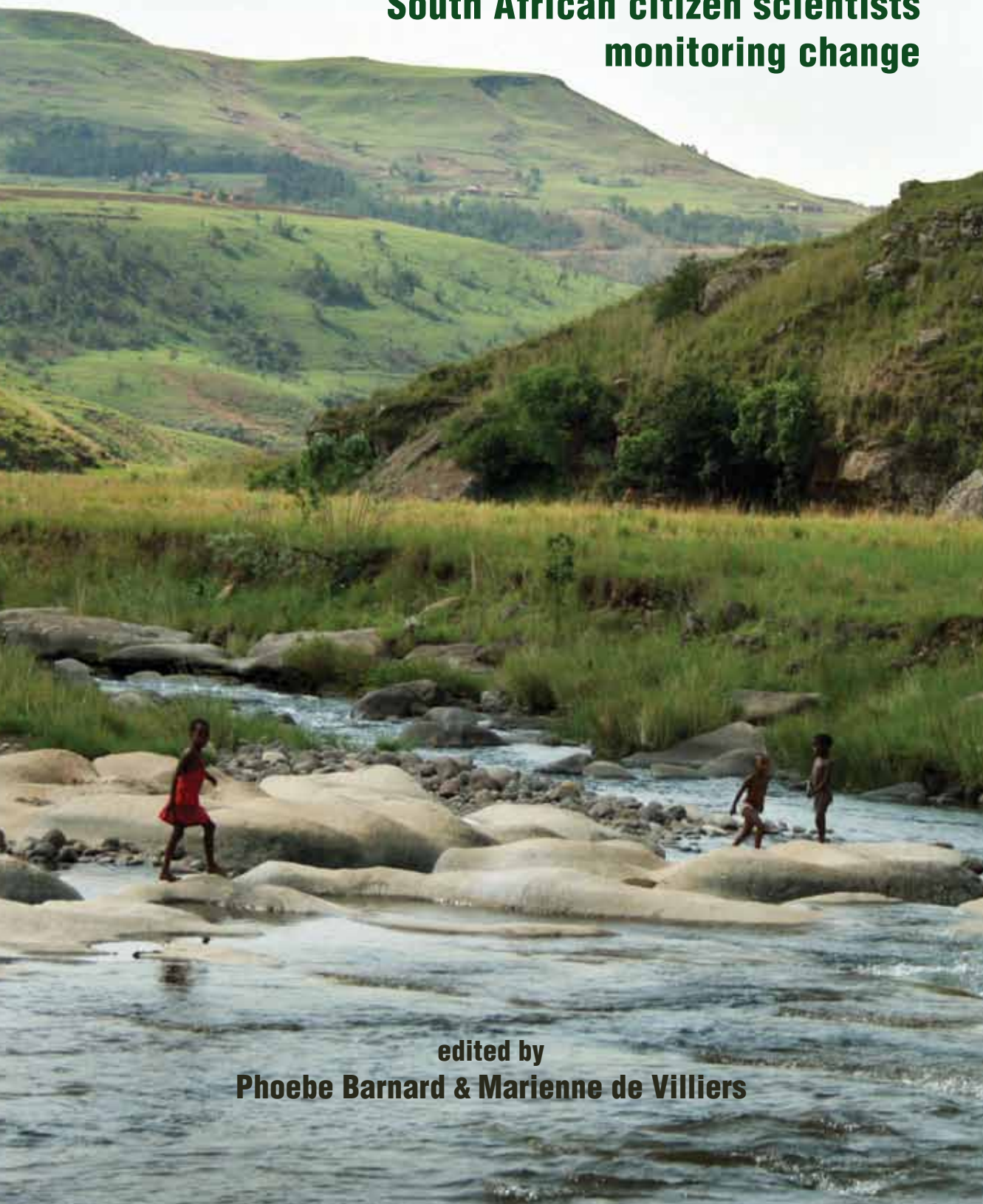
Biodiversity early warning systems

South African citizen scientists monitoring change



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Dedication

This booklet pays tribute to the foresight of Professor Les Underhill,
Director of the Animal Demography Unit, at the time of his retirement.

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This booklet is the result of a collaboration between the South African National Biodiversity Institute (SANBI), the Animal Demography Unit (ADU) of the University of Cape Town and the South African Department of Environmental Affairs.

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

The vision of South Africa's Department of Environmental Affairs (DEA) is a prosperous and equitable society living in harmony with the country's natural resources. DEA aims to protect, conserve and enhance our environment, natural and heritage assets and resources. Through proactive planning, management and the prevention of pollution and environmental degradation, DEA strives to ensure a sustainable and healthy environment. DEA also provides leadership on climate change adaptation and mitigation. Furthermore, the department contributes to sustainable development, livelihood, green and inclusive economic growth, by facilitating skills development and employment creation. Lastly, DEA contributes to a better Africa and a better world by advancing national environmental interests through a global sustainable development agenda.

SANBI
Biodiversity for Life

Animal
Demography
Unit

Foreword

Climate change presents the global community with one of the biggest challenges of human history. If we cannot rise to this challenge, and use our skills to our advantage, our future could admittedly be bleak. Yet it does not have to be that way. Human foresight, human ingenuity, and clear-sighted leadership are all qualities which tend to appear in times of need. South Africa has shown the world that it is capable of all these things, from the peaceful transition to democracy in 1994, to our emergence as a world talent in science and social development, to the quality of our leadership and our vibrant democracy.

So as the nations of the world struggle with the means to transform society to a path of sustainability, and face the difficult times of increasing climate change, there are good reasons for us all to watch the horizon carefully. Knowing the future is never possible, but we can anticipate it by "watching the clouds" as sailors have always done. Indicators of environmental change are all around us – we need only recognize them, and track them proactively over time, to enable us to predict as much as possible what lies in store, and shift our course where necessary.

Fortunately, we in Africa and South Africa have some excellent environmental datasets at hand which can be fairly easily drawn together to help in this task. Built with our own and our partner country's investments over some years, they equip us quite well for many of the tasks ahead. Since the environment underpins human development and the economy, at national and household levels, and in both rural and urban communities, we in South Africa are building "early warning systems" for biodiversity and ecosystems. We see these systems as every bit as important as early warning systems for drought, famine, disease outbreaks, desertification or economic crises, and indeed they will in time be integrated with these other systems.

With climate change, the ability of ecosystems to buffer human society and biodiversity from the worst of its effects is a priceless global asset, but one with which we have been too careless. Ecosystems and biodiversity face serious challenges now, at the time we need them most. Ecosystem-based adaptation to climate change is the simplest, most cost-effective, and wisest approach to climate adaptation that any country can make. South Africa has embraced this challenge. Yet we need to know that our actions to protect and increase the resilience of ecosystems are actually working to safeguard ecological services and biodiversity. Early warning systems for biodiversity under rapid environmental change are a powerful and proactive tool to do this, and one in which South Africa is now making modest, but highly cost-effective investments in our future.

South Africa hosts three global biodiversity hot-spots, as well as other immensely rich and important ecosystems filled with unique endemic species. Some of these species are important for food, medicine or building materials; others such as locusts and queleas may imperil our food security. All are profoundly integral to our global and national heritage, and are part of complex ecosystems that deliver immeasurable benefits to our lives.

We are delighted to say that South Africa has a wealth of talent in its civil society for identifying, monitoring and conserving our biodiversity. Our "citizen scientists" are justly becoming famous on the world stage for their participation in excellent species atlases, wildflower conservation schemes, and projects on Red Data species population trends. These species are our "canaries in the coal mine." You can read about some of these wonderful initiatives, part of our emerging early warning system for biodiversity, in this booklet.

We believe strongly that it is the active participation of the broad citizenry in engaging with biodiversity and the environment that will be the saviour of our natural assets. This booklet gives us a glimpse of this possibility. We hope that our experiences so far on this journey will inspire and encourage you.

Ms Nosipho Ngcaba
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Department of Environmental Affairs

Dr Tanya Abrahamse
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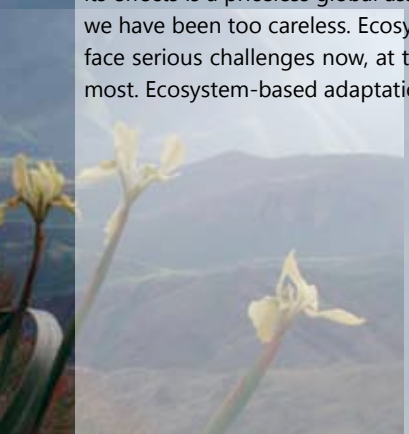
Chief Executive Officer



Building on what we have

Time is short to build the tools we need to '"scan the horizon" for trends in biodiversity. We have most of the right ingredients, but need a bit of investment to combine them in the right way. South Africa is in a good position with excellent biodiversity databases, some large-scale, long-term, or both.

Civil society biodiversity projects are highly cost-effective ways of tracking biodiversity in space and time. South Africa's projects track changes in groups like plants, birds and coral reefs, and make use of the skills and enthusiasm of volunteers in detecting changes and trends. Volunteerism is well-developed in South Africa, and we estimate that for every rand (or dollar) of public money invested in projects, volunteers themselves invest a further twenty. The participation of these "citizen scientists" in biodiversity work is a huge national asset. It helps build public awareness and passion for biodiversity, and recognition of how our policies and practices strengthen or undermine biodiversity conservation.

However, three major unmet needs remain to be tackled.

First, volunteerism for biodiversity programmes has so far been concentrated among South Africa's middle and upper classes. For many of the country's people, life is a struggle and it is simply not feasible to offer up time and money without recompense. So at the same time that the country's dreadful inequalities of wealth and opportunity are being addressed, we need to develop innovative ways of inspiring and involving a wider spectrum of South Africans in biodiversity monitoring.

Early warning systems as a tool to support government's reporting obligations

For well over a decade, climate change has been recognized as a significant threat to biodiversity in the Convention on Biological Diversity, Convention on Migratory Species, Ramsar Convention on Wetlands, and United Nations Convention to Combat Desertification. Biodiversity is already under pressure from changes in weather patterns and intensity of storms and droughts, and from changes in human use of land, water and other resources. This is especially so in wetland, coastal, agricultural and fire-affected mountain environments.

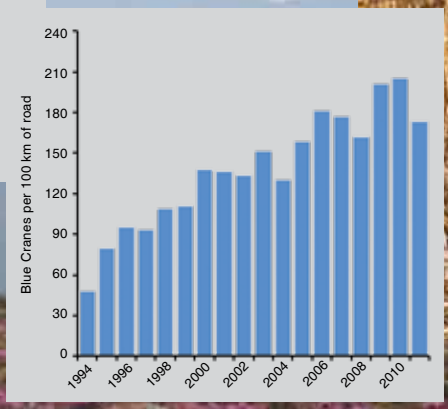
All member states of these and other conventions have complex reporting requirements that can be greatly assisted and streamlined by the policy support tools provided by a coherent biodiversity early warning system. The Convention on Migratory Species, for example, requires national updates on species that regularly cross national borders, some of which may be profoundly affected by climate change impacts across the entire African continent. The long-term and large-scale spatial biodiversity databases highlighted in this booklet are being built into our national early warning system as a central support tool for South Africa's policy, planning, management and reporting needs under the CMS and other environmental conventions.

Second, the datasets which result from biodiversity projects must be analysed robustly in order to deliver reliable information on changes and trends. Not only is there a general lack of capacity in the field of biodiversity, including taxonomy, in South Africa, there is also a shortage of the statistical ecology skills required for data analysis. There is thus an urgent need for capacity building in the application of advanced statistics, including predictive modelling.

Third, the analysis and synthesis of these results must be converted into clear, graphic messages for decision-makers. Better integrated information will support the needs of national planners, policymakers and managers. The web platforms for the decision-support side of the early warning system have yet to be built.

With these three ingredients in place, early warning systems for biodiversity will become a reality. Several of the important components of these systems are highlighted in the next pages.

In the Overberg, where wheat and pasture fields act as artificial grasslands, there has been a three-fold increase in Blue Cranes over the last 18 years. In natural grasslands, Blue Crane numbers have declined drastically due to habitat transformation.



South African National Biodiversity Institute

SANBI explores, reveals, celebrates and champions biodiversity for the benefit and enjoyment of all of South Africa's people. South Africa occupies only 2% of the world's land area, but is home to nearly 10% of the world's plants and approximately 7% of its reptiles, birds and mammals. This makes South Africa the third most biodiverse country in the world, following Indonesia and Brazil.

As well as being the custodian of the National Botanical Gardens System, SANBI is a respected authority in research, especially on southern African flora. Its research covers applied biodiversity science, climate change and systematics. SANBI's work makes biodiversity science more accessible through a wide variety of "mainstreaming" initiatives, and ensures that knowledge informs policy, management and decision-making. As part of its mandate, SANBI also monitors and reports to the Minister of Environmental Affairs on the state of South Africa's biodiversity.

SANBI's biome programmes aim to ensure that the country's most important biodiversity regions are protected in a sustainable and beneficial way. This includes investigating ways to improve ecosystem-based adaptation of biodiversity and society to climate change. Together with its partners and stakeholders, SANBI develops and implements strategies to improve biodiversity management for the benefit of current and future generations.

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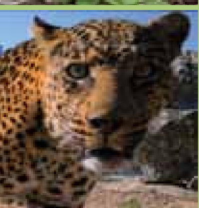
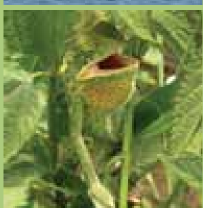
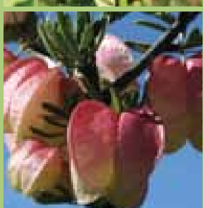
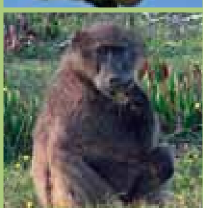







Our biodiversity wealth: in the red?

Plants and animals are essential components of the natural systems upon which humans rely for food, fuel and water. These systems absorb and store carbon and are essential to our efforts to adapt to climate change. In the 21st century, climate change is expected to be a major cause of species extinctions. By keeping tabs on the responses of species to climate and other environmental variables, we are keeping ourselves informed about our own future.

SANBI's Threatened Species Programme (TSP) co-ordinates the evaluation of the risk of extinction of South African plant and animal species, thereby improving our knowledge of the status of South African biodiversity. TSP co-ordinates and promotes the application of this knowledge in biodiversity conservation, through national biodiversity legislation and policy, conservation planning, protected area selection, *ex situ* breeding programmes, and the development of Biodiversity Management Plans for Species.

Plants: In 2009 the first comprehensive assessment of South African flora was completed. Of the 20,456 types of plants evaluated, 13% were rated at risk of extinction. An updated assessment was published in July 2011 (*redlist.sanbi.org/*).

Butterflies: The first comprehensive assessment of the butterflies of South Africa, Lesotho and Swaziland was completed in 2011 (see page 7). Of the 793 species evaluated, at least three are extinct and 8% are threatened.

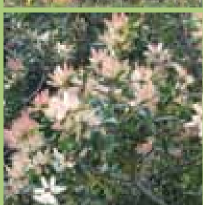
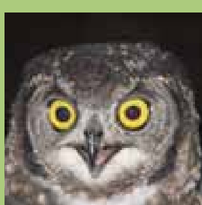
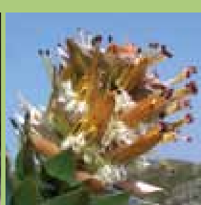
Reptiles: The *Atlas and Red List of the Reptiles of South Africa, Lesotho and Swaziland* will be published in 2012. Two species are considered to be extinct and 9% of the remaining 401 reptiles assessed are judged to be at risk of extinction.

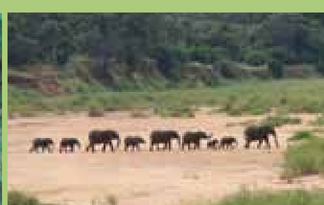
Arachnida: The South African National Survey of Arachnida (SANSA, *www.arc.agric.za/home.asp?pid=3272*) has produced the first spider atlas for South Africa. In 2011, Red List assessments were completed for baboon spiders and three groups of scorpions.

Frogs: The *Atlas and Red Data Book of the Frogs of South Africa, Lesotho and Swaziland* was published in 2004, and all frog species of South Africa were re-assessed in 2010. It is believed that 35% of the 118 species assessed are now threatened with extinction.

Birds: The Second Southern African Bird Atlas Project, SABAP2, like SABAP1 (1987–1991), collects data on bird distributions in South Africa, Lesotho and Swaziland. This will be used to update the Red List status of South African birds. Comparisons of SABAP1 and SABAP2 data are shedding light on the impacts of climate change on bird distributions (see page 6).

Habitat destruction and degradation are the most serious immediate threats to many species, and protection and rehabilitation of habitat is of the utmost importance. Climate change vulnerability is more difficult to evaluate; the potential responses of most species to changes in climate are poorly understood. Yet climate change is a very real threat. Intensive ongoing monitoring of selected species, together with repeated assessments of groups of species, will allow us to predict its potential impacts on our biodiversity and, ultimately, on ourselves.



Flower power: proteas as predictors of change

Apart from lending their name to South Africa's national cricket team and having as their representative the King Protea, the country's national flower, proteas are also a symbol of the "hottest" biodiversity hotspot in the world – the Cape Floristic Region or "fynbos".

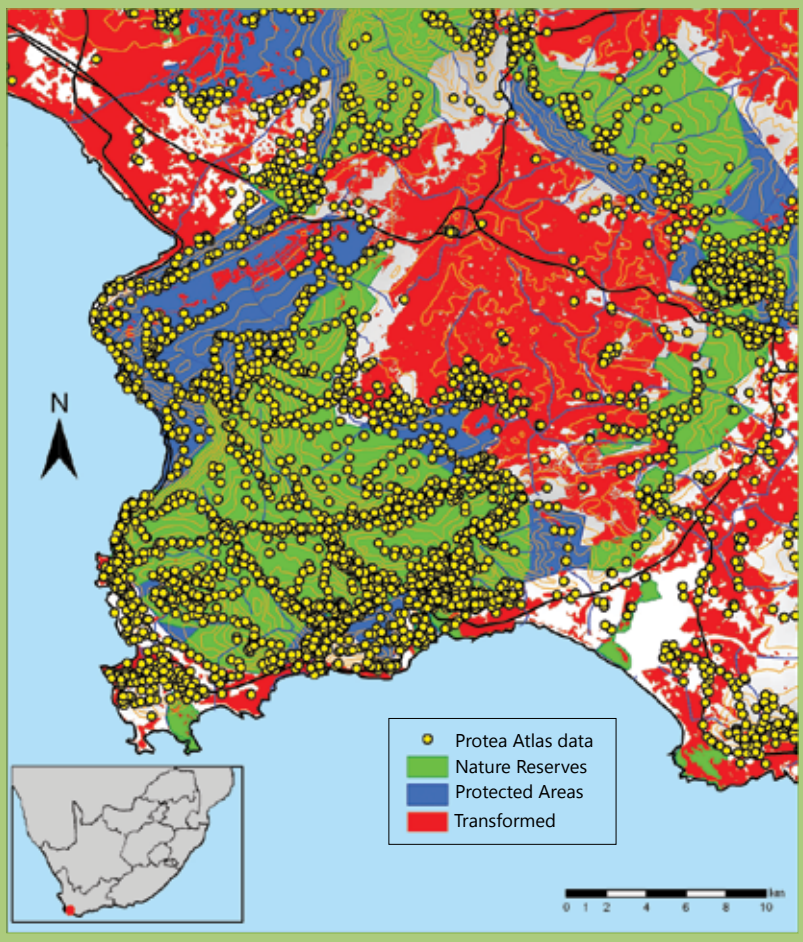
But 120 of the 370 protea species could be at risk of extinction by as early as 2050, due to warming and drying of the region. This has worrying implications for the South African economy and its people. The country's cut flower industry employs a quarter of a million people and the Cape's spectacular seasonal flower displays are a major tourist attraction – through wildflower harvesting and ecotourism ventures, fynbos is estimated to be worth at least R77 million per year. The Cape Floristic Region also has a vital role in delivering clean water to major cities such as Cape Town and Port Elizabeth.

The Protea Atlas Project, launched in 1992, drew in nearly a thousand volunteers to collect a vast amount of information on the distribution of proteas and related plants. This has been a valuable resource for predicting the potential effects of climate change. Researchers have used Protea Atlas data to develop models that estimate suitable climate for the survival of each protea species, and to determine the potential effects of future climate change. SANBI is now investigating new approaches for determining what levels of climate change will produce undesirable effects on fynbos species, and is developing adaptation strategies in the event that these effects are unavoidable.

Information from the Protea Atlas has also been vital for effective conservation planning. For example, atlas data was used by the Cape Action for People and the Environment programme to develop a systematic conservation network for the Cape Floristic Region. Using predicted changes in plant distribution, scientists have been able to determine the long-term effectiveness of different conservation strategies under different climate change scenarios.

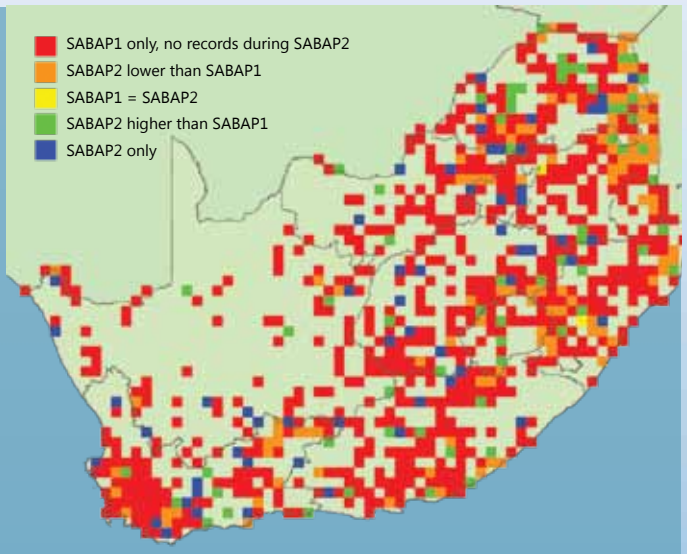
Through the involvement of ordinary South Africans, the Protea Atlas Project has created a pool of enthusiastic volunteers that has contributed to other biodiversity projects such as CREW (page 8), iSpot (*za.ispot.org.uk*) and the Virtual Museum (page 13). It has also provided the ingredients needed for effective environmental modelling, planning, policy and management in South Africa. The spin-offs of this are far-reaching, with financial and employment benefits for rural communities, farmers, reserve managers, researchers, tourism and the cut-flower trade.

Protea Atlas data from the Kogelberg area show that protected areas are critical for fynbos conservation.



Falling through the cracks: red flags for birds in trouble

Changes in Black Stork distribution: comparison of SABAP1 and SABAP2 reporting rates, showing areas where this bird now appears to be locally extinct (red) or declining (orange).



Two of the first signs that a species is in trouble are that its range or distribution starts to shrink or to fragment. Researchers are using long term datasets collected by volunteers to detect early evidence of these changes.

Since 1987, the Southern African Bird Atlas projects (SABAP1 and SABAP2) have involved members of the public in collecting data on bird distributions in South Africa, Lesotho and Swaziland. SABAP2, a partnership between SANBI, BirdLife South Africa and the ADU, divides up the region into over 17,000 5′ x 5′ grid cells or "pentads". Trained citizen scientists compile bird lists for these pentads and their incoming data are automatically updated every five minutes (*sabap2.adu.org.za*). The bird lists are used to calculate "reporting rates" for each species and pentad – an indication of how rare or common a species is.

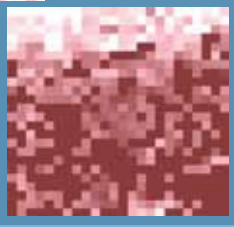
People notice when common species, like the Hadeda Ibis or Pied Crow, spread into new areas. It is much harder to detect when species no longer occur in an area. This is something that SABAP data can do. For example, from atlas data it has become clear that the Black Stork, a Red Data species, is declining rapidly over large parts of its range. The red squares on the map above show where the species was recorded by SABAP1 in 1987–1991, but not by SABAP2 from 2007 to 2011. The orange squares show where the stork still occurs but is now encountered less often.

To detect range fragmentation, SABAP data has been used to develop a "roughness index" for bird distributions. If the reporting rate for a species is fairly even between adjacent pentads, the distribution is "smooth" and unfragmented. If the reporting rate varies a lot between pentads, the distribution is "rough"and probably fragmented. The roughness index has been tested using data from South Africa's Gauteng region, where keen atlasers have collected hundreds of checklists per pentad. "Smooth" species include common birds like the Common Fiscal, whereas "rough" species include many wetland birds such as the Lesser Swamp-Warbler. The roughness index will come become extremely useful once SABAP2 has accumulated a longer term dataset spanning 10 or more years, allowing the detection of range fragmentation over time.

SABAP2 data not only allows the detection of coarse changes in bird distributions that have already taken place, but can provide an early warning that species are getting into trouble, thus allowing timely management interventions for their conservation.

In a "rough" range, adjacent pentads have very different reporting rates, resulting in a random "chessboard" effect.

In a "smooth" range, adjacent pentads show more gradual changes, resulting in a smoother effect.



Going south: butterflies as indicators of environmental change

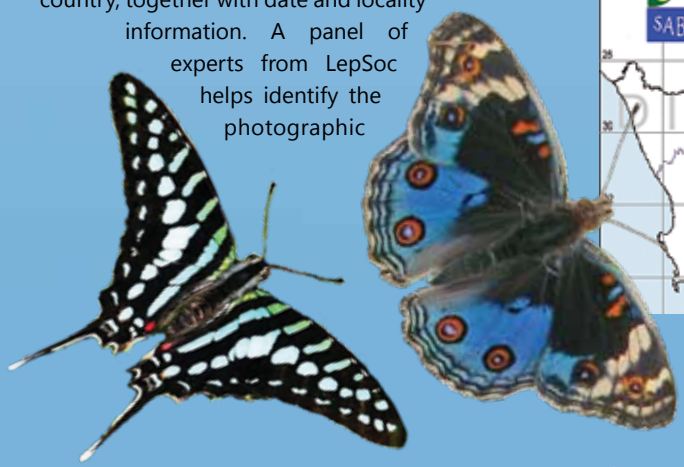
Butterflies can be good indicators of the health of the environment, and can provide an early warning of change in environmental conditions. They also play an important role in ecosystems, especially through the pollination of flowering plants. SABCA, the Southern African Butterfly Conservation Assessment project (*sabca.adu.org.za*), is an excellent example of citizen scientists helping to track environmental change and climate vulnerability in South Africa. Through SABCA, members of the public contributed about 350,000 of important butterfly records via four main routes: private collections, field surveys, an online Virtual Museum (see box, page 13) and butterfly census weeks.

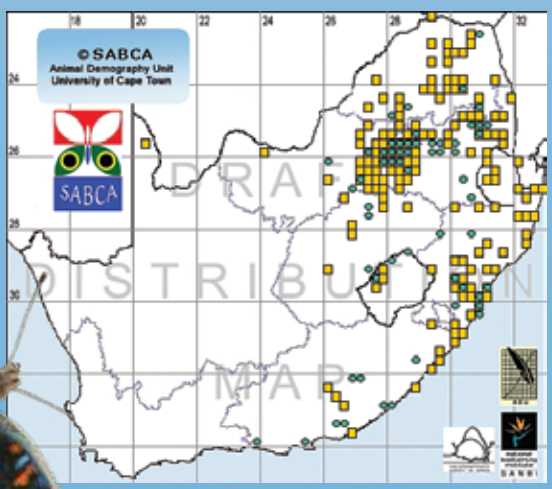
Members of an amateur society, the Lepidopterists' Society of Africa (*www.lepsoc.org.za*), contributed a significant amount of data to SABCA through their private collections of specimens and through field surveys conducted in areas of the country where there was previously little information on butterflies. Most of the historical records held by museums were also collected by amateurs. Comparison of historical and current records is important for monitoring changes in patterns and trends over time.

The online Virtual Museum (*vmus.adu.org.za*) formed an integral part of SABCA and due to its popularity, will continue into the future through LepSoc. The Virtual Museum requires volunteers to submit photographs of butterflies from around the country, together with date and locality information. A panel of experts from LepSoc helps identify the photographic specimens. This is an enjoyable way for citizen scientists to participate in biodiversity monitoring, using technology such as digital cameras, cell phones and the internet.

Butterfly census weeks were initiated in 2010 during SABCA and are now being continued through LepSoc (*www.lepsoc.org.za/butterfly-census-weeks/sa-butterfly-census-weeks.html*). They are conducted every autumn and spring, so that the same localities are repeatedly surveyed for butterfly species and numbers over many decades, as is done in the United Kingdom and the United States.

Overall, through the contributions of citizen scientists, valuable information has been received on shifts in the distributions of butterflies. For example, the Eyed Pansy seems to be extending its range southwards, perhaps as a result of climate change or changes in land use practices. This kind of information can act as an early warning of changes which may have detrimental impacts on other biodiversity, or on human health and food security.





The distribution of the Eyed Pansy (left), based on records from the SABCA project.
= Virtual Museum records,
= other records.

Involving the whole CREW: citizen scientists and threatened plants

The Custodians of Rare and Endangered Wildflowers (CREW) programme of the Botanical Society of South Africa (BotSoc) and SANBI involves volunteers in the monitoring and conservation of threatened plant populations. Volunteers are local people from regions identified in SANBI's bioregional plans as critically threatened areas in need of conservation. CREW volunteers operate in groups, with each group having a champion who liaises with the programme's co-ordination team.

CREW was initiated in 2003 in response to the need to monitor and protect the unique botanical diversity of South Africa. One in four of the country's 20,456 plant species is rare or threatened, but there is little recent information about the status of their populations in the wild. CREW participants provide this kind of information by surveying the areas where they live for threatened plant species, and by monitoring highly threatened plant populations in detail. They also monitor selected species to help SANBI assess the impacts of climate change, habitat degradation and habitat fragmentation.

Since the inception of the programme, CREW volunteers have made several significant discoveries, including the discovery of 15 new species of plants and 13 species previously thought to be extinct. Participants have recorded data on 825 species of conservation concern and surveyed over 2500 sites in South Africa.

The data that participants collect is used to identify priority conservation areas in local, provincial and national conservation planning processes, and in land-use decision making. Volunteers also support conservation agencies in the implementation of conservation stewardship initiatives, which encourage private landowners to conserve and protect natural vegetation on their properties.

Coming unstuck: fynbos insects and climate change

Insects are the glue that holds natural systems together. They are integral to ecosystem functions and services such as nutrient recycling and water purification, while pollination of a range of fruit and vegetable crops by bees and flies is essential to food security. With complex life cycles and narrow habitat requirements, they are also highly sensitive to climate change.

South Africa's fynbos biome hosts a unique and rich insect diversity. Fynbos insects are ideal candidates for biodiversity early warning systems, and consideration of insect diversity is essential for effective biodiversity policy planning. Localized warming, and the southward movement of sub-tropical insect species, pose serious threats to fynbos. To date, we know of three beetle and five butterfly species that have shown significant southward expansions. These species are aided in their spread by human activities such as the transport of nursery plants across provincial boundaries, and may persist in fynbos due to increased temperatures.

In South Africa, southward movements of insects have been tracked mostly by citizen scientists, particularly members of the Lepidopterists' Society of Africa. Through SABCA, members have established a successful online photographic identification service and well-supported Facebook and blogging sites. These have opened up new avenues for a broader spectrum of South Africans to become interested and involved in biodiversity monitoring.

Monkey beetles are an important and rich group of beetle pollinators. They are most diverse in fynbos, with over 550 species endemic to South Africa.

Prevention rather than cure: early detection of invasive alien plants

Invasive alien plants are transforming South African landscapes, not only threatening biodiversity but also disrupting ecosystem function. Invasive plants can increase soil erosion and intensify the impacts of fires and floods, threatening water security and agriculture.

The control of invasive plants for ecosystem service benefit is the focus of several large and successful public-works job creation programmes, such as Working for Water (*www.environment.gov.za/workingforwater/index.html*). But prevention is better than cure. The early detection of invaders such as Jointed Cactus and Triffid Weed could have saved the country's economy millions of rands.

The Southern African Plant Invaders Atlas (*www.arc.agric.za/home.asp?pid=1033*), a partnership between the ARC Plant Protection Research Institute and the Department of Water Affairs, involves a network of amateurs and professionals in mapping invasive species. The programme supports SANBI's Early Detection and Rapid Response Unit, which identifies and targets emerging invasive plant species. In the last five years, 83 new species have been added to the atlas database, which now contains records spanning three decades. Re-surveys of certain parts of the country have shown a dramatic increase in the number of invasive alien plants.

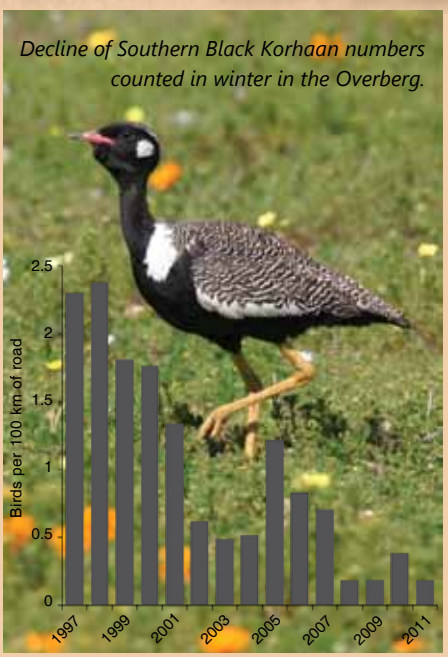
Is farming for the birds?

Eighty percent of South Africa – a net food exporter – is farmland; farming is fundamental to the country's economy and development. But farming cannot be sustainable unless ecosystems continue to provide services essential for continued food production and for human health and wellbeing, such as healthy soils and clean water.

Large terrestrial birds, for example the Blue Crane (South Africa's national bird), storks and bustards, are good indicators of ecosystem health and changing environmental conditions on farmland. Because they are easily visible, they are also relatively easy to monitor.

The Coordinated Avifaunal Roadcounts project, CAR, has mobilized 800 people in seven provinces to count large birds along fixed routes through agricultural lands. Counts are performed by farmers (over half of all routes), bird club members, conservationists and school children. Twice a year and at their own cost, volunteers travel a total of 19,000 km – double the distance between Cape Town and Europe! There have been regular CAR counts for at least 10 years in most areas, and patterns are now emerging that point at worrying environmental changes.

Take, for example, the decline in counts of Southern Black Korhaans in the southern Overberg and Swartland regions of the Western Cape over the last 15 years (graph above). Data from the first and second bird atlas projects (SABAP1 and 2, page 6) confirm that changes within this species' range are greatest in the southern areas most transformed by agriculture. These korhaans have only been recorded on at most four out of thirty routes in the Overberg during the last six years. The decline in korhaans is thought to reflect a reduction in the amount or condition of renosterveld, a natural vegetation type whose extent has declined by more than 95% over the last 100 years. Korhaans rely on natural vegetation for protection, and avoid cultivated areas unless there is cover nearby.



Decline of Southern Black Korhaan numbers counted in winter in the Overberg.

By protecting remaining patches of renosterveld, farmers not only help conserve korhaans but also help safeguard important ecosystem services such as pollination and seed dispersal by birds, bees, butterflies and ants. The involvement of farmers in CAR also contributes to other biodiversity-friendly land management practices on farmlands, such as the responsible use of poisons, appropriate management of fire, and creation of ecological corridors (see: *www.adu.org.za/docs/farming_for_the_future_lr.pdf*).

A whiter shade of pale: coral health as a marine early warning tool

Reefs built or colonized by corals support high biodiversity, act as nurseries for many species of commercially important fish, and help protect coastlines from extreme waves. South African reefs in northern KwaZulu-Natal also support a valuable scuba diving industry, attracting local and international visitors to enjoy the beautiful underwater biodiversity. But climate change impacts, such as changes in sea temperature, can result in the loss of the photosynthetic algae that are hosted by corals. This is accompanied by a loss of colour, known as bleaching. Bleaching can be minor, substantial or complete, and in the latter case will kill the coral. The death of reefs can, in turn, endanger human lives and livelihoods.

The sea plays an important role in the global carbon cycle by absorbing carbon dioxide, but increased carbon emissions have increased its acidity. Corals are vulnerable to this ocean acidification. Acidification can dissolve or weaken the skeleton of stony corals, and is likely to reduce the ability of coral reefs to grow and remain healthy. Acidification not only affects corals, but all those species that rely on them for food and shelter.

Coral bleaching is one of the highly visible responses to climate change in South Africa. Monitoring of corals in the iSimangaliso World Heritage Site in KwaZulu-Natal is helping us to track climate change. No bleaching was documented in 1993, but since 2000 a worrying increase has been observed. Dive operators, who depend on healthy reef ecosystems for their livelihoods and spend many hours underwater, are well-placed to monitor coral health, and can potentially add valuable information to databases compiled by researchers. Underwater photography can also be used to collect data and engage divers' interest. Recent bleaching has catalyzed interest in climate change amongst recreational divers who, along with researchers, have helped monitor the health of South Africa's corals by tracking bleaching.

South Africa has a wealth of corals, both shallow-water coral communities and reef-building cold water corals in deep water. Early warnings of changes in coral health are invaluable in informing rapid management responses, including improved reef protection.

Something fishy: shifting marine resources

Internationally and in South Africa, it has been shown that sea temperature changes can cause shifts in the ranges of near-shore species. Shifts in the distributions of anchovies, sardines and rock lobsters, and lobsters growing more slowly and performing mass walkouts from the sea: these are warning signals that the seas around South Africa are changing in ways that will affect the economy of the country and the livelihoods of its people.

An important component of South Africa's fishing industry is the fishery for sardine and anchovy. This fishery has been hard-hit by changes in distributions of its target fish. Ocean cooling east of Cape Agulhas is associated with improved feeding conditions for fish, and has led to an eastward shift by both species. For sardines, the situation is worsened by intense fishing pressure. These shifting distributions have led to a mismatch between fish and fish canneries, with serious socio-economic ramifications. The shifts also put at risk the food source and survival of the already threatened African Penguin, a flagship of South Africa's marine environment and a multi-million rand tourist attraction.

Commercial, subsistence and recreational fishers all depend on West Coast Rock Lobsters. Declining lobster numbers in St Helena Bay, and a rapid shift to the east of Cape Hangklip, are probably in part due to environmental changes. Between 1978 and 2005, increases in southerly winds caused increased upwelling near St Helena, resulting in less oxygen in shallower waters. This caused lobsters to escape the suffocating waters by moving eastward or, more drastically, by walking out of the sea and dying. But environmental changes are not only to blame for the shift – heavy fishing pressure may also have contributed. The lobster shift has serious implications. One ecological impact is a reduction in sea urchins, which results in less shelter for and thus decreased survival of young abalone ('perlemoen'), another commercially important and highly threatened species. Social and economic impacts include reduced numbers of long-term lobster fishing rights on the west coast, and job losses at processing facilities.

An improved understanding of the response of marine resources to environmental variation should be a research priority. Yet the protection of these resources will only be assured through wise and effective implementation of South Africa's Integrated Coastal Management policy. ICM is aimed at protecting biodiversity and allowing for sustainable use of resources, and also strives to ensure continued delivery of coastal ecosystem services, such as protection from sea level rise and severe storms.

South African Environmental Observation Network

SAEON undertakes long-term research and observation on global change. It also archives environmental data for future analysis on a publically accessible data portal. Volunteers, schools and research institutions contribute to the monitoring data that SAEON manages.

SAEON has a country-wide presence of monitoring sites that encompasses our major terrestrial habitats and our coast and oceans. SAEON's vision is to provide a comprehensive, sustained, coordinated and responsive observation network that delivers long-term, reliable environmental data for research, and informs decision-making for a knowledge society and improved quality of life.

SAEON was established in 2002, after the South African government, National Research Foundation and researchers together identified the need for long-term environmental observation in order to promote an informed and timely response to global change.

Science by the people, for the people

In many of the studies reported in this booklet, the role of "citizen scientists" has been pivotal.

As an example, the second bird atlas project, SABAP2, involves nearly 1000 participants – mostly volunteer amateur naturalists – across South Africa, Lesotho and Swaziland. By learning the data-recording system used for the project, these people are being trained in the methods of scientific data collection. This large team of fieldworkers allows the simultaneous collection of scientific data at many places in southern Africa. It is a strategy that works. It is science by the people.

By participating in biodiversity monitoring programmes such as those described in this booklet, citizen scientists are empowered to contribute to national work on the threats to biodiversity posed by climate change, land-use change, invasive alien plants and pollution. No matter how small, their contribution is a valuable piece in the jigsaw puzzle of biodiversity conservation. This puzzle is not static, but is changing under the stresses of human developments and global climate change, hence the need for repeated and repeatable data collection over a long time period.

Citizen scientists help build pictures of the state of biodiversity that are used to influence recommendations to government about conservation policy and actions. Ultimately, this improves the quality of life for all South Africans by improving the health of the environment. In other words, citizen scientists are ambassadors for biodiversity: science by the people is science for the people.

A virtual first

The ADU's Virtual Museum (VM, vmus.adu.org.za) provides a platform for citizen scientists to contribute to biodiversity projects.

For many people, museums are places to see stuffed animals on display. But behind the scenes, museums have large collections of specimens labelled with the date and place of collection. The Virtual Museum is like this, but instead of specimens in drawers or bottles, it has digital photographs in a database.

Through the VM, people are encouraged to submit digital photographs of plants and animals, along with basic information. Species identifications are confirmed by a panel of experts. Distribution maps for each species are available online and serve as conservation and education tools. So far, the VM accommodates photos of reptiles, frogs, butterflies, dragonflies, damselflies, mammals, trees and weaver bird colonies. These records help expand the distribution databases for these groups. They have confirmed the presence of certain species at a particular time and place, have provided new distribution records for some species, and have extended the known ranges of others.

The VM is an ideal tool for involving the public in the collection of information that may signal environmental change. For those less familiar with identifying species, public-participation web platforms like iSpot (za.ispot.org.uk) may also open up biodiversity monitoring to a wider audience.

Free for All: Biodiversity Data

One of the challenges faced by the Animal Demography Unit (ADU) is to make its biodiversity databases accessible to researchers, managers and anyone else who might find them useful, for example tourism operators.

The projects described in this booklet produce very different types of information. How does one integrate data from the tagging of animals, atlas data and census data?

A new online facility at *udp.adu.org.za* allows users to ask two key questions: "What species occur in a region?" and "Where does a particular species occur?" The two queries that are generated simultaneously interrogate all ADU databases, searching "by region" or "by species".

Using the first query, users can select regions of interest and define the scale of the query, down to an area of five minutes of latitude by five minutes of longitude. The query searches all ADU project databases and returns a summary of relevant information held by each project. It provides a list of species recorded by all projects for each area, and indicates the quantity of data available.

For many users, this list of species is the endpoint of their search. But other users will want to dig down deeper. For example they may wish to find out whether there are enough records with data about mass, measurements or moult of birds to make it worthwhile applying to SAFRING (*safring.adu.org.za/*), the bird ringing unit, for more detailed information.

Using the second query, the user can produce maps of the overall distribution within South Africa of species of interest. More importantly, this query can identify those sites at which large amounts of data – tagging information, or species counts – have been collected.

It is also possible to run the query for a particular time interval, so that one can quickly visualize whether or not there is sufficient data to be able to detect changes in distributions over time. The second query allows for the rapid and efficient planning of detailed studies, and has the potential to be useful for detecting climate change effects.

Animal Demography Unit

The ADU (*adu.org.za*) is based at the Department of Zoology at the University of Cape Town. The unit curates, analyses, publishes and disseminates information about changes in animal populations. Citizen scientists are the eyes and ears of the ADU, and their participation is key to the success of the unit's projects. For example, the time and resources contributed by volunteers to SABAP2 (page 6) are estimated to be 20 times the value of the formal funding received by the project.

The data submitted by citizen scientists is used to produce conservation assessments of species. These feed into State of the Environment reports and ultimately influence conservation policy. Previous ADU projects include SARCA (Southern African Reptile Conservation Assessment: *sarca.adu.org.za/*), SABCA (Southern African Butterfly Conservation Assessment: *sabca.adu.org.za*) and SAFAP (Southern African Frog Atlas Project: *adu.org.za.frog_atlas.php*). Ongoing ADU projects include SABAP2 (see page 6), SAFRING, CAR (page 10) and the Virtual Museum (*vmus.adu.org.za*, pages 7 and 12).

Animal Demography Unit