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The importance of natural science collections in South Africa

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Our ability to understand the natural world depends on the collection, preservation, and study of natural history specimens. These natural science collections are the physical record of earth's biological diversity. As a megadiverse country, it is essential that South Africa documents not only its aboveground diversity but also its below-ground richness.

Ecosystem functionality is equivalent to biodiversity. This is particularly evident in the soil environment, and Pimentel et al.[1] estimated the global economic benefits of soil diversity at USD1.5 trillion. Soils provide a high number of ecosystem services due to the complex communities of organisms living there. These biota contribute to nutrient cycling, waste decomposition, soil formation and water regime control[2], and the majority of these organisms are still unknown. These interactions were also highlighted by Louw et al.[3] in a South African context, and led to the establishment of the South African Soil Ecology Group in 2011, and a subsequent publication by Janion-Scheepers et al.[4] highlighting the gaps in knowledge regarding soil biota in South Africa.

It is thus essential to establish a platform that encompasses all biodiversity, from a micro- to macroscale, and not only a fragment of it.[5,6] Having a publicly accessible platform for different research sectors to submit and compare taxonomic data of specimens will go far in establishing this inclusivity. Natural history collections and herbaria provide such a platform in South Africa under the umbrella of the Natural Science Collections Facility (NSCF). With the establishment of the NSCF, over 30 million preserved plant, animal, fungal and fossil specimens from more than 40 institutes across the country have been integrated under a single coordinating hub.

A fundamental role of natural history collections and herbaria involves safeguarding type specimens. These are preserved specimens of the individuals that were used to describe and name a species. As well as these, every natural history specimen with good data provides a physical snapshot of a species or community at a particular point in time and space. It is this physical scientific record that makes collections so valuable. The specimens play a vital role in our understanding of biodiversity, evolution, population genetics and the environmental impacts of climate change and pesticide use. This is because historical collections provide baseline data against which modern observations can be compared and from which various mathematical models can be produced. These observations and models can inform the vast majority of our agricultural production, essential ecosystem services for rural communities and agro-ecology systems. In turn, these benefits will support agricultural productivity, improved conservation planning, management of global climate change and maintenance of ecosystem services as demonstrated internationally.[7] All this is only possible if there are records to consult on the pathogens, pest and beneficial species.

Furthermore, the baseline ecosystem data that are documented in collections support the enhancement of dryland agricultural resilience through the improved assessment of climate change scenarios, and identification of research gaps and information systems, amongst others.[8] For example, the first high-throughput sequencing study on soil diversity was published in 2006[9], while the impact of such technologies has led to the discovery and description of a much larger below-ground diversity than was originally expected. The majority of soil organisms is still unknown and it has been estimated that the currently described fauna of Nematoda and Acari represents only 5% of the total number of species that actually exist.[10] Thus the need for collections in documenting and preserving the known and newly discovered biodiversity is vital.

Collections also provide a public platform for decision-making in fields such as quarantine and diagnostic services. The identifications based on specimens catalogued in these collections, and the taxonomic skills associated with collections that scientists provide, are clearly evident from the hundreds of specimen identifications done by NSCF partner institutions over the past 3 years. These identifications are either based on morphological characteristics or Sanger sequence data. This service also supports biosecurity agencies in making decisions about imports and exports, such as whether to authorise, or to request, quarantine, or recommend another treatment of horticultural products, which impacts on food security and the economy. A study by Van den Hoogen et al.[11] includes data based on specimen holdings in the National Collection of Nematodes and has contributed to high-resolution models serving as first steps towards representing soil ecological processes in global biogeochemical models, thus supporting the prediction of elemental cycling under current and future climate scenarios.

Furthermore, the information presented in the national collections assists in identifying taxa that have the potential to be commercially adapted under the regulations of the *National Environmental Management: Biodiversity Act, 2004*. There is already a successful drive by the National Collection of Fungi to support the development of biocontrol agents based on its specimen holdings, with one commercial product already on the market both locally and internationally. The specimens and associated data in the collections can also reduce the monetary losses incurred by South Africa due to unscrupulous bioprospecting and the development of products without proper permits and intellectual property protection.

Data and specimens in national natural history collections and herbaria contribute to spatial planning and decision-making for development. Examples of these include the plan developed with the South African National Biodiversity Institute's Threatened Species Programme for assessing the threat status of biota in areas with ecologically or economically important biodiversity. Other assessments included the National Biodiversity Assessment, and the Department of Environmental Affairs' land-use decision-making tool. These are used by conservation authorities and the national Departments to make decisions on development applications (e.g. infrastructure such as mining, housing, roads). Promotion of specimen data sets amongst national and provincial conservation

authorities, municipalities and consultants for use in impact assessments and decision-making in development applications is another product of data sets based on catalogued specimens in natural history collections and herbaria.

In conclusion, it should also be emphasised that collections of objects often serve us in ways that could not have been imagined at the time at which they were created. Sometimes these unanticipated uses can help solve today's most pressing scientific problems. Likewise, in years, or even decades from now, new analytical techniques will allow researchers to use the same specimens to answer new questions. There are countless examples of 'new' specimens being 'discovered' in collections and recognised as scientifically important long after their original acquisition.

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