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The 2030 Declaration on Scientific Plant and Fungal Collecting

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Summary: Almost all life depends on plants and fungi, making knowledge of their diversity and distribution – primarily derived from biological collections – fundamental to national and international conservation, restoration and sustainable use commitments. However, it is estimated that some 15% of all plant species and over 90% of all fungal species have not yet been scientifically described, hampering our ability to assess and demonstrate the impact of efforts to halt biodiversity loss. In addition, organisations and researchers around the world lack a concerted strategy for increasing complementarity and avoiding overlap in botanical and mycological research, particularly in relation to the collection of specimens. We here present a declaration summarising a commitment towards such a necessary strategy. Components for this declaration were identified from discussions during and after a series of four workshops and plenary discussions at the 2023 State of the World's Plants and Fungi symposium convened by the Royal Botanic Gardens, Kew, and were then consolidated into the present form by the authors. The declaration was subsequently opened up for endorsement by co-signatories. Collectively, we agree on a set of five commitments for cataloguing the world's flora and funga, designed to maximise efficiency, facilitate knowledge exchange and promote equitable collaborations: 1) Use evidence-based collection strategies; 2) Strengthen local capacity; 3) Collaborate across taxa and disciplines; 4) Collect for the future; and 5) Share the benefits. This declaration is a first step towards increased global and regional coordination of scientific collecting efforts.

Keywords: Biodiversity mapping; Biological collections; Conservation; Equity; Fungi; Kunming-Montreal Global Biodiversity Framework; Plants; Training.

Societal Impact Statement: Biological samples, such as living and dried plant and fungal specimens and their associated metadata, are essential for helping scientists to inform policymakers and governments on the identity, number and geographic distribution of species, so that biodiversity can be appropriately protected and sustainably used. Yet, considering the sizeable task of documenting and characterising the vast numbers of as-yet-unknown plant and fungal species, greater international coordination for biological collecting and recording is necessary. In addition, much of the progress made thus far in cataloguing life on Earth has been achieved through inequitable collection practices, or the absence of adequate standards, which future efforts need to address. Here, we propose five commitments to accelerate and enhance what we know about plant and fungal diversity by focusing collecting activities in the regions and groups we know least about and ensuring that future collecting is more efficient and equitable.

Introduction

Knowledge of the diversity and distribution of plants and fungi is paramount to developing effective conservation and restoration aims, assessing the impact of climate and anthropogenic changes, and delivering the targets of the Kunming-Montreal Global Biodiversity Framework (Conference of the Parties to the CBD, 2022). This is recognised in the proposed set of complementary actions related to plant conservation (CBD Secretariat, 2023), representing an update of the original *Global Strategy for Plant Conservation 2011-2020* (Convention on Biological Diversity, 2012), to be adopted by the Parties to the Convention on Biological Diversity at COP 16. Although the targets of the Global Biodiversity Framework cover all biodiversity, including fungi, proposals to address fungal conservation concerns explicitly in overarching global strategies have not been successful so far. Our community intends to provide the impetus and evidence to allow this to be rectified in future initiatives.

To a large extent, the knowledge underpinning such policies and actions is derived from botanical and mycological reference collections – preserved plant and fungal specimens deposited in herbaria and fungaria, and living collections of plants (e.g., seeds, full-grown individuals) and fungi (e.g., culture collections). It is from those reference specimens – collected for various purposes and under different sampling methodologies, from taxonomic surveys to ecological studies – that new species can be scientifically described, with their associated data revealing occurrence patterns across space and time. Living and preserved physical specimens, particularly when digitised and DNA-sequenced, constitute an invaluable and irreplaceable resource for science, society and the environment (e.g., National Academies of Sciences, Engineering, and Medicine 2020; Bakker et al., 2020; Davis 2022; Johnson et al., 2023). Their value is enhanced by citizen science observations of species reported on iNaturalist (www.inaturalist.org), Mushroom Observer (https://mushroomobserver.org), or other communities (e.g., Haelewaters et al., 2024)), which can then be integrated with specimen data on platforms such as the Global Biodiversity Information Facility (www.gbif.org). Of particular value are those observations with identifications vetted by specialists (classified as 'research-grade' in iNaturalist, although reliable identification of many fungi and some plants may require detailed molecular or micro-morphological investigation). The broad, interdisciplinary utility of modern primary collections is becoming amplified through the creation of 'extended specimens', digitally interlinked products including some or all of physical specimens, digital photographs, ecological data, tissue samples, DNA sequences, phylogenies, species descriptions, functional traits, biotic interactions and conservation assessments (Schindel & Cook, 2018; Lendemer et al., 2019).

Despite their manifold uses and great importance, biological collections and the information they provide remain largely incomplete and spatially uneven (e.g., Meyer et al., 2016). It is estimated that some 15% of all plant species (Joppa et al., 2011) and over 90% of all fungal species (Niskanen et al., 2023) have not yet been scientifically described, hampering our ability to guide, assess and demonstrate the impact of efforts to halt biodiversity loss. Filling these gaps alone would require considerable time under a 'business as usual' scenario. This is particularly the case for fungi – describing all species would require some 750 to 1,000 years at the current rate of around 2,500 new species each year (Niskanen et al., 2023). Unfortunately, this is time we do not have when considering the rising threats to biodiversity. With three in four undescribed plant species threatened with extinction (Brown et al., 2023) and certain regions containing a high diversity of plant species with known human uses under no effective protection (Pironon et al., 2024), there is an overwhelming risk of our planet losing species (and their associated and dependent organisms; e.g., Hawksworth, 1998) before we even know about them or can explore their potential benefits to humanity (Antonelli et al., 2020). It is estimated that more than half of plant species remaining to be scientifically described are already present in biological collections (Bebber et al., 2010) and so filling the gaps requires both new collections and intensive study, digitisation and sharing of information in current accessions.

The challenge of scientifically describing all species on Earth (commonly referred to as the 'Linnean shortfall') is mirrored by another major challenge: that of ascertaining the full distribution of each species (the 'Wallacean shortfall'; Hortal et al. 2015). Addressing these shortfalls is critical for multiple reasons, such as inferring the climatic preferences and tolerance of species; developing effective conservation strategies *in situ* (such as inclusion in regional and national conservation targets, including the identification and protection of 30% of terrestrial, inland water, coastal and marine areas by 2030) and *ex situ* (such as through seed banking, culture collections of fungi and living plant collections); guiding the distribution of any benefits derived from bioprospecting activities back to the local and indigenous communities who have sovereignty over the species in their territories and are the effective stewards of their preservation; and providing essential scientific knowledge to support research in taxonomy, ecology, biogeography, evolution and biotechnology.

Understanding the diversity and distribution of species is also critical for mapping their potential threat status, an activity which suffers yet another major shortcoming – the recently proposed 'Scottian shortfall' (Haelewaters et al., 2024) – expressed as the difference between the number of described species and the number of species assigned a Red List category by the International Union for Conservation of Nature (IUCN) and partners. For instance, while 100% of all known bird species have been assessed for their threat status, this proportion is a mere 0.4% for fungi (Niskanen et al., 2023; IUCN, 2023), and so we are only just scratching the surface of understanding the threats they face and their risk of extinction (but see Mueller et al., 2022).

This declaration aspires to sow the seeds (and indeed, spores!) of transformative change to the status quo by proposing a level of international coordination, collaboration and benefit sharing not previously attempted across the world's biodiversity institutions. We focus on a relatively narrow activity – the collection of plant and fungal specimens and samples – to increase the chances of making a distinctive contribution.

Development of the Declaration

The 2030 Declaration on Scientific Plant and Fungal Collecting has its foundation in the *State of the World's Plants and Fungi 2023* report (Antonelli et al., 2023), with its associated underlying papers and international symposium. It has arisen from workshops and discussions involving some of the 228 in-person symposium delegates (Fig. 1), including scientists, students, educators, policymakers, and members of non-governmental organisations spread across 31 countries worldwide. While every effort was made to design and implement an inclusive, equitable and open process, we acknowledge inherent geographic biases and power imbalances (see our position statement below). The identification of just over 30 global plant diversity darkspots and areas of high fungal diversity presented in the report and associated papers (Ondo et al., 2023; Niskanen et al., 2023) highlighted areas of the world where digitally available plant and fungal specimen data are most likely to be lacking. Those analyses, set alongside a stark assessment of the threats facing undescribed species (Brown et al., 2023), provided the impetus to galvanise and better coordinate global collecting efforts. The primary aim was to join the botanical and mycological communities in a collaborative endeavour to produce recommendations for accelerating collecting activities, taxonomic work and training to fill important knowledge gaps.

Figure 1. On-site participants of the 2023 State of the World's Plants and Fungi symposium held at the Royal Botanic Gardens, Kew, in October 2023. The symposium also included online participants and was streamed on social media. Free online access, reduced fees for students and two bursaries for participants from low-income countries contributed to a diverse and international representation of backgrounds, career stages, professional affiliations and individual perspectives.

The process involved two focused workshops on the knowledge gaps and additional workshops on taxonomy training and financing, all held during the symposium from 11-13 October 2023. Participants contributed to the direction and substance of the discussions through direct questions and comments and through an online Mentimeter survey (www.mentimeter.com; Fig. 2). The paper was then drafted by a core team of botanists and mycologists before being opened up to all co-authors for feedback. Finally, the declaration was sent to a broader range of stakeholders to invite signatories to support the commitments (see Appendix 1, an online repository of signatories; Antonelli et al., 2024).

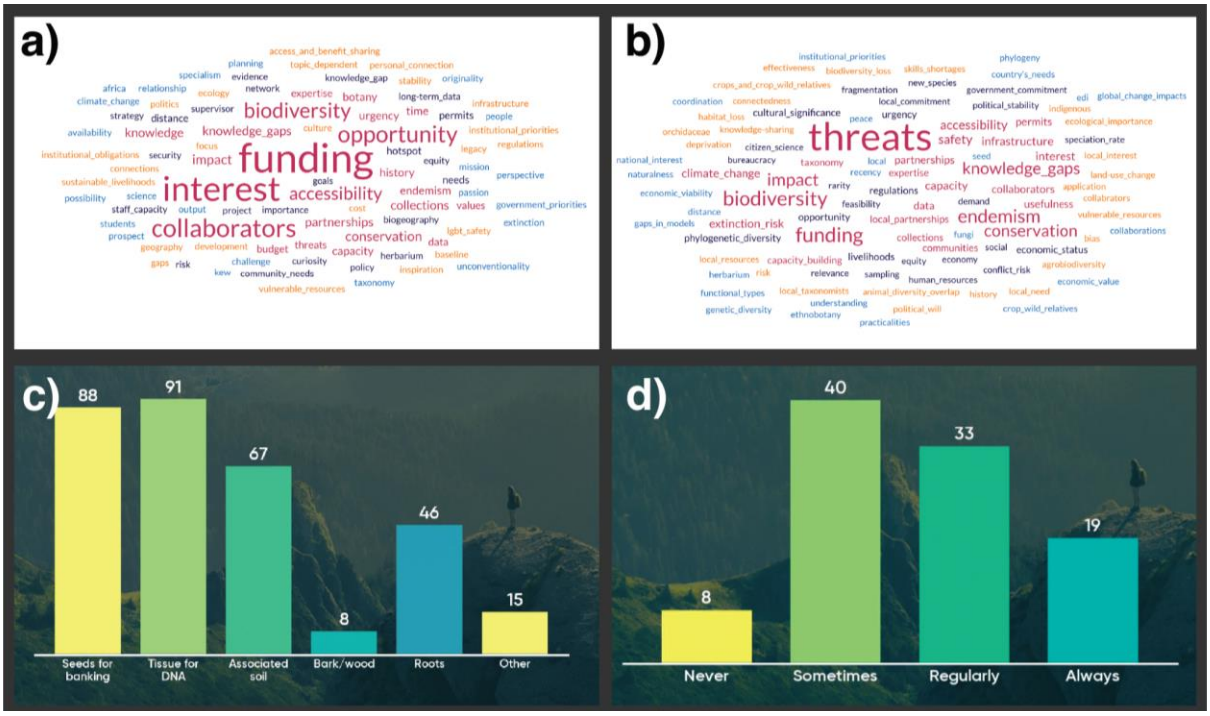

Figure 2. Selected results from the survey among participants of the 2023 State of the World's Plants and Fungi symposium held at the Royal Botanic Gardens, Kew, in October 2023. Results are shown for each of the following questions: a) *What is the biggest factor determining where you work?* (231 responses from 93 respondents); b) *What other factors should be considered when identifying priority areas for collecting and research?* (239 responses from 105 respondents); c) *In addition to traditional voucher specimens, what else should be collected?* (116 respondents); d) *Do you (or colleagues at your institution) collect additional material for DNA extraction?* (100 respondents). The word clouds in panels a-b were compiled using freewordcloudgenerator.com, with font size proportional to the word's frequency in the responses (note that variations were standardised [e.g., collaboration, collaborators], and responses were grouped into words that captured their intended meaning, where unambiguous).

Discussions at the symposium focused on the geographical knowledge gaps for plant diversity and on the lack of comprehensive data for the world's funga (Kuhar et al., 2018). While there are many data resources covering all regions and continents for plant diversity and distribution, leading to the darkspots map from Ondo et al. (in press, 2024) covering vascular plants, data on the very small percentage of known fungal diversity (<10%) are limited, but include global syntheses for soil fungi (Niskanen et al., 2023; Mikryukov et al*.,* 2023), airborne fungal spores from various environments (Ovaskainen et al., 2024), and marine fungi (Laiolo et al., 2024).

The scale of the task differs by orders of magnitude for the two groups. Joppa et al. (2011) estimated more than a decade ago that c. 15% of all flowering plant species remained to be described. If that proportion also applied to all vascular plants (current number c. 350,000; Govaerts et al., 2021, accessed in January 2024), this would mean there are approximately 52,500 undescribed species (dropping by >2,500 each year as new species are described; Antonelli et al., 2023). So, while for plants the number of unknown species is probably in the order of tens of thousands, for fungi it is likely to be in the order of millions – recently estimated at around 2.5 million, representing over 90% of the global estimated fungal richness (Niskanen et al., 2023). The less complete knowledge of fungi is due to their higher diversity, inconspicuous nature and the complexities of collecting and preserving voucher specimens, including fungi detected in various substrates but not recorded as spore-bearing structures (and vice versa: species known only from visible sporing bodies but whose DNA is not detected in the substrate). These factors are compounded by a lack of specialists, funding for mycological research, training opportunities, local reference collections, and facilities for culturing fungi and sequencing DNA, and by the absence of a global taxonomic strategy.

Plants are still largely identified on morphological grounds, due to the abundance of vegetative, flowering and fruiting characteristics and also partly because most species have not yet been sequenced, particularly those with narrow distributions (Rudbeck et al., 2022). In contrast DNA-based species identification is now standard practice for many groups of fungi, and, indeed, is the only viable method to detect species present only as mycelia in the soil and other substrates. Concerted efforts to sequence the genomes of type specimens in the world's fungaria would therefore be a critical step for accelerating species descriptions, increasing precision in the taxonomic assignment of environmental DNA (eDNA) samples and providing a framework to advance fungal conservation.

Priority regions for fungal and plant collection

Given the close relationships between plants and fungi, a collecting strategy based on knowledge gaps for plants is likely to also yield novel data for fungi. Although no joint analysis combining plants and fungi has been conducted to date to identify the regions most likely to yield new species to science and new distribution records for known species, a visual comparison between the darkspot analysis of Ondo et al. (2023) alongside a species richness map for soil fungi from Mikryukov et al. (2023) suggests that several regions will contribute novel insights for both taxonomic groups (Fig. 3). Large gaps in knowledge exist for both groups in tropical areas, while for fungi some temperate areas are also unusually diverse and in need of further exploration. For both groups, finer-scale analysis could reveal additional priority areas and regional subtleties. For example, fungi are more diverse than plants in extreme environments. Local knowledge, collaboration and consultation are essential for identifying collecting priorities and planning any collecting activities.

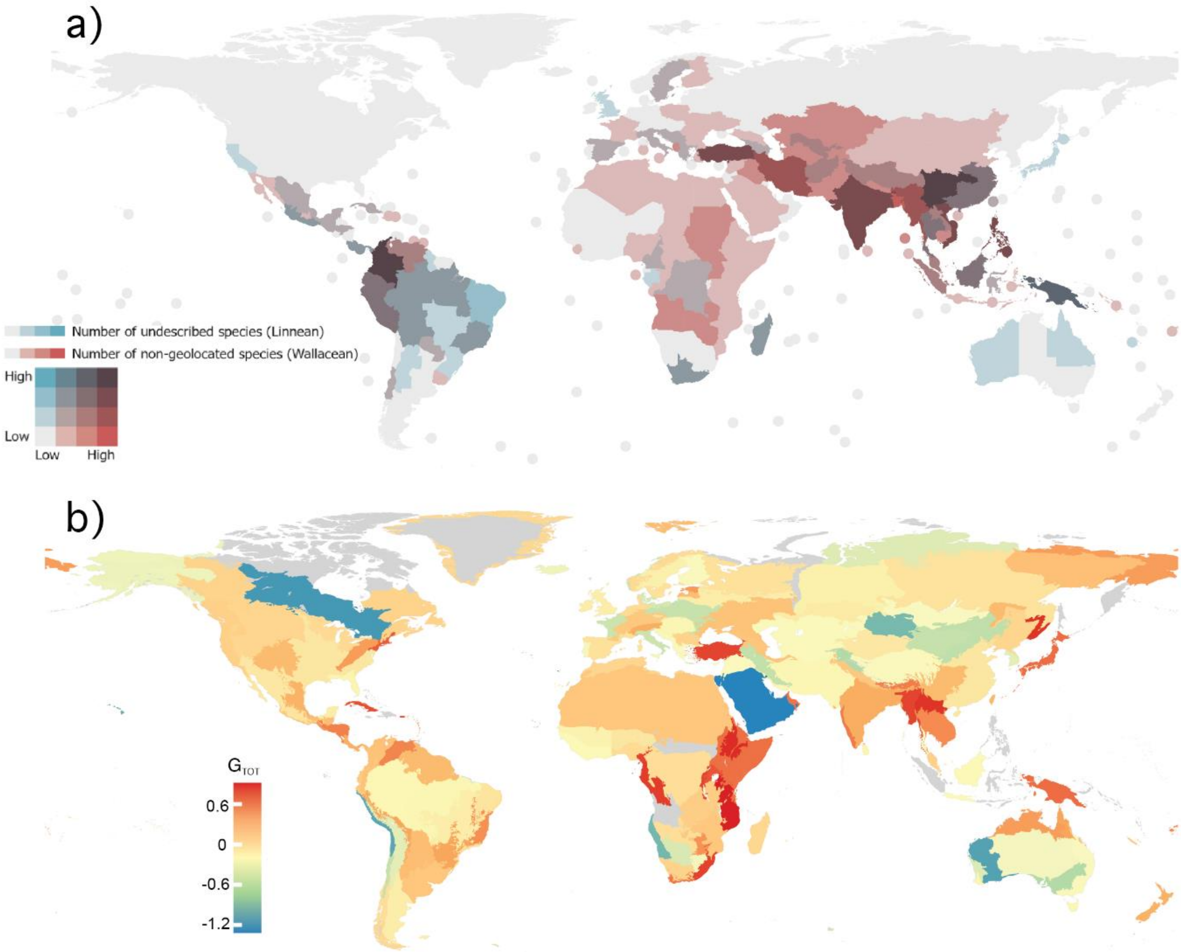

Figure 3. Where should we concentrate future collecting efforts for plants and fungi? Despite important limitations on data availability and completeness, current knowledge on the diversity and distribution of species provides valuable clues to which regions are most likely to yield novel scientific insights. **a)** Botanical countries coloured according to their expected contribution of new plant species to science and new records of previously known species (darkspot analysis from Ondo et al., 2023; map reproduced under CC-BY-NC-ND 4.0 International license with permission of the author). **b)** Total fungal richness (residuals of gamma diversity at the ecoregion scale) based on environmental DNA sequence data of soil fungi (from Mikryukov et al., 2023; Map reproduced under CC BY-NC 4.0 license with permission of the author). Zero indicates the observed gamma diversity matches what is expected for a fixed sampling effort. Values below zero suggest lower than expected diversity,

positive values indicate higher than expected diversity. Note that no similar darkspot analysis has been conducted to date and that other functional groups – such as lichenised and wood-inhabiting fungi – might show different patterns. See original publications for details on methodology and additional analyses and maps.

Five commitments

Against the urgency of the biodiversity crisis and the manifold benefits of increasing international collaboration on plant and fungal collecting, we identified a set of five principles which we considered appropriate to meeting our ambitions of change and synergy. As well as recommending them for consideration by the global scientific community, we – the authors of this publication and co-signatories listed in Appendix 1 – commit, on a voluntary and non-binding basis, to those principles. *In the years leading to 2030, we collectively agree to:*

1. USE EVIDENCE-BASED COLLECTION STRATEGIES

Historical accounts, our combined personal experiences and several studies indicate that botanical and mycological collecting and research have concentrated on particular regions of the world, at least partly because of non-biological aspects such as tradition, political regimes, economics, accessibility, and personal and institutional preferences or constraints, policies and partnerships (e.g. see Meyer et al., 2016; Zizka et al., 2021). Clearly, all countries and regions would benefit from more collections and further taxonomic research, to help meet the conservation goals set by the Kunming-Montreal Global Biodiversity Framework (Conference of the Parties to the CBD, 2022). However, optimising a rapid increase in overall global knowledge will require concentrating efforts on regions that would provide the best outcomes for filling plant and fungal data gaps. This includes those that are highly biologically diverse and insufficiently collected, and those with highest potential for hosting undescribed or highly threatened taxa. Candidate regions are, for example, plant diversity darkspots (Fig. 3a), which can be based purely on biological criteria or derived from the interplay between biological and socio-economic-political variables (see Ondo et al., in press).

For fungi, notable efforts and data initiatives have been undertaken, such as GlobalFungi (https://globalfungi.com), the Global Soil Mycobiome Consortium (https://gsmc-fungi.github.io) and the Society for the Protection of Underground Networks (www.spun.earth), particularly focused on soil fungi but with Global Fungi also covering litter, dead and living plant material, water, air, dust and more. We still lack similar data-driven prioritisation analyses at a global scale for all groups, although diversity maps now exist for particular functional groups (such as arbuscular mycorrhizal and ectomycorrhizal fungi; Mikryukov et al., 2023) and efforts are underway to increase sampling in areas of expected high mycorrhizal fungal diversity (e.g., https://www.spun.earth/maps). Collecting focus could also be on areas of high predicted dissimilarity, endemicity, vulnerability or ecosystem services (Fig. 3b, Niskanen et al., 2023; Fig. 3a, Mikryukov et al., 2023; for soil fungi). There are also in-depth initiatives at the national scale, such as a UK-Government-funded, long-term soil monitoring project that includes mycorrhizal fungi, which is being carried out in England as part of the terrestrial National Capital and Ecosystem Assessment programme (www.kew.org/science/tncea-mycorrhizas)

We recognise that real-world decisions on where to conduct research are complex and must consider imbalances and inequalities in scientific resourcing, local needs, national and international laws, safety concerns, access to electricity, internet and research facilities, and challenges for scientists in low-income countries to conduct research in their own countries and abroad, among others. The prioritisation of areas for the collection of plants and fungi should also be a dynamic and iterative process, to be constantly revised in light of novel data being made available through digitisation efforts and analytical tools, and it should avoid deepening systematic biases (Chapman et al., 2024). Moving forward, we will strive, where possible, to be primarily guided by evidence – data, analyses and knowledge – through iterative, inclusive, and reproducible processes.

In practice, this could mean that we – individually and organisationally – prioritise regions or taxa that we have not worked on before (with clarity on mutual expectations and timeframes for commitment) and potentially reduce biological collecting in regions or on taxa for which considerable data have already been produced, always fully engaging with local partners throughout the process and responding to their decisions, requests and sovereignty.

To enable those actions, further coordination of efforts will be needed following the work initiated in the 2023 State of the World's Plants and Fungi symposium and this Declaration. Additional modelling and ground-truthing work will be needed to increase spatial resolution within countries and regions already identified as top priorities for botanical and mycological sampling, including how collecting may best support national conservation priorities.

2. STRENGTHEN LOCAL CAPACITY

The uneven distribution of financial resources across the world has led to pronounced variation in the ability of individual nations to document their flora and funga. This is particularly problematic in high-biodiversity, low-income regions, where the ratio of taxonomists to species is low, financial resources to develop basic research are limited, access to printed and online literature can be difficult, and biological collections are smaller, less well-resourced and with a lesser degree of molecular characterisation than those hosted by large international organisations. However, local and national reference collections such as these can be even more important in the local context (see, e.g., Delves et al., 2024, Diazgranados et al., 2022; Ortiz-Moreno et al., 2022). Additionally, with the majority of undescribed plant species likely to be threatened with extinction (Brown et al., 2023), investing resources in the areas where these species are likely to be found will be essential to effective conservation. Greater local capacity can also support active monitoring and *in situ* study of very rare species for which collecting would potentially cause irreparable harm to the population. Whenever possible, we will strive to support professional development and research infrastructure in the regions in which we work, and, for international fieldwork, commit to depositing at least one set of duplicates for all specimens in the country of origin where there are established fungaria or herbaria.

In practice, this could mean developing and implementing equitable training opportunities adapted to local conditions and needs; promoting internships for students and staff across institutions for knowledge exchange; building or improving safe and functional biological collections; supporting digitisation and data integration efforts; supporting the development of field stations that are initiated, owned and managed by local researchers, or research offices hosted by local institutions; and providing support for the purchase of laboratory equipment such as microscopes, culturing facilities, and DNA extraction and analysis equipment and software.

To enable those activities, international and national partners should consider producing joint bids for funding from public, corporate and private sources; seeking the maintenance and longevity of such activities for the time that is necessary; and sharing good practices and experiences.

3. COLLABORATE ACROSS TAXA AND DISCIPLINES

There are several reasons why individual taxonomists, and sometimes organisations, specialise in a particular set of taxa and scientific disciplines. While specialisation is often a prerequisite for scientific depth, one downside is that when scientists carry out biological surveys, they usually only cover a fraction of the total biodiversity of a site and do not always address the wide range of taxonomic, ecological, conservation and evolutionary questions that are possible. This sampling pattern, combined with the general scarcity of taxonomists, means that very few regions have been researched thoroughly for multiple taxa, but this is particularly the case in the tropics. In addition, many ecological studies, such as those involving plot-based surveys, do not usually involve the collection of voucher specimens. To counteract these challenges and gain a better and more complete understanding of species in priority regions and ecosystems, their evolution, biological interactions, conservation status and environmental requirements, we recommend a comprehensive natural history collection approach (Wu et al., 2024) and we will strive to increase collaboration across taxonomic groups, methods and disciplines.

In practice, this could mean organising collecting campaigns that include international and local specialists in as many taxa as possible (ideally covering fungi, plants and animals, and their incidental and associated microbiomes); integrating 'systematic' (i.e., targeting specific taxa), 'ecological' (i.e., following specific collection protocols such as in permanent plots; ter Steege et al., 2011), and 'functional' (for fungi, including all potential life-styles) sampling; developing training opportunities for the collection and processing of samples of a diverse range of taxa; and further promoting educational and scientific interchange, such as cross-taxonomic seminars and projects that help strengthen connections among researchers.

To enable these actions, funding bodies, research organisations and individual scientists should evaluate how existing resources could be (re-)deployed and new funds pursued. Alongside this, workstyle ('cultural') changes are needed. These may not always require more funding, such as more frequent communication between experts in different taxa, driven by the willingness and curiosity for botanists and mycologists to work more closely together.

4. COLLECT FOR THE FUTURE

Biological collections have been accumulating for over five centuries, and their use has often extended far beyond the original purpose envisioned by the collector. For instance, no botanist or mycologist prior to the late 20th century could have imagined that their samples – which may often represent populations and even species no longer surviving in nature – would be widely used for DNA sequencing to illuminate the relationships, evolution and adaptations of species. Novel uses of such collections are constantly being developed, from the mapping of microbiomes to the quantification of individual molecules and chemical compounds, and computer tomography (CT) scans of morphological structures such as pollen, seeds, spores and hyphae. A wide range of studies in ecology, conservation and environmental sciences are increasingly aided by artificial intelligence tools to help researchers capture and interpret information from specimens (Davis, 2022; Burbano & Gutaker, 2023). Without doubt, the uses of specimens in the future will likewise expand vastly beyond what we can foresee today. Similarly, living collections – such as seeds, living plants and fungal cultures – will continue to constitute critical resources for pharmacological studies and biotechnological innovation, and other uses. We will strive to collect and store samples in ways that maximise their future use and safeguard existing and new collections.

In practice, this could mean exploring current and future collection techniques and protocols that capture a wider range of structures and organisms associated with a particular specimen than is commonly done. Potential activities include leveraging and expanding the extended specimens, including ancillary collections (e.g., carpological, wood, palynological, spirit collections); collecting tissues set aside for the extraction of DNA and other molecules, either in silica gel or liquid nitrogen; collecting seeds, spores and mycelia for *ex situ* biobanking (such as seed banks, many of which are partners of the Millennium Seed Bank Partnership; and fungal Genetic Resource Centres – culture collections – such as the Westerdijk Fungal Biodiversity Institute in Utrecht); collecting additional tissues, such as roots, mycorrhizal root tips and bark for plants; putting plant tissues in culture, when possible *in situ*, to maximise the capture of fungal endophyte and epiphyte diversity; and initiating novel types of collections, such as soil and freshwater samples containing environmental DNA. Such ancillary collections can also be critical when studying populations that are so severely threatened that collection of traditional specimens poses too much risk.

A forward-looking approach is essential: seeking flexibility for the use of collections for future scientific endeavours, including the cross-national transfer of samples when necessary – from the permit application stage to conform to national and international regulations; collecting ample metadata, such as trait observations to fill critical knowledge gaps (Gallagher et al., 2020; Maitner et al., 2023) and characteristics of the habitat in which a specimen was collected, through annotations by experts or citizen scientists and other techniques such as photographs and 3D LiDAR scans; and ensuring that collections are 'born digital' and their information is fully and globally integrated and accessible. Both new and existing collections should be treated as critical assets and given the best possible conditions for permanent storage without compromising their accessibility (Davies et al., 2023).

To enable these actions, international collaboration will be key, including among the co-signatories of this declaration. Such interactions will be important in helping to overcome regional constraints for collections storage space and capacity, and to jointly manage the allocation of available resources to researchers and institutions with careful consideration of the trade-offs (such as whether to make many collections with few associated data and samples, or fewer collections with more diverse sampling and richer metadata).

5. SHARE THE BENEFITS

It is crucial for biological research to properly and equitably benefit the custodians of biodiversity – from Indigenous Peoples and local communities to society at large. In 1992, the Convention on Biological Diversity (ratified by 196 nations) recognised nations' sovereignty over their biodiversity. While many countries now have established routines for Access and Benefit Sharing of physical samples, tensions still exist. There are many reasons for this: benefits arising from the use of biodiversity are not always shared with countries of origin; there are ongoing discussions to find a global solution to the many complexities in regulating access to Digital Sequence Information derived from physical specimens and ensure the benefits of their associated microbiomes are shared equitably; and there is potential for publicly available biodiversity data to be used commercially by companies unwilling to support data generation through taxonomic work; among other reasons. To overcome some of these difficulties and ensure that policies and legislation continue to protect biodiversity and its custodians without hindering research activities, there has been a push to improve the functionality and efficiency of regulatory mechanisms (Williams et al., 2020). <u>We will strive to share the benefits of collecting efforts widely, particularly with the source communities and national data centres</u>.

In practice, this could mean co-creating and jointly running collaborative collection campaigns involving multiple stakeholders through transparent processes that help build trust (e.g., Ramírez-Castañeda et al., 2022); identifying opportunities for deriving financial and non-monetary benefits through such processes; making sure that prior informed consent is always provided; following other key principles (such as CARE Principles for Indigenous Data Governance; https://www.gida-global.org/care) when scientists wish to access local and Indigenous knowledge (e.g. Villani et al., 2023), with clarity on how such knowledge will be used and how benefits will be shared; encouraging people transitions and knowledge exchange between academia and the public and private sectors; ensuring that local stakeholders are adequately included in derived publications and other forms of deliverables; and choosing to publish open access whenever possible.

To enable those actions, more researchers and organisations could share their success stories of benefit sharing with the public and their peers; governments could consider ways to drive environmentally sustainable policies that seize opportunities for sustainable development from their biodiversity resources (such as Colombia´s National Bioeconomy Strategy); and further partnerships could be made between academic, public and private stakeholders to define and seek solutions to pressing challenges where increased knowledge on the diversity, distribution and uses of plants and fungi could make an important contribution.

Conclusions

In this Declaration, we have provided a set of simple and concrete principles towards increased, more efficient and more equitable coordination of scientific collecting efforts at regional and global scales – our commitments. Given the background and rationale for this paper, we hope these principles will be received positively by the community of collections-based organisations and professionals around the world, and will help shape their policies and plans. A public call for signatories of this Declaration has at the time of submission gathered 691 individual and 106 organisational signatories across 86 countries. These are listed in Appendix I (Antonelli et al., 2024), along with a summary of the taxonomic interests, fields of expertise and sphere of work of the individual co-signatories. We view this as the beginning, rather than the completion, of a discussion bringing collectors and collections managers together around shared strategic objectives. We hope that further conversations can happen at relevant fora, such as upcoming botanical and mycological congresses, meetings and workshops held at various levels (international, regional, national and local). As part of this open and interactive process, we will continue to invite co-signatories until 31 December 2024, updating Appendix I to reflect the final list of organisational and individual signatories.

Position statement

The authors of this paper include individuals based in institutions across 25 countries around the world, with different career stages, scientific backgrounds, sexes, ethnic backgrounds and other diversity parameters. However, we acknowledge an over-representation from wealthy nations, in particular the UK and Europe, which stands in striking contrast to the regions where future research, collecting, training and conservation are mostly needed: low-income, biodiverse countries in tropical regions. While we strived for an inclusive process of co-authorship and co-signatories, we make no claims to represent all key voices and perspectives.

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Author contributions

All authors were involved in discussions and workshops on the subject of this Declaration at the State of the World's Plants and Fungi symposium in October 2023. AA, JT and RS wrote the first draft. AMA, GF, EG, SCG, DLH, IL, EBS, A-RGS and LMS provided extensive feedback, and all authors then contributed additional feedback before the manuscript was finalised by AA, JT and RS and re-circulated for final approval.

Data Availability

The data presented here are fully reported for Fig. 2 and available from the original publications for Fig. 3. Signatories to the Declaration were informed of our intention to publish names and country of residence in this manuscript before signing. The data collection, use and publication are General Data Protection Regulation compliant.

Conflict of Interest

The authors declare no conflicts of interest. The views expressed in this article do not necessarily represent official positions from the authors' organisations or their funders.

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