

What can museum and herbarium collections tell us about climate change?

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In 1926—the year of my late mother's birth—the South African Museum conducted a collecting trip to South West Africa (now Namibia). The participants went by train to Windhoek, where they hired ox wagons, in which they spent three months travelling to the Kunene River and back. The staff walked beside the wagon train each day, collecting specimens as they walked to supplement the museum's collection. Over eighty years later, is there much that biological collections such as these can tell us about climate change?

This was the question discussed at the annual meeting of the South African Biosystematics Initiative (SABI) in Bloemfontein in November 2008. The answer, at least in Africa, appears to be: not much yet—in climate change research we are lagging even further behind the northern hemisphere than in most other realms of science. Michelle Hamer of the South African National Biodiversity Institute (SANBI), presented the results of a review of the literature that found only two published studies reporting the impact of climate change on South African biota, compared to more than 28 000 from Europe.

At temperate latitudes, studies suggest that global warming is driving species ranges poleward and towards higher elevations, but evidence for range shifts is scarce for the tropics, where the upslope shifts are predicted to be more likely than poleward shifts. Colwell *et al.*,¹ working on plants and insects on an elevational transect in Costa Rica, have assessed the potential for lowland and mountaintop extinctions, as well as range changes, under projected warming. They conclude that tropical lowland biotas may face a level of net lowland biotic extinction far greater than at higher latitudes (where range shifts may be compensated for by species from lower latitudes) and that the elevational ranges of many remaining tropical species are likely to change.

One of the two local examples was a field study by Wendy Foden *et al.*,² formerly of SANBI, which documented the

recent decline of the quiver tree (*Aloe dichotoma*) in South Africa and Namibia. This species appears to conform to these trends: it is disappearing in the north of its range in northern Namibia; and at lower altitudes. So far, it has been unable to establish itself in the cooler south, seemingly because rains are not heavy enough. Reduced rainfall is expected to accompany rises in temperature in Africa, and is likely to have severe effects on biodiversity. South Africa's dry west will be worst affected, and it includes two biomes with particularly diverse plant species, the Fynbos and the Succulent Karoo, in which species numbers are predicted to fall.

But why are collections of old dead biological specimens potentially interesting? The answer is that they offer us a temporal perspective which experiments or contemporary observations often cannot do. Foden was fortunate in that she was able to use photographs of quiver tree 'forests' taken last century, in which individual trees could be identified, to document their decline. Good museum and herbarium collections—often combined with contemporary surveys—can inform us not only of temporal shifts in distribution, but changes in morphology, size or colour; and even life-history variables such as changes in breeding season, or the emergence of adult stages.

Hamer found over 70 studies in the northern hemisphere which have used natural history collections to monitor climate change. She could find none, by contrast, in South Africa. In an interesting recent example from the northern hemisphere, Moritz *et al.*³ have documented small-mammal responses to global warming over the past century, by repeating an early 20th-century survey across a 3 000 metre altitudinal gradient in Yosemite National Park in the USA. As this was declared a park in 1890, differing patterns of land use are unlikely to be responsible for changes in community structure. Consistent with an observed 3°C increase in minimum temperature, they found that half of the 28 species monitored had

higher (500 m on average) elevational limits to their distribution. Formerly low-elevation species had expanded their ranges by migrating to higher altitudes. But ranges of high-elevation species had contracted, and some of these are threatened. Community structure at mid- and high elevations also changed as a result of different community dynamics arising from the upwards migration of species formerly limited to lower altitudes.

Moritz and his colleagues deliberately chose to replicate a study which had been particularly thorough and well-documented in terms of specimens and exactly where they had been collected. Are there similar collections from a bygone age lurking in the dusty corners of South African museums and herbaria waiting to be revisited? Unlike their predecessors in the early part of the 20th century, nowadays museum curators often whiz up and down national roads (when their collection budgets permit), so it is unsurprising that collections of many taxa reflect localities along these routes.

One solution to the problem of variable sampling effort is atlas projects, where observers are sent out to every quarter-degree grid square of the area being surveyed to record the presence/absence of a species. Provided that the sampling effort is carefully quantified, it can be replicated at a later date, as pointed out at the workshop by Barend Erasmus of the University of the Witwatersrand. In South Africa, atlas projects on proteas and birds were both completed in the mid-1990s, and could soon be replicated to see how distributions have changed. More recently, a frog atlas was completed, and atlas projects for reptiles, arachnids and butterflies are currently in progress.

Good taxonomy, together with well-maintained biological collections, are two essential prerequisites for predicting and understanding the impacts of climate change on biodiversity, so we should be building capacity in this area. In terms of plant diversity, we aren't doing too badly, largely due to the efforts of Brian Huntley, director of the National Botanical Institute from 1989 to 2004, and then of SANBI until 2007. Plant biodiversity is probably of primary importance in South Africa, which comprises less than 1% of the world's land surface, but contains 8% (over 20 000) of all species. But less well known is that the country also contains 7% of all bird, mammal and reptile species, and 15% of known coastal marine species. And in terms of animal taxonomy, by contrast, capacity appears to be declining, largely due to the demise

of South Africa's museum sector.

In two of the country's four natural history museums: the Iziko South African Museum in Cape Town and the Northern Flagship Transvaal Museum in Pretoria, research staff numbers are down to between a third and half of their complement 20 years ago. Generally when curatorial posts are vacated they aren't filled, but frozen. In the main, it appears that the saved resources are being re-directed not towards new exhibitions, but towards new management posts. The result is that these institutions now have too many chiefs, and too few Indians.

The problem is often laid at the door of the Ministry of Arts and Culture, under whose aegis the national museums fall. But this explanation doesn't really wash, as both the Natal Museum in Pietermaritzburg and the National Museum in Bloemfontein, have managed to retain their full complements of curators. SABI—set up seven years ago in an attempt to develop and maintain capacity in bio-

diversity science—has been valiantly trying to make interventions by creating internships for students and postdoctoral positions at museums. But as long as posts are frozen rather than advertised, the perception will remain that taxonomy is a dead-end career.

1. Robert K., Colwell R.K., Gunnar Brehm G., Cardelús C.L., Gilman A.C. and Longino J.T. (2008). Global warming, elevational range shifts, and lowland biotic attrition in the wet tropics. *Science* 322, 258–261.
2. Foden W., Midgley G.F., Hughes G., Bond W.J., Thuiller W., Hoffman M.T., Kaleme P., Underhill L.G., Rebelo A. and Hannah L. (2007). A changing climate is eroding the geographical range of the Namib Desert tree *Aloe* through population declines and dispersal lags. *Diversity Distrib.* 13, 645–665.
3. Moritz C., Patton J.L., Conroy C.J., Parra J.L., White G.C. and Beissinger S.R. (2008). Impact of a century of climate change on small-mammal communities in Yosemite National Park, USA. *Science* 322, 261–264.

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