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Karoo research update: Progress, gaps and threats

It has been more than three decades since the conclusion of the Karoo Biome Project (KBP).¹ At its height in the late 1980s, the KBP coordinated the efforts of nearly 100 research projects across a range of mainly ecological and agricultural disciplines. In this brief update we examine the research that has occurred in the Nama-Karoo and Succulent Karoo biomes since then and describe the relative contributions made by different disciplines to this body of knowledge. We also highlight efforts to synthesise knowledge across the disciplinary divides. Finally, we identify notable gaps in the research, especially considering the major land-use changes that are occurring across the Karoo. We conclude that new questions should be asked and that significantly greater collaboration between disciplines should be fostered in order to address the pressing challenges facing the Karoo more effectively. This necessitates a far more coordinated response than has been the case to date. Institutional leadership and additional funding will also be required to achieve this.

Growth and disciplinary focus in the published Karoo literature

To identify the research that has taken place in the Karoo, we searched the Web of Science for all articles using the words Karoo, Karroo, Namaqualand, Richtersveld, Sperrgebiet, Bushmanland, Knersvlakte or Augrabies in their titles, keywords or abstracts. The 5277 articles identified from this search were then reviewed separately by two of the authors (M.T.H. and H.P.). Articles which extended beyond the Karoo region, narrowly defined as the Nama-Karoo and Succulent Karoo biomes², were not considered further. Articles for which an abstract was not available were also excluded. The remaining 1578 journal articles (~30% of the original list) were then each assigned a keyword to reflect the primary disciplinary focus.

The selection criteria for our bibliography meant that several important books, book chapters, articles in non-peer reviewed journals, field records and short research notes that are either not indexed in the Web of Science or do not meet our full selection criteria fell out of the analysis. While this is a limitation, particularly with respect to the human sciences, we nevertheless consider that this database provides a broadly indicative and useful overview of the state of Karoo studies, one which can be expanded through follow-up work.

Results show that there has been a steady increase over time in the number of publications concerned with the Karoo (Figure 1a). The last decade of the 20th century was a clear turning point for Karoo research. More than four times the number of articles were published in the decade 1990–1999 than had been produced in all the years since 1946. The momentum created by the KBP undoubtedly contributed to this surge in publications. The number of publications has increased by 30% or more in each subsequent decade. This suggests an ongoing and vibrant research interest in the Karoo which shows little sign of abating.

Research output is, however, not evenly distributed across disciplines (Figure 1b). For example, the geological and palaeosciences together comprise 19% of all articles in our database while the human sciences (primarily anthropology, sociology and archaeology) make up just 9.5%. Most research (~70%) forms part of a broad environmental focus which includes articles in the biological, agricultural and geographical sciences. Evidently, the study of Karoo environments, their biology, their dynamics and how they are used and have changed over time is where the largest research effort has been expended.

Given our selection criteria, the disciplinary emphasis should be interpreted with some caution. Many non-environmental disciplines are not fully represented in the database. This is not only because of the database (Web of Science) and list of keywords used in the initial search, but also because of the additional criteria for inclusion that were applied to the initial selection. Several journals in the human sciences, for example, do not require abstracts with their articles and were excluded. So too were several articles in the geological and palaeoecological sciences which consider deposits and features over regions far larger than our more narrowly defined Karoo study area. Despite these shortcomings, the list of journal articles examined here is revealing of broad trends, both in terms of the increase in overall output and the relative distribution of disciplines.

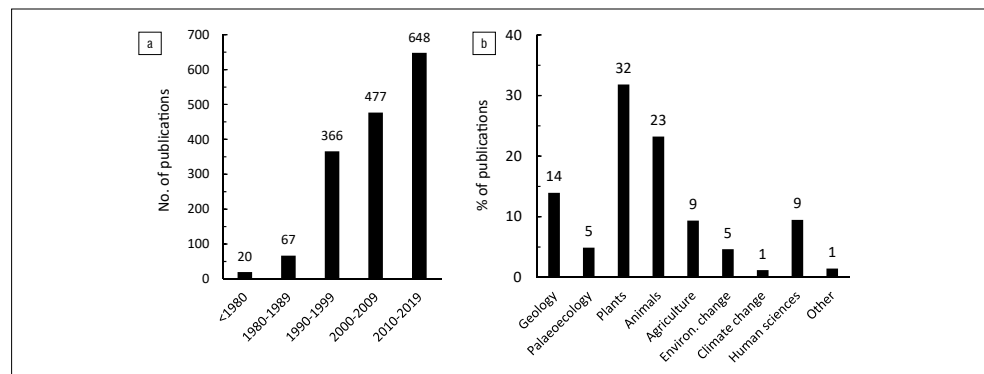


Figure 1: (a) The number of articles (N=1578) concerned with Karoo research and which are listed in the Web of Science for the period 1946–2019. (b) The percentage of publications on the Karoo according to their main disciplinary focus.

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Integration: Noteworthy syntheses of Karoo research

The bibliographic analysis highlights the progress that has been made in Karoo studies in specific research disciplines. What effort has been made to synthesise these findings and to integrate knowledge across disciplinary divides? To answer this question, we drew on our own scholarly engagement with Karoo studies spanning several decades.

Two edited book collections (neither of which was captured in our database) and three special issues of peer-reviewed journals have attempted this since 1999, albeit at somewhat different levels of disciplinary integration. The first comprehensive book on Karoo ecology³ built on the research that had emanated from the KBP. The focus was primarily on a synthesis of what was known about the natural environment at the time. It comprised 20 chapters concerned with the physical environment, the biogeography of the biota as well as the form and function of key plant and animal groups. Chapters on ecological dynamics and the impact of people on the environment were also included. It remains the most important synthesis of the ecology of the entire region to date and several chapters have been cited over 100 times.

The 15 papers in the special issue of *Plant Ecology*, also published in 1999, took Karoo ecological research in a relatively new direction, into the Namaqualand, Richtersveld and Knersvlakte areas of the Greater Cape Floristic Region for the first time.⁴ The emphasis was on the diversity, biogeography, physiology and conservation of the flora of the Succulent Karoo biome in relation to key environmental gradients. The impact of grazing and long-term changes in vegetation in response to climate and drought were also included. This was the largest single collection of peer-reviewed ecological research to cover this internationally recognised biodiversity hotspot. It laid the foundation for the subsequent explosion of interest in the region's conservation.

These two syntheses were followed in 2007 by another collection of articles dedicated to the winter rainfall Namaqualand region, published in a special issue of the *Journal of Arid Environments*.⁵ Its focus, however, was less on the extraordinary biodiversity of the region and more on pressing management and social issues such as land reform and the contribution of agriculture, remittances and state grants to household livelihoods. The 20 papers in this special issue reflected a relatively new multidisciplinary focus for Karoo studies, with the history, ecology, and sociology of the communal areas in Namaqualand addressed in a single volume for the first time.

One of the longest-running research programmes in the Karoo is BIOTA (Biodiversity Monitoring Transect Analysis) Southern Africa. This initiative was supported by the German Federal Ministry of Education and Research (BMBF) over the period 2000–2010. Its primary focus was on the assessment and monitoring of biodiversity at 37 observatories along a 2000-km transect in South Africa and Namibia. A synthesis of the many outputs of this project by German and southern African scientists is contained in a three-volume set of books, which is freely available online.⁶ Measurements at some of the observatories have extended beyond the lifespan of the project to provide valuable insights into long-term changes in plant diversity, especially in response to unusual events such as major droughts.⁷

The need for greater integration of the natural and social sciences has become a regular call in Karoo studies. The most recent synthesis of Karoo research⁸ provides the clearest effort to date to understand the region's complex social-ecological systems more holistically. The 22 papers in the special issue of the *African Journal of Range and Forage Science* cover both the Nama-Karoo and Succulent Karoo biomes. Although the natural sciences still dominate, there is a notable presence of the human sciences, with nearly a quarter of the articles drawn from history, archaeology, sociology and anthropology.

Gaps and threats

One important research gap identified through our bibliographic analysis concerns the impact of climate change. Only 20 articles in our database

are on this theme, nearly all of which address either changes in climate directly (50%) or the potential impact of future climate change on vegetation (40%). The potential impact of climate change on animals and agriculture is very poorly represented, with only one article listed for each, while broader social impacts are not covered at all. These are critical gaps given the cross-cutting impacts that have been projected for the arid parts of southern Africa as a result of climate change.⁹

Many researchers have also yet to fully appreciate the magnitude of the land-use changes in the Karoo over the last few decades and the need to adjust their research foci accordingly. For example, while commercial agriculture still dominates the landscape, livestock production has declined significantly since the early 1980s. Farm sizes have also increased, and wildlife farming has become more prominent. Relatively little is known about the full extent of such changes and their intersecting social and ecological impacts. The Karoo has also become a major location for the installation of wind and solar energy developments, with some 4% of the combined area of both biomes designated for renewable energy installations.¹⁰ Concerns have been raised about the potentially harmful consequences for biodiversity¹¹; their significance for South Africa's energy mix and local social impacts are just beginning to be studied.

Another set of pressures on the Karoo concerns the mining industry's interest in heavy metals and uranium extraction, as well as the targeting of the Nama-Karoo by the fracking industry as a potential source of shale gas. The two main syntheses which address concerns over fracking^{12,13} highlight the paucity of information about the likely impacts of this industry on Karoo hydrology and environments. The effect of habitat fragmentation and noise, light and dust pollution created by the preparation and establishment of fracking sites is likely to be extremely consequential for the biota of the Karoo, while the local jobs created are expected to be largely unskilled and short term. Unfortunately, little of the published literature on the Karoo is helpful when trying to predict the impact of such large-scale disturbances on the environment; these developments present unique pressures which demand new studies.

The wide-open spaces and relatively unpolluted skies of the Karoo have also caught the attention of astronomers. The Southern African Large Telescope opened outside Sutherland in 2005 while the world's largest radio telescope, the Square Kilometre Array (SKA), is being constructed near Carnarvon. The environmental impacts are likely to be broadly positive, with the establishment of a national park around the SKA adding considerably to the area under conservation protection in the Nama-Karoo. However, assessing the impact on local social and economic dynamics of the regulatory controls associated especially with radio astronomy is a more complex undertaking.¹⁴

Final thoughts

There has been an increasing flow of research outputs for the Karoo since 1986. While the interest has been primarily within the environmental sciences, a greater emphasis on the human sciences and interdisciplinary studies is becoming evident. However, much research underestimates the extent to which and significance of how land-use changes have reconstituted the Karoo's social and ecological environments. In this context, knowledge about rangeland ecology and the impact of domestic livestock has relatively limited reach. The new research questions that are emerging also underscore the need for more inter- and cross-disciplinary collaboration.

Even though the Karoo appears peripheral to the major centres of power, it is an historically and ecologically important region that features increasingly prominently in national development plans. Greater investment in Karoo research is urgently needed to advance our understanding and inform policy debates. To be effective, such research needs better coordination and stronger support by stakeholders across the disciplines.

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Competing interests

We declare that there are no competing interests.

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