

PERSPECTIVE ARTICLE

The plant checklist: Building the foundation of botanical knowledge in South Africa

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Abstract Taxonomic research and resultant checklists play a crucial role in underpinning all biodiversity research. Compiling an inventory of plants that occur in a region or country is a complicated task that can be subject to errors and incompleteness, which in turn can hinder other fields of botanical research. South Africa has put in place a rigorous and defensible method of compiling and updating a national checklist, which can serve as a guide to any country in the process of doing so. The process of creating the checklist and significance of this is presented, and the governance, including the choice of classification followed and use of common names, is discussed. Methods for compilation and dissemination of the checklist are described.

Keywords checklist; conservation; flora; South Africa

INTRODUCTION

The invaluable work of plant taxonomists holds a unique and crucial role in the realm of biodiversity research and conservation, both in South Africa and on a global scale. The South African National Plant Checklist (hereafter the “Checklist”), comprising over 23,000 taxa, has been developed and maintained by the South African National Biodiversity Institute (SANBI) as part of its mandate to coordinate taxonomy in South Africa. The immense feat of providing an accurate and up to date checklist for a rich flora requires an organised system with adherence to procedures and protocols in an understandable and transparent manner so that decisions are objective, scientific, and justifiable, and ultimately, provide a meaningful product for end-users. Here we aim to expand on the *Best practice guide for compiling, maintaining and disseminating national species checklists* (Hamer & al., 2012) by outlining the history of the development of the Checklist by experts in South Africa and convey the lessons learned in the process, which can be used to guide other countries in producing a useful, comprehensive and scientifically rigorous product.

The Checklist is the cornerstone of research on the country’s flora, and evolves through ongoing foundational taxonomic research. In South Africa, botanical research in taxonomy is guided by the *Research plan for plant taxonomy 2020–2030* (Victor, 2021). This strategic framework encompasses a set of objectives and programmes designed to bridge

gaps in biodiversity science by discerning and elucidating the boundaries that define taxa. By doing so, it ensures the accurate classification of plants while seamlessly linking the names to pivotal initiatives like the International Union for Conservation of Nature Red List of Threatened Species (IUCN Red List), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), online Floras including the e-Flora of South Africa (hereafter the “e-Flora”) and World Flora Online (WFO), the Important Plant Areas programme in the United Kingdom and analogous Listed Ecosystems in South Africa. Access to the information required for various projects flows from primary biodiversity data that is gleaned from herbarium specimens, and the resultant taxonomic publications based on these. For South African plants, the link between names given to specimens and their evolving applications is dynamically managed within the taxonomic core of SANBI’s botanical database, the Botanical Database of Southern Africa (BODATSA). The Checklist along with information about each species is subsequently disseminated through the SANBI Biodiversity Advisor website.

HISTORY OF PLANT CHECKLISTS IN SOUTH AFRICA

The first electronic database of names of southern African plants and related specimens was developed at the National

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Herbarium in Pretoria (PRE). This PRE Computerised Information System (PRECIS; Gibbs Russell & Arnold, 1989), running on bespoke software initially based on Burroughs DMS and later Interbase and MySQL (the latter for the stand-alone PC-version), was created in the 1970s. The accuracy and completeness of this database enabled publication of the first plant catalogue for the Flora of Southern Africa (FSA) region, which includes South Africa, Botswana, Eswatini, Lesotho, and Namibia (Gibbs Russell & Staff of the National Herbarium, 1984). This checklist comprised 24,030 plant taxa (including species and infraspecific taxa) and was soon followed by a second, updated edition in two volumes (Gibbs Russell & al., 1985, 1987). The next major output from the database was *Plants of southern Africa: Names and distribution* (Arnold & De Wet, 1993), which expanded on the previous publications to also provide synonyms and distributions for 22,211 plant species (24,503 taxa). Subsequent checklists have been published in book format (Germishuizen & Meyer, 2003; Germishuizen & al., 2006) with occasional updates in the journal *Bothalia* between 1988 and 1991. In 2013, SANBI adopted the Botanical Research and Herbarium Management System (BRAHMS) software (developed by the BRAHMS project, which is managed by the Oxford University Innovation), and the PRECIS data was migrated to this platform to become the BODATSA database. There are currently 23,046 plant species (25,227 taxa) catalogued in BODATSA for the FSA region, of which 21,500 species (23,518 taxa) occur in South Africa (Klopper & Winter, 2023).

Collaboration among SANBI and external taxonomists is integral in compiling taxonomic information for plant checklists. The online availability of the Checklist (see <https://biodiversityadvisor.sanbi.org/>; with an annual release in spreadsheet format available at <http://opus.sanbi.org/handle/20.500.12143/6880>) since 2006 marks a significant milestone. The catalogue of known taxa in South Africa has expanded considerably over time. This is attributed not only to the continuous incorporation of published literature, primarily revisions and Floras, but also to discoveries of novel plant species and established populations of alien species through botanical exploration. The processes of compiling names and refining distributions are ongoing pursuits.

■ THE SIGNIFICANCE OF CHECKLISTS AND FUNDAMENTAL TAXONOMIC INFORMATION

The aim of a checklist is to consolidate taxonomic information and provide the accepted, standardised, scientific names for all plants representing the flora of the country in a transparent manner. This not only includes adding newly described indigenous or newly recorded naturalised taxa to the list, but perhaps more importantly provides a system for managing all changes that are published regarding our taxonomic knowledge. The Checklist covers the

embryophytes only, i.e., bryophytes (hornworts, liverworts, mosses) and vascular plants (ferns, lycophytes, gymnosperms, flowering plants) (One Thousand Plant Transcriptomes Initiative, 2019). The Checklist is considered to be complete and up to date, although dynamic, as taxonomic changes and new species descriptions are continuously taking place.

Specimens correctly identified, meticulously catalogued, and prudently curated within herbaria form an intricate mosaic depicting species composition across geographical landscapes over time. Within the domain of taxonomic research, herbarium collections serve multifaceted roles, directly or indirectly capturing the dynamics of biodiversity transformation. Specialists within herbaria collaborate with counterparts and experts from other institutions, to collectively build an expansive institutional knowledge repository. This serves as a bedrock of information supporting other fields of research such as climate change research, phytochemistry, phytopathology, ethnobotany, and distribution range dynamics for analysing the spread of alien species (Heberling & al., 2019), or population trends for conservation analyses.

Data generated by taxonomists and herbarium collections has a particularly important use in conservation. Legislation often prioritises charismatic, highly visible, well-known or utilised taxa. While species of conservation importance are individually protected by law in South Africa, additional legislation is needed to protect their habitats. For the country to achieve its biodiversity conservation goals (e.g., relevant targets of the Convention of Biological Diversity Global Strategy for Plant Conservation [<https://www.cbd.int/gspc/>] and the new Kunming-Montreal Global Biodiversity Framework [<https://www.cbd.int/doc/c/e6d3/cd1d/daf663719a03902a9b116c34/cop-15-l-25-en.pdf>]), it is necessary to conserve representative components and processes of biodiversity, particularly those outside formal protected areas in South Africa. Globally, the Important Plant Areas project (<https://www.plantlife.org.uk/protecting-plants-fungi/important-plant-areas>; <http://biodiversityadvisor-dev.sanbi.org/planning-and-assessment/plant-conservation-strategy/target-5/>) was initiated to conserve areas of exceptional botanical richness or supporting an outstanding assemblage of rare, threatened or endemic plant species. In South Africa, threatened terrestrial ecosystems have been identified and catalogued in the Red List of Ecosystems 2022 (<https://bgis.sanbi.org/Projects/Detail/1233>). These ecosystems are categorised according to their threat status, which is determined by factors such as the amount of untransformed habitat remaining in each unit, their diversity, and their numbers of endemic or threatened species. These key attributes of listed ecosystems are ultimately derived from the data generated by taxonomists.

Developing a country list of naturalised plants depends on a pool of available names in the national checklist and on the submission of new country records to the national checklist. Only when such a reference is in place can herbarium collections be searched systematically for changes in introduction status. It further provides a key to knowing what

plants to search for in the field when monitoring introduced species.

■ GOVERNANCE OF THE CHECKLIST

Nomenclatural practice is governed by the *International Code for Nomenclature for algae, fungi, and plants (ICN)* (Turland & al., 2018). It is critical that the Checklist is objectively compiled in a standardised manner, and therefore the policy and procedures that govern the compilation and updating of the Checklist are documented. Contributors and users are thus able to understand the rationale for the incorporation of taxonomic changes.

The Checklist for South African plants is compiled by two coordinators at SANBI, with expert input from in-house and external taxonomists. The coordinators regularly search journal indexes for publications that need to be incorporated into the Checklist. They also receive requests to add newly described species or new country records to the Checklist or to update the Checklist following a recently published revision of a group. Often this is not a straightforward task, considering that different “correct” classification systems can be applied to one set of taxa, especially at genus level. Although species concepts are mostly stable (Govaerts & al., 2021), there is frequently disagreement amongst users regarding placement of species in one genus or another. The South African National Plant Checklist Policy and procedures (available at <http://hdl.handle.net/20.500.12143/6880>) ensure consistency and credibility in decision-making relating to the Checklist. According to the Checklist Policy, all names which are validly published (according to the *ICN*) are added to the Checklist. Therefore only published changes are incorporated, and the latest evidence-based, published treatment for each taxon is followed, unless there is a formal, motivated objection submitted to the committee via its Chair (Dr. Ronell R. Klopper, SANBI, r.klopper@sanbi.org.za) following the guidelines as set out in the Checklist Policy (see Fig. 1 for a flow diagram explaining the governance and processes involved in updating the Checklist).

In 2014 the South African National Plant Checklist Committee was formed, comprising taxonomists from SANBI and various South African universities. The primary objective of this committee is to assist the Checklist Coordinators by ensuring consistent updating of the Checklist in alignment with the policy, and to facilitate decision-making on contentious classification matters. An example was an objection to the expanded circumscription of *Ceropegia* to include multiple former genera of the tribe Ceropegieae (Apocynaceae, Asclepiadoideae) (see Bruyns & al., 2017). There has been strong objection to subsuming the many morphologically diverse genera into one genus, with some arguing that a paraphyletic approach is acceptable, while others argue that using more DNA regions could provide a different answer, and that alternative interpretations of the phylogenetic tree could result in creation of more genera. Subsequent to the publication by

Bruyns & al. (2017), Endress & al. (2018) followed a paraphyletic approach in recognising multiple genera as opposed to a single genus. The decision remains controversial but with a lack of concrete molecular evidence to support the alternative classification, the Committee made the decision to follow the latest publication according to the rules of the Checklist Policy. It was acknowledged that future publication of an alternative classification could lead to reverting to a multi-genus classification.

The Checklist Committee also reviews and comments on formal proposals to conserve or reject plant names (as published in the journal *Taxon*), particularly those pertinent to the South African flora. This process serves to represent the South African viewpoint within the Nomenclature Committee for Vascular Plants. Notably, the current Chair of the Checklist Committee is a member of this committee, ensuring effective communication from the South African perspective.

Users of plant names, e.g., in status reports on alien plants and their management, are encouraged to restrict the names they use to what is in the national checklist or propose addition of names that should be on the list.

■ CHOOSING THE FAMILY CLASSIFICATION SYSTEM

In South Africa, a consultative process was followed to choose a family classification system that was appropriate for the flora of the region. While the importance of following the latest publication is recognised, it was decided that in South Africa a modified classification system is more suitable for recognition of the smaller plant families, which are easily separated at a local scale.

A single higher-level classification system is used for each different phylum. The classifications that are followed for gymnosperms (Yang & al., 2022), lycophytes and pteridophytes (Pteridophyte Phylogeny Group I, 2016), and hornworts, liverworts, and mosses (<https://www.bryonames.org/>), are fully adhered to. However, the system currently followed for the angiosperms is a modified system based on the Angiosperm Phylogeny Group (APG) II (Angiosperm Phylogeny Group, 2003) classification. In the South African Family and Genus Classification System (available in spreadsheet format at <http://hdl.handle.net/20.500.12143/6880>) the so-called “bracketed families” of APG II are recognised, and all newly described families and family divisions as in APG III (Angiosperm Phylogeny Group, 2009) and APG IV (Angiosperm Phylogeny Group, 2016) are accepted. However, the post-APG II family amalgamations are not accepted. For example Agavaceae, Asparagaceae, Ruscaceae, and Hyacinthaceae are recognised as separate families and not all included under a broadly circumscribed Asparagaceae as in APG III and APG IV. The reason for following this approach is that it makes more sense from a southern African perspective to recognise smaller, more narrowly defined family groups, rather than the often large and widely circumscribed

families of APG III and IV. Many of the contentious “bracketed families” of APG II and later amalgamations have their centres of diversity in southern African and the classification followed in the Checklist is therefore better suited for our flora.

While we ultimately aim for an international consensus classification (see below), it is important, until that is a reality, to at least use the same classifications at a national level.

■ PRINCIPLES OF COMMON NAMES

A common, or vernacular, name is given to an organism by local people, in the language used in the region. The vernacular names of a particular plant can vary from one area to another and even between different countries, with the same

name sometimes being used for different plant species. The prevalence of vernacular names for a given species increases with its wider distribution and commonness across various regions. Conversely, plants that lack prominence or economic significance often remain devoid of vernacular designations. Over time, vernacular names applied to different plants can change and fall into disuse. Standardisation of vernacular names is therefore complex and dynamic, and there is no universally accepted convention governing their spelling and format. At SANBI, the following principles have been applied for curation and dissemination of common names in the Checklist and e-Flora:

1. SANBI will not formally standardise common names, but will record and database existing names linked to the scientific names in the Checklist.

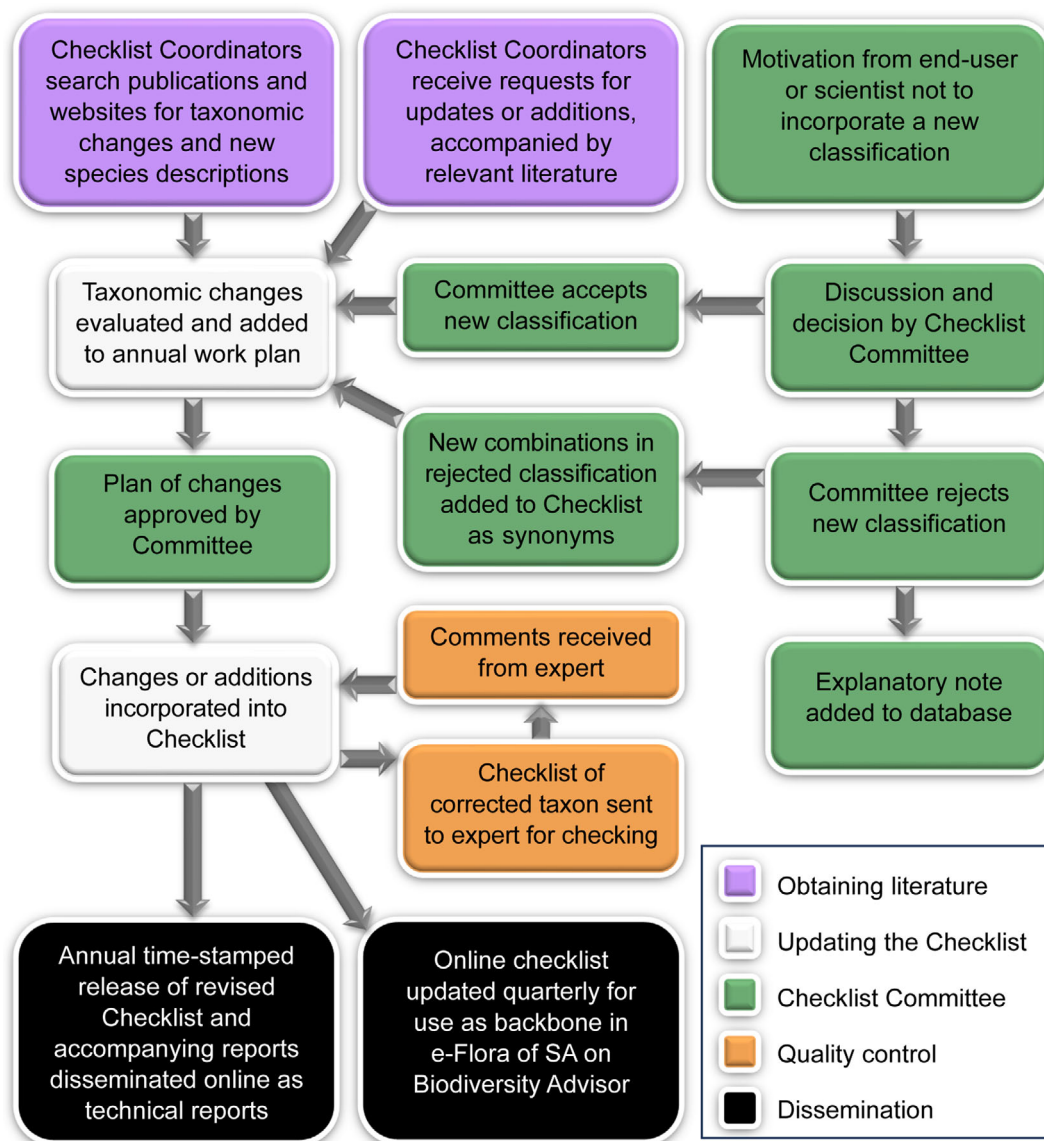


Fig. 1. Flow diagram illustrating the governance of the Checklist and the steps involved in updating and curating the Checklist. The different processes involved in maintaining the Checklist are summarised, namely obtaining literature that needs to be incorporated, updating the checklist, the involvement of the Checklist Committee, quality control, and dissemination.

2. Only South African common names are compiled, as opposed to names used elsewhere in the world for South African plants.
3. Only common names available in the literature (including unpublished sources), and recorded on herbarium specimen labels, are included in the database. These names are linked to the source in the database. No common names will be made up for taxa without a common name.
4. The spelling, as it appears in the literature or on the specimen label, is used verbatim, without corrections or alterations. Thus there could be a number of variations for each name.
5. Vernacular names containing obviously politically incorrect or derogatory words offensive to certain racial or religious groups, will not be incorporated into the database, nor disseminated via online resources. Such names that are already in the database are flagged so that they do not appear in any extracts or online sources. Where a decision needs to be taken as to whether or not a name is offensive due to unintended derogatory associations, it is referred to a specialist for decision.

Common names are documented in BODATSA, and disseminated online as part of the e-Flora project.

■ DISSEMINATION OF THE CHECKLIST AND ASSOCIATED DATA

The Checklist, along with summaries of changes and additions made to the taxonomic backbone, is published annually online (<http://hdl.handle.net/20.500.12143/6880>). The Checklist can be downloaded in spreadsheet format so that users can incorporate it into the taxonomic backbone in their own databases, or to do comparisons to update their taxon lists.

Information from the Checklist is integrated with the e-Flora, which harnesses existing floristic and other taxonomic data for all indigenous species, as well as with data from specimens in SANBI herbaria, and disseminated online through SANBI's Biodiversity Advisor (<https://biodiversityadvisor.sanbi.org/>). The Biodiversity Advisor website therefore offers comprehensive supplementary information for each taxon, including descriptions for each species, distribution details, and associated literature.

Datasets from the Checklist and the e-Flora are contributed to the WFO (<http://www.worldfloraonline.org/>). Due to the high level of endemism in South Africa (57%), the Checklist and e-Flora play critical roles in the global context by making unique contributions towards both the WFO Plant List (the taxonomic backbone) and WFO taxon pages.

Aligning the Checklist of South Africa with global taxonomic checklists is important for inter-operability and data sharing between information providers and users. Taxonomists worldwide are aiming to compile a consensus classification for all plants, to minimise the problems currently encountered with discrepancies between different lists. To this end, Taxonomic Expert Networks (TENs) have been

established by the WFO consortium (Borsch & al., 2020) to develop consensus classifications that can be used for the WFO taxonomic backbone, and potentially other projects and initiatives such as the IUCN Red List and CITES. In this way, a formally accepted classification is adopted, with TENs providing the information required for the groups (preferably at family level) that they curate. Where there is no TEN, the Checklist provides guidance for the taxonomic treatment of South African endemic taxa in the WFO backbone.

■ CONCLUSION

The objective of this overview of the development of the Checklist in South Africa was to shed light on the challenges involved in creating a country checklist that can equip users of taxonomic information with comprehensive insight to make informed decisions. This document also guides decisions in creating checklists and associated taxonomic databases, amplifying the potential for positive impact on taxonomic initiatives and the broader spectrum of biodiversity research and conservation. Compilation and maintenance of the Checklist is done in a transparent and standardised way, and the Checklist is made freely available online for the benefit of all end-users. Through the Checklist taxonomists, as well as users of taxonomic and occurrence data, can keep track of the current names and identities of all plant species in South Africa, tracing their changing names through historical records in the database and ensuring the accuracy of all plant-based programmes. The Checklist enables users to obtain the latest accurate information about, for example, the number of plant species in South Africa, their residence status, and degree of endemism. Taxonomists, and the work they do in collections, are responsible for the scientific content of the database and its taxonomic backbone. Taxonomists conduct the research leading to updating of taxon names, and ensure changes are implemented to allow ongoing continuity and consistency in associated collections, databases, Red Lists, and vegetation maps. Taxonomic research resulting in comprehensive checklists are well positioned to provide critical information to assist conservation managers in their response to biodiversity change and is thus an invaluable global resource for the flora of a country.

■ AUTHOR CONTRIBUTIONS

JEV and RRK formulated the concept for the manuscript, wrote the first draft, and amended the manuscript following review; PJDW and MMLR contributed additional text to the manuscript.

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