most of the undeveloped KwaZulu-Natal and Wild Coast regions lie within marine and/or nature reserves, so development there is more restricted, but pressure is mounting to 'open up' these areas for exploitation.

Port and harbour development

Much coastal development has to do with constructing new ports or harbours or expanding existing ones. South Africa currently has seven ports, the most westerly being Saldanha Bay and the most easterly, Richards Bay. In 2002, construction of the most recent port development in South Africa, the Port of Ngqura (Coega) began in the Eastern Cape. This port, expected to be operational by 2008, will be South Africa's eighth and is anticipated to bring significant trade, industry, and economic growth to the region, although not without environmental costs.

Mining

South Africa's marine and coastal environment is mined in the northeast for heavy metals (titanium and zirconium), in the south for fossil fuel (oil), and in the northwest for diamonds.

An unavoidable consequence of mining is disruption of the sediment, which ranges from extensive, in the case of titanium, to limited in the case of oil¹. In most instances, mining completely destroys the biological community, including vegetation, in-fauna, and epi-fauna. Newly introduced environmental policies require coastal mining



Diamond boats off the coast at Port Nolloth.

Photography: South African Tourism