TOO HOT TO HANDLE?

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THE IMPACT OF CLIMATE CHANGE ON AFRICAN BIRDS

Africa is a continent in which the grand sweep of environmental change has always been impressive. Over past millennia, rainforests have expanded and shrunk like a pulsing green heart; corridors of open and sunny savannas have opened up and then been pinched off. Climate change has always been a fact of life for this continent, one which doubtless helped drive the evolution of inquisitive and problem-solving humans every bit as much as it helped drive the diversification of our extraordinary mammals, plants, insects, reptiles and birds. It has been a powerful shaper of the continent's biodiversity. ▸

Above *The frequency of fire in fynbos is critical in the life history of the region's 8 000-plus plants. Under climate change they will probably have to adapt to more frequent burns as temperatures increase and soil moisture goes down.*

Previous spread *Cape Sugarbirds are intimately tied to the flowering of nectar-rich plants such as this* Leucospermum *species. Climatic stresses on the bird or on the plant could move either into new territory, breaking the delicate bond between pollinator and pollinated.*

But that was before 6.45 billion people (and counting) were crammed onto the planet, more than 850 million of them in Africa. The single fact of human population pressure alters everything about the vulnerability of birds, other biodiversity and ecosystems to global environmental change, and especially climate change. At present there can be few starker prospects on the horizon than the visions of how our world will change in the next century as a result of us fouling our own nest. For the affluent and comfortable among us, it is a matter of worry, potential discomfort and inconvenience, perhaps even danger. For the poor, though, and especially subsistence farmers in Africa, the additional pressure of climate change is potentially devastating.

How will climate change affect birds and their habitats in Africa?

Studies of the impact of climate change on Africa's rich diversity have lagged badly behind the rest of the world. In 2001, when the Intergovernmental Panel on Climate Change (IPCC) produced its Third Assessment Report, there were few published field studies in south–central Africa. Since then, a steady trickle has emanated from a number of institutions, the precursor to a small flood. Ecologists at the South African National Biodiversity Institute (SANBI), Kirstenbosch, and the University of Cape Town have modelled climate change impacts on the distribution of plants and biomes, and published a popular booklet, *The heat is on... impacts of climate change on plant diversity in South Africa*. These models, which use correlational techniques to map climate change effects based on increased temperature, carbon dioxide and reduced soil moisture, predict especially serious impacts on the Succulent Karoo biome. Despite the many assumptions underlying this modelling, it seems that the Succulent Karoo, which stretches from South Africa's Northern Cape Province to south-western Namibia, is likely to be fundamentally altered, and other biomes may be shifted southwards and eastwards. However, biomes are not likely to move *en masse* as intact units – climate change will affect individual species within them differently, causing some species relationships to uncouple (see box on page 60) and ecosystem composition to change in complex ways.

Birds in southern Africa are probably already responding in different ways, some of which may be hard to predict. Unlike birds from temperate climes, such as those in Europe (see box on page 60), many bird species in Africa breed in response not to rising temperature, but to rainfall. Rainfall often sparks intense nesting activity in birds, especially in arid regions. Rainfall can also help to predict clutch size and the number of clutches laid in a season. Most climate models foresee reduced and less predictable rainfall over most of southern Africa. If this proves true, we can expect that birds will breed less regularly, and fewer pairs will be successful, under lower rainfall regimes. Large birds may be somewhat better 'buffered' against these effects than small birds, because they can store resources during good times for use under poorer conditions. But we also know that larger-bodied birds tend to be threatened by other environmental changes, such as habitat fragmentation or pollution.

For birds migrating from Europe and Asia, such as storks, eagles, kestrels and rollers, which exploit the vast locust and termite swarms that arise after good rains, we can predict that their long journey south may be increasingly fraught with uncertainty. They may have to spend more time in southern Africa wandering from rainfront to rainfront, thus reducing the time actually spent feeding. The effects of such trends on populations both here and in Europe may be subtle, but could include increased attempts by Palearctic migrants to breed in Africa, later migration departures and arrivals, and overall population declines (see box on page 60).

Climate change might not be detrimental for all species. For some in winter-rainfall areas, for example, higher spring temperatures may be important. Falcon biologist Andrew Jenkins has found a positive link between breeding success and warm spring weather in the south-western Cape. Success is less strongly related to rainfall. If climate changes mean that seasonal temperatures climb, as universally predicted, Peregrine populations could potentially increase, if ▷

Blue Swallows are among a suite of species that may be pushed eastwards from an already tenuous hold in highland areas towards extinction as temperatures increase.

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ALBERT FRONEMAN

Above *While larger species such as this Tawny Eagle may be buffered against the immediate effects of climate change, their slow breeding rate may make them less able to adapt to the rapid tempo of climatic shifts forecast for future decades.*

Right *The dwarf succulents of the Knersvlakte may seem the least likely candidate for susceptibility to increasing temperatures. However, climate modelling suggests this biome may completely disappear by 2080.*

they become more successful at rearing young. Like so many other ecological predictions, this may be complicated by the effects of climate change on their avian prey, and on the food and life history of that prey.

Detailed work on what climate change may mean for African vertebrates has been much slower than similar work done in the northern hemisphere; indeed, there are only three published reports assessing the possible changes to African birds and mammals. In their study of birds, mammals, reptiles and insects, Barend Erasmus and his colleagues modelled likely shifts in species distribution. They showed that 78 per cent of species are likely to contract their ranges under a climate in which mean temperature is raised by only 2 °C. Most species moved in an easterly direction. A few species were expected to become locally extinct, and the Kruger National Park was predicted to lose a large proportion of the species assessed in this study. Because the study was not based on the full distributional limits of many of the species modelled, it may have overestimated the seriousness of the effects. For Tawny Eagles, German and South African researchers noted that even slightly less predictable rainfall may contribute to a marked population decrease. So sensitive is this species that its extinction in southern Africa was predicted with only a 10 per cent drop in mean annual precipitation. Such predictions require field testing, and will hopefully prove incorrect. After all, birds, like other species, have been through climate shifts in their evolutionary history, and have usually been able to adapt somehow to change. The worry now is that climate is changing so rapidly, in evolutionary terms, that large birds such as this which breed so slowly will be unable to adapt in time.

Newer modelling has looked at the likely prospects for six smaller birds in South Africa. Together with Richard Dean, Guy Midgley, Wilfried Thuiller and Greg Hughes, we recently used bioclimatic modelling of summer and ▷

CLIMATE CHANGE EFFECTS AT A GLANCE

What will climate change mean for African birds and ecosystems? Some fairly stark pointers are provided by thousands of pages amassed by the Intergovernmental Panel on Climate Change (IPCC). Broadly, temperatures will increase across the globe, faster at the poles than in the tropics. Antarctica and the Arctic already show significant temperature-induced ecological changes. Where they are not constrained by coastlines or other barriers, biomes and species will often shift towards the poles. Rainfall will increase in many temperate areas and decrease over much of the subtropics.

Episodic hazards, such as storms, droughts and fires, are expected to increase in frequency, as are the warm-water El Niño and cold-water La Niña events which alter regional weather patterns. Many senior scientists are now concluding that sea levels will probably rise by up to five metres through displacement – independent of any melting – when the ice sheet in western Antarctica slips into the sea. If the Greenland ice sheet melts, as is expected if global temperatures rise by 3 °C, sea levels might rise by a further seven metres. Both seem increasingly likely in the next century. By human time frames, these trends are essentially irreversible: it would require a major ice age to re-form ice sheets many kilometres thick.

HOW IS CLIMATE CHANGE AFFECTING BIODIVERSITY?

Two of the world's richest biodiversity 'hotspots' lie in southern Africa: the Fynbos and Succulent Karoo. In South Africa several important modelling exercises have shown what might happen to these biomes. The Global Change Research Group of the South African National Biodiversity Institute at Kirstenbosch has shown that the Succulent Karoo and Fynbos may undergo serious changes, and could be reduced by 35–55 per cent in the next 50–100 years (Fynbos) or, in the case of the Succulent Karoo, virtually disappear. Experimental work by this group has also shown increased mortality of quartz field succulents as a result of increased temperature and ultraviolet light, and enhanced growth of woody species such as acacias under increased carbon dioxide conditions.

In the context of global change, long-term field studies come into their own. We need lengthy datasets to distinguish the noise of annual variability from the signal of long-term trends. Using such data, surveys have documented 15 species of northern hemisphere butterflies moving further north, as expected. The recent extinction of a cloud forest toad in Costa Rica has been linked to a significant decrease in the frequency of mist, associated with changes in sea surface temperatures. More than 434 species (trees, shrubs, invertebrates, fish, mammals, birds) already show recent climate-induced changes in range, 80 per cent in the direction predicted by climatic models. The timing of flowering of trees and egg-laying in birds has also changed significantly in some species.

When species in an ecosystem respond to change, it is unlikely that all react in the same way or at the same speed – as Darwin realised more than 130 years ago. Thus some species are quite vulnerable to climate change, but others are not. Species may move out of the range of others, which could cause the breakdown of mutualisms, such as that between the nectivorous sugarbirds and their protea food plants. While some proteas are re-sprouters and can reproduce vegetatively, others are seeders and could face extinction if the sugarbirds are not around to assist in transferring pollen.

Above *The stunning visual floral displays of the Northern Cape may begin earlier if spring temperatures are warmer, but could be on a knife edge if spring rains become less predictable.*

Below *Of six species of birds assessed for risk to climate change in South Africa, the Drakensberg Rockjumper was predicted to lose most of its high-altitude range.*

winter temperature, rainfall and evapotranspiration to assess the probable changes to six African passerine birds. All are likely to be threatened by climate change. We looked at pairs of birds representing species we felt might be at different levels of risk. These included two high-risk species with restricted ranges confined to high ground or mountaintops (Drakensberg Rockjumper and Blue Swallow), two medium-risk species restricted to the Fynbos biome (Cape Sugarbird and Orange-breasted Sunbird), and two low-risk species with wide ranges in South Africa (Mountain Wheatear and Cape Bulbul). We modelled the present distribution of each, as well as its predicted distribution in 2050 based on climate models.

For each species, our model suggested losses in overall range. The average range reduction of these six species was 40 per cent, and all shifted south- and eastwards. The two nectar specialists declined the least in range, but the model took no account of preferred food plants. Given that the producers of one of their chief nectar sources, proteas, show strong declines for some species in independent modelling by Midgley's team, both nectivores may be faced with fewer suitable feeding areas and a fragmented functional range.

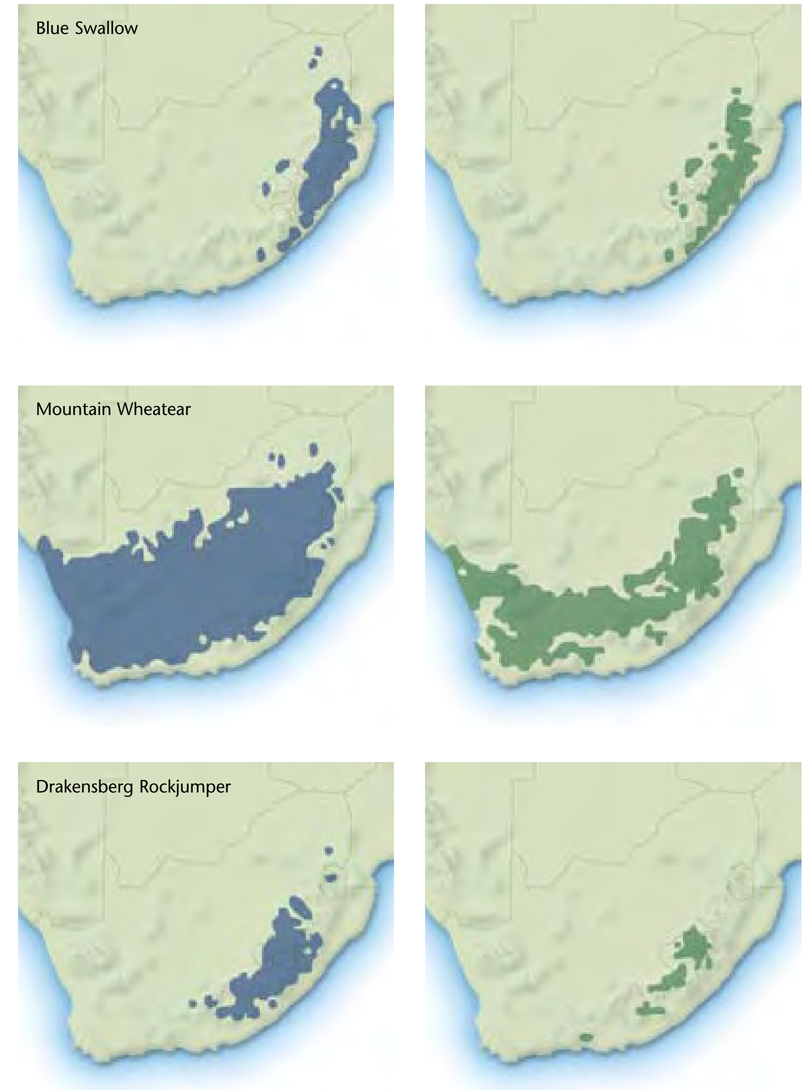
The largest range decrease in this study was predicted for the Drakensberg Rockjumper, which was projected to lose over two thirds of its current range. This was expected, as this bird already occurs on high slopes and mountaintops and has few places to retreat to as temperatures increase. There are also worrying predictions for the Blue Swallow, a Critically Endangered South African Red Data species. Modelling suggests that by 2050 it will lose about a third of its present range and will move eastwards, out of its high-altitude grasslands and into lower areas. It is quite possible that this will edge the Blue Swallow close to the brink of extinction in South Africa.

This approach can give us clues to species which are not currently on our Red Data lists, but which may be in need of urgent conservation attention in the near future. There are several initiatives under way that have already begun this process of identifying birds across Africa that will potentially be influenced by climate change. We predict that these will include species that:

- occur on mountaintops or slopes;
- have restricted ranges or specialised habitat requirements;
- occur in the Succulent Karoo, which is likely to be significantly reduced by 2080;
- occur at the southern edge of their range in habitats which are likely to be squeezed southwards as temperatures increase, for example Fynbos endemics;
- rely on temporary wetlands which may fill less often and remain wet for shorter periods as evaporation rates increase and water resources are pressurised;
- are large species with slow reproductive rates;
- are island endemics with nowhere to 'run'.

Based on this, we speculate that among species most at risk in southern Africa will be (from higher to lower risk): Orange-breasted Sunbird, Cape Rockjumper, Victorin's Warbler, Drakensberg Rockjumper, Knysna Warbler, Yellow-breasted Pipit, Mountain Pipit, Hartlaub's Spurfowl, Violet Wood-Hoopoe, Barlow's Lark, Herero Chat, Cinnamon-breasted Warbler, Cape Siskin and Protea Canary. Some cliff-nesting vultures occurring at low densities, such as the Bearded Vulture, may also be at risk if their montane retreats warm significantly and numbers are further reduced below a minimum critical level.

These are first-cut assessments, and for each species we require a better understanding of the climatic controls on their geographic ranges to accurately predict shifts in range. It is interesting to note, though, that only 14 per cent of the 14 species (Knysna Warbler and Violet Wood-Hoopoe) are currently listed in the South African and Namibian Red Data books. This means that every species should be reassessed in terms of climate change threat, and a new category – Vulnerability to Global Climate Change – could be introduced into future listings.



Potential changes in distributions of South African birds under low- to mid-range projections of climatic change. The maps on the left illustrate the present distribution as depicted by Harrison *et al* (1997), while those on the right indicate the probable projections of distribution by the year 2050. All species are projected to lose between 22 and 69 per cent of their present range by 2050.
Maps generated by the Global Change Research Group at Kirstenbosch (G. Midgley, W. Thuiller and G. Hughes).

Shifting ranges

From the twitcher's point of view, climate change is good! It will undoubtedly bring vagrant species into our backyards in Africa. Take for example Eurasian species that migrate to warm areas with rich food supplies. If temperate parts of southern Africa become more tropical, those species that are typically vagrant now should make it all the way past northern Namibia, the Kruger National Park or northern KwaZulu-Natal. They may become more common at latitudes further south in future years, and thereby serve as important indicators of the rate of changes to come.

Several common southern African species have already shifted their ranges in the past few decades, including the Hadeda Ibis, Black Sparrowhawk, Egyptian Goose and, not so recently, the Blacksmith Lapwing. All these species are resident and common in South Africa's Western Cape Province, but this was not always the case. The lapwing was rarely seen before the ▷

WHEN LINKS IN THE FOOD CHAIN ARE BROKEN

Four examples of European birds becoming 'uncoupled' from their prey by climatic factors have been well studied, and numerous other cases may come to light.

Golden Plovers return earlier to their breeding grounds in northern Britain, since earlier snow melt exposes potential nesting sites. But the plovers fall short: their insect prey is unavailable when the earliest chicks hatch, since the insects have not reacted to climate change in the same way. Either these plovers will have to move to a new area where they can breed in synchrony with their prey, or they will have to time their breeding to prey availability rather than nest site availability.

Blue Tits feeding on caterpillars in France and Corsica fell out of synch with their prey because warmer temperatures advanced the flush of leaves and leaf-feeding caterpillars. Tits normally time their breeding to coincide peak nestling demands with peak caterpillar supplies. As the two became mismatched, with caterpillars peaking too early, adults became energetically stressed, which can reduce their lifespan. This may become a familiar theme in food chains, as shown by another population of tits in The Netherlands. Great Tits studied there by Marcel Visser did not breed earlier in response to warming, but their caterpillar prey peaked two weeks earlier than in 1985. Again, although tits used to time their breeding so that their young fledged when caterpillar populations were highest, these activities have now become uncoupled.

In a fourth example of uncoupling, the arrival of long-distance migrating flycatchers in The Netherlands is controlled by day length. The flycatchers, which also rely on caterpillars, arrive on migration from Central Africa at the same time as they have done since 1980. However, caterpillars now emerge 13 days earlier than in 1980 – too early for all but the earliest flycatchers. In an attempt to compensate, the flycatchers start breeding sooner than they previously did after a 5 000-kilometre migration. Even so, only the earliest birds succeed in matching nestling demands with peak caterpillar biomass.

Other examples are coming to light from marine environments, as plankton blooms occur earlier in warmer oceans, often too early for their fish predators. Potentially, this could generate a significant breakdown in food chains if it affects fish stocks. Perhaps it is only a temporary mismatch. But while it is an exciting time to study these fast-paced environmental changes, the consequences for birds and ecosystems could be dire. Although African ornithologists have been slow to take up these issues, a joint UCT/SANBI team is looking collaboratively at modelling and testing impacts on African birds' behaviour, breeding, ranges and populations.

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The Hadeda may be a recent arrival pushed into the Western Cape by climatic factors rather than the availability of alien pine and gum plantations.

early 1940s, and is now common. Hadeda Ibises were first recorded in the south-western Cape in the late 1960s, and are now noisily common on lawns and road verges. Black Sparrowhawks were rarely seen before the mid-1990s, and at present 28 breeding and thriving pairs have been recorded on the Cape Peninsula. We have seen Little Sparrowhawks with young in pine plantations on the peninsula where the species did not previously occur; the closest breeding record was from Sutherland in the arid Karoo basin, itself an outlier, in 1993.

The traditional reason given for these 'invasions' into previously unexploited areas is the advent of pine and gum plantations for the raptors, and diversified feeding areas, wetlands, and plantations which allow nesting of some wetland species. Phil Hockey has argued in this magazine (Vol.8, No.5) that structural changes in the landscape rather than vegetative changes *per se* appear to be important for birds. So culverts, plantations and pylons have made life easier for these overland invaders. However, a closer look shows that pine and gum plantations have been present in this region since the mid-1800s, yet sparrowhawks, ibises and geese only arrived much later. It is hard to argue that long-distance movers such as birds required 150 years to discover these new habitats as they move rapidly in response to climatic events elsewhere. It seems more probable that climatic factors have helped these recent invasions along, allowing subtropical species to expand into more temperate areas.

There is no doubt that the contribution of different environmental change factors will become clearer as more examples are gleaned from this rich continent of ours. Models are only ever as good as their assumptions and predictions, and bioclimatic modelling is evolving rapidly to improve on both those scores. More important is the need to use the best knowledge and tools we have in order to plan for and adapt to a hotter, drier world in Africa – not to wait for the day when it's been proven beyond doubt that we are already surrounded by desert. □

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FURTHER READING

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