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Essays and Perspectives

Brazil as a global player in fungal conservation: A rapid shift from neglect to action

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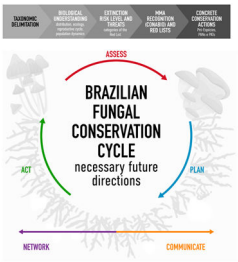
HIGHLIGHTS

- Brazil harbors high fungal diversity, much of it still undocumented.
- Fungi have long been overlooked in national biodiversity conservation policies.
- Recent policy change enables a turning point for fungal conservation in Brazil.
- Inclusion of fungi in public policies is essential for biodiversity goals.

GRAPHICAL ABSTRACT



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ABSTRACT

Fungi are critical for maintaining healthy ecosystems and a thriving economy, being responsible for a trillion-dollar industry worldwide. Fungal conservation has been gaining momentum over the past decade, with steady efforts in Brazil, where 123 species occurring in the country have been published in the IUCN Red List. Despite their remarkable diversity, efforts to effectively protect Brazilian fungi remain incipient. Legal recognition is recent, and environmental impact studies, as well as specific conservation plans and actions targeting fungi, are still limited or absent. This paper explores the current state of fungal conservation in Brazil, highlighting their importance, diversity, endemism, and the threats they face, while addressing practical challenges to fully integrating Brazilian funga into the national biodiversity conservation agenda. We emphasize that the 67 Brazilian endemic species published in the IUCN Red List could serve as the basis for the first official National Red List for Brazilian Funga, as recognized by the Ministry of the Environment and Climate Change (MMA - Ministério do Meio Ambiente e Mudança do Clima). Following this milestone, a formal proposal was submitted to the MMA for the official recognition of 24 endemic species, further advancing national listing process. This step enables the integration of threatened, specially endemic, fungal species into broader conservation strategies and public policies, in alignment with the National Biodiversity Strategy and Action Plan and Brazil's commitments under the Convention on Biological Diversity. Finally, we discuss ongoing initiatives and future directions for fungal conservation in Brazil.

Introduction

Fungi (including lichens) are a megadiverse group of organisms with an estimated 2.5 million species (Hawksworth and Lücking, 2017; Niskanen et al., 2023). The forms and roles of fungi in nature are equally diverse – from microscopic yeasts to giant mushrooms, including the largest living organism on Earth (Anderson et al., 2018). They are central to ecosystem functioning and health, mediating interactions between different organisms and ecosystems (Bahram and Netherway, 2022). Fungal diversity is extremely important from a human-centered perspective, with high biotechnological potential (Hyde et al., 2019) that sustains a global economy estimated to value ca. USD 54.57 trillion (Niego et al., 2023), impacting several aspects of our daily lives and cultures based on these traded fungal products. Fungi also contributes significantly to food security by supporting forest sustainability, biocultural conservation, and mitigating climate change (Heilmann-Clausen et al., 2014; Case et al., 2022). Their multifaceted contributions align with 10 out of the 17 Sustainable Development Goals of the United Nations (UN General Assembly, 2015; Meyer et al., 2020) and 12 targets of the Kunming-Montréal Global Biodiversity Framework (Fungal Conservation Network, 2024), and global biodiversity conservation stands to benefit from efforts focused on fungi (Cannon et al., 2018; Bahram and Netherway, 2022).

Brazil is the world's most biodiverse country, with extensive and unique phytogeographic domains housing a rich but threatened biodiversity (Crouzeilles et al., 2017). Around 15% of global biodiversity is estimated to occur in Brazil (BRASIL, 2023), including many endemic taxa. With ongoing species description rates of fungi and plants, Brazil holds great potential for new biodiversity discoveries (Cheek et al., 2020; Ellwanger et al., 2023). Taking into account current estimates of tropical biodiversity loss of 229 to 1947 extinctions per million species-years (E/MSY) (Giam, 2017), the country must be at the forefront of biodiversity conservation, underscoring the urgent need to incorporate fungi into major national conservation programs and agenda.

The Brazilian Federal Constitution (BRASIL, 1988) states that an ecologically balanced environment is a universal right essential to a healthy life, with the government and the population being responsible for defending and preserving it for present and future generations (Federal Constitution of Brazil, Art. 225, § 1°). It further establishes that to assure these rights, essential ecological processes must be preserved and restored, "demanding environmental impact studies for actions with the potential for degradation of the environment […]", and "to protect the Fauna and Flora […] from practices that risk their ecological function […]" (Federal Constitution of Brazil, Art. 225, § 1°). Furthermore, the Native Vegetation Protection Law (no. 12,651/2012) mandates mitigating actions for threatened species listed on any recognized national Red List at the federal, state, or municipal level, particularly in areas with anthropogenic disturbances.

Historically, this protection applied only to fauna and flora, excluding funga from environmental impact studies (Amaral-Silva et al., 2025), government policies, and regulatory frameworks. However, the recent Decree No. 12.137 of August 12, 2024, has expanded this scope, now officially including fungi. According to Article 14 of the decree, the *Centro Nacional de Conservação da Flora* (CNCFlora) at the Rio de Janeiro Botanical Garden Research Institute (JBRJ) is responsible for planning, promoting, coordinating, monitoring, and evaluating the execution of conservation activities for Brazilian flora and funga. This legal advancement acknowledges the critical role of fungi in ecosystems, the group diversity, and ensures their inclusion in the national conservation

agenda, rectifying previous oversights in the Brazilian legislation regarding fungal species.

This paper aims to explore fungal conservation in Brazil, highlighting the vast diversity of this organismal group, importance, endemism, and the state of threats, while addressing legal and practical challenges to effectively integrating Brazilian funga into the national biodiversity conservation agenda. Such unprecedented legal recognition of fungi in Brazil sends a powerful message to the global conservation community about the urgency and feasibility of inclusive biodiversity policies.

Brazilian funga: current diversity estimated based on accessible digitalized knowledge and conservation challenges

Based on accessible digital fungal knowledge gathered from Global Biodiversity Information Facility, we estimate that there are 17,296 to 20,554 accepted fungal species names and 3713 to 4276 genera confirmed to occur in Brazil (Supplementary File 1 for methodological details). Of these, 14,030 to 16,241 species have occurrences with associated coordinates or precise locality metadata (Fig. 1), allowing the inclusion of 79% to 81.1% of the Brazil's digitalized accessible fungal diversity in future and current national-wide conservation efforts based on spatial data.

The total fungal diversity estimate is nearly triple the number on current authoritative governmental lists (Flora e Funga do Brasil, (continuously updated) and aligns with dated estimates of 13,090 to 14, 520 fungal species predicted to occur in the country (Lewinsohn and Prado, 2005). However, these figures still fall far short of recent best estimates based on fungi-to-plant ratios of 3.5:1 for tropical regions (Niskanen et al., 2023), which suggest around 126,000 fungal species occurring in the country if only angiosperms are considered. Therefore, our estimates highlight that only around 13.7 to 16.3% of fungal species occurring in Brazil have digital accessible knowledge, and thus potentially minimal data required for further conservation efforts. Based on georeferenced records, we updated the distribution of known fungi across Brazilian biogeographic provinces (sensu Morrone et al., 2022) and phytogeographical domains. The Atlantic Forest shows the highest recorded diversity (up to 11,963 species), followed by the Amazon and Caatinga. However, these patterns largely reflect uneven sampling, with domains like the Pampa, Pantanal, Chaco, and Guianan Lowlands severely underrepresented despite their ecological importance. This unbalanced knowledge limits our ability to assess species' conservation status and implement effective strategies. Closing these gaps is urgent to ensure fungi are adequately represented in national conservation planning and policy.

The sheer number of species in the country highlighted here makes the creation of a comprehensive fungal inventory challenging. Although Brazil is one of the leading countries in terms of described species diversity (Cheek et al., 2020), the lack of specialists and science funding (Mega, 2019; Andrade, 2024), as well as the uneven distribution of available funding (Stegmann et al., 2024), has led to a concentration of collections along the coast and capital cities, where the largest science centers and the majority of mycologists/lichenologists are located (Fig. 1a). As a consequence, the absence of a consolidated species list and knowledge about their distribution (Wallacean shortfall) hinders assessments and the implementation of conservation actions for fungi, reflecting the lack of more comprehensive sampling.

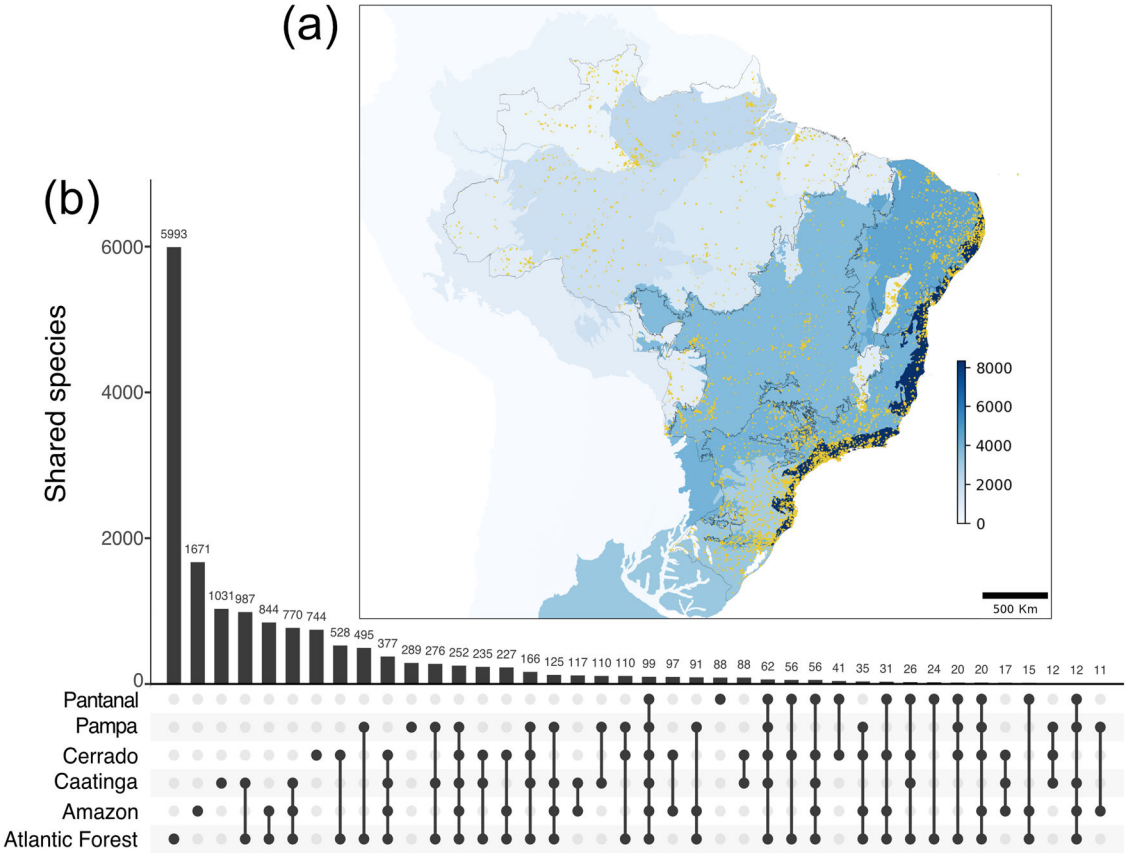

Fig. 1. Digital accessible Brazilian fungal diversity spatial distribution retrieved from online public repositories. Fungal richness within each Brazilian province is indicated by blue shades (from lighter to darker as richness increases). Provinces were defined based on Morrone et al. (2022) classification for the Neotropical region. Provinces definitions and associated biomes are given in the Supplementary Fig. 1 and Supplementary File 2. All retrieved and filtered occurrence points (relaxed dataset, check Supplementary methods under Supplementary File 1 for details) are presented in yellow. Brazilian phytogeographical domains are outlined with solid black outlines (a). Number of shared species among Brazilian phytogeographical domain groups is indicated by dot connections (b).

Despite this, in recent years, Brazil has emerged as a leader in advancing knowledge and conservation of its Funga. Since the term 'Funga' was proposed as an equivalent to 'Fauna' for animals and 'Flora' for plants (Kuhar et al., 2018), mycologists, lichenologists, and conservationists have promoted its inclusion in official documents and global initiatives (Fauna Flora Funga, 2024). Their goal is to expand efforts that were previously concentrated in European countries (Dahlberg et al., 2010; Lõhmus et al., 2018), and notably in South America, where Chile was the first country to formally include fungi in conservation efforts (Haelewaters et al., 2024). Efforts to popularize the term 'Funga' aim to elevate the perception of fungi to the same level of importance as Fauna and Flora. The term is featured in publications by the Brazilian Mycological Society (e.g., Calderano, 2022) and on various platforms linking fungal experts with education, cultivation, tourism, and gastronomy (Silva-Flores et al., 2021; Costa-Rezende et al., 2022; Calaça et al., 2023; Trierveiler-Pereira et al., 2022; Drechsler-Santos et al., 2023b). The term 'Funga' is now part of the "Flora e Funga do Brasil" (FFB), formerly known as "Flora do Brasil". This authoritative taxonomic platform, which includes a comprehensive catalog and monographs of plants, algae, and fungi in the country, was developed as a governmental initiative to support Target 1 of the Global Strategy for Plant Conservation of the Convention on Biological Diversity - CBD (Flora e Funga do Brasil, continuously updated).

Despite the growing recognition of the importance of fungal diversity, conservation of fungi in Brazil still lags behind. This is reflected in the limited assessment of the current status of the country's Funga, with only 0.60% to 0.71% known fungal species based on our estimates being currently published in the IUCN Red List, highlighting the persistent Scottian shortfall for Brazilian fungi (Haelewaters et al., 2023). As national conservation efforts generally focus on endemic species, we also inferred putative endemic Brazilian fungal species (Supplementary Methods under Supplementary File 1) and compared this number to compare with the current number of endemic fungal species published in the IUCN Red List. Based on the gathered accessible fungal knowledge for Brazil, we infer that 2495 to 2631 species are potentially endemic to the country, showing that only 2.54% to 2.68% of endemic species have been formally assessed using IUCN criteria based on our estimates.

These gaps in conservation knowledge highlight the historical negligence or low priority given to fungi in comparison to the conservation efforts devoted to plants and animals within national or subnational legal framework. Nonetheless, our estimates show that there is

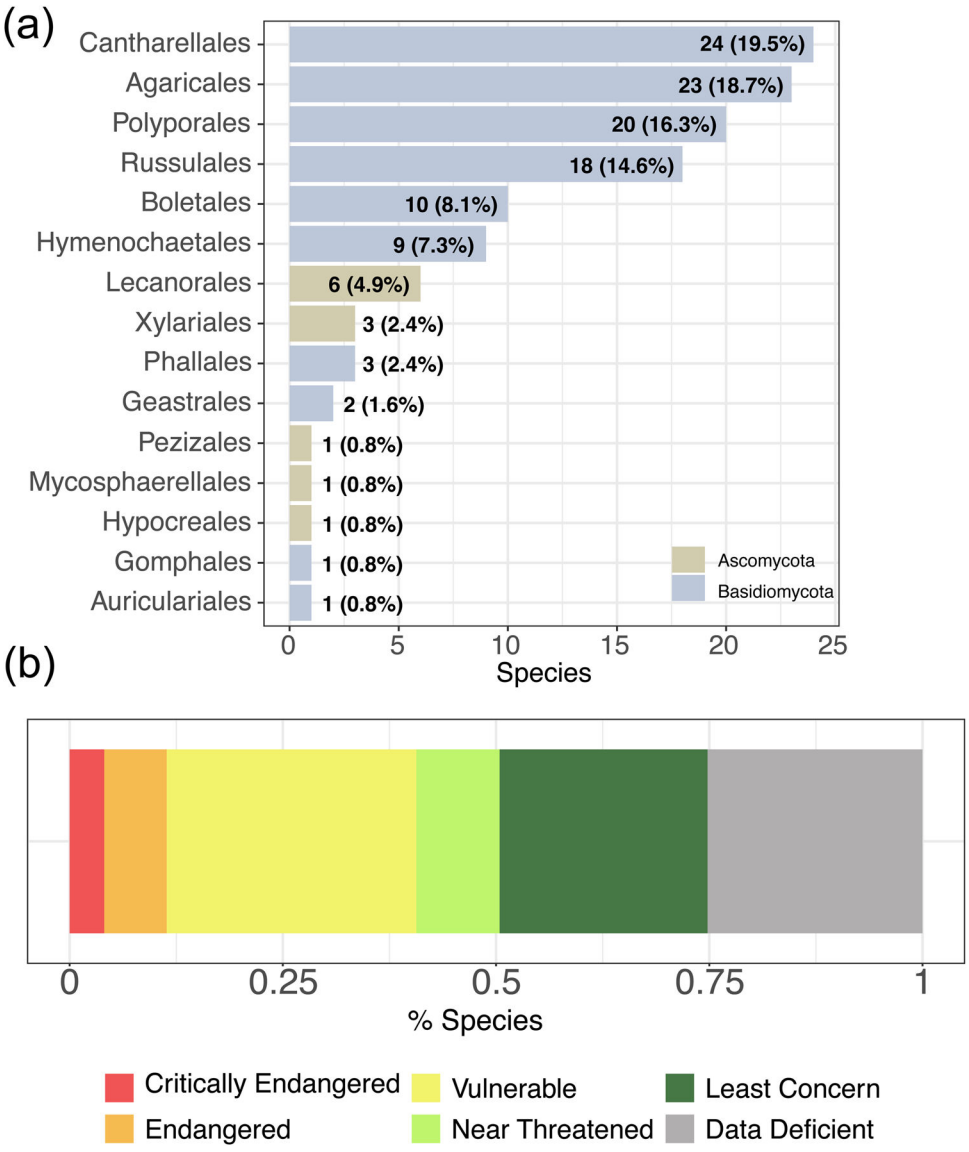

Fig. 2. Distribution of assessed Brazilian fungal species based on the IUCN criteria between orders and IUCN category. Absolute numbers are followed by percentages for each order, with distinction between orders belonging to Ascomycota (beige) or Basidiomycota (light blue) (a). Categories are represented as percentages in (b).

available data for inclusion of a significant portion of the Brazilian funga in national conservation legislation and efforts (e.g. the Atlantic Forest province in coastal Brazil). At the same time, we show that future sampling efforts aimed at uncovering Brazil fungal diversity should focus on areas with low accessible fungal knowledge, such as the Chacho and Guianan Lowlands provinces (Fig. 1a) and the Pantanal (Fig. 1b, Supplementary Fig. 2).

Current scenario and trends for Brazilian funga on the red list

Since 2019, when the first Brazilian fungal species was added to the Red List, a total of 123 species have been published in the IUCN Global Red List (IUCN, 2025). Over 90% of these assessments occurred after 2020, following international efforts to train Latin American mycologists in the IUCN assessment process through annual workshops and latter, the creation and engagement of the Brazil Fungal Specialist Group (BrazFunSG). This trend aligns with global patterns, as the number of

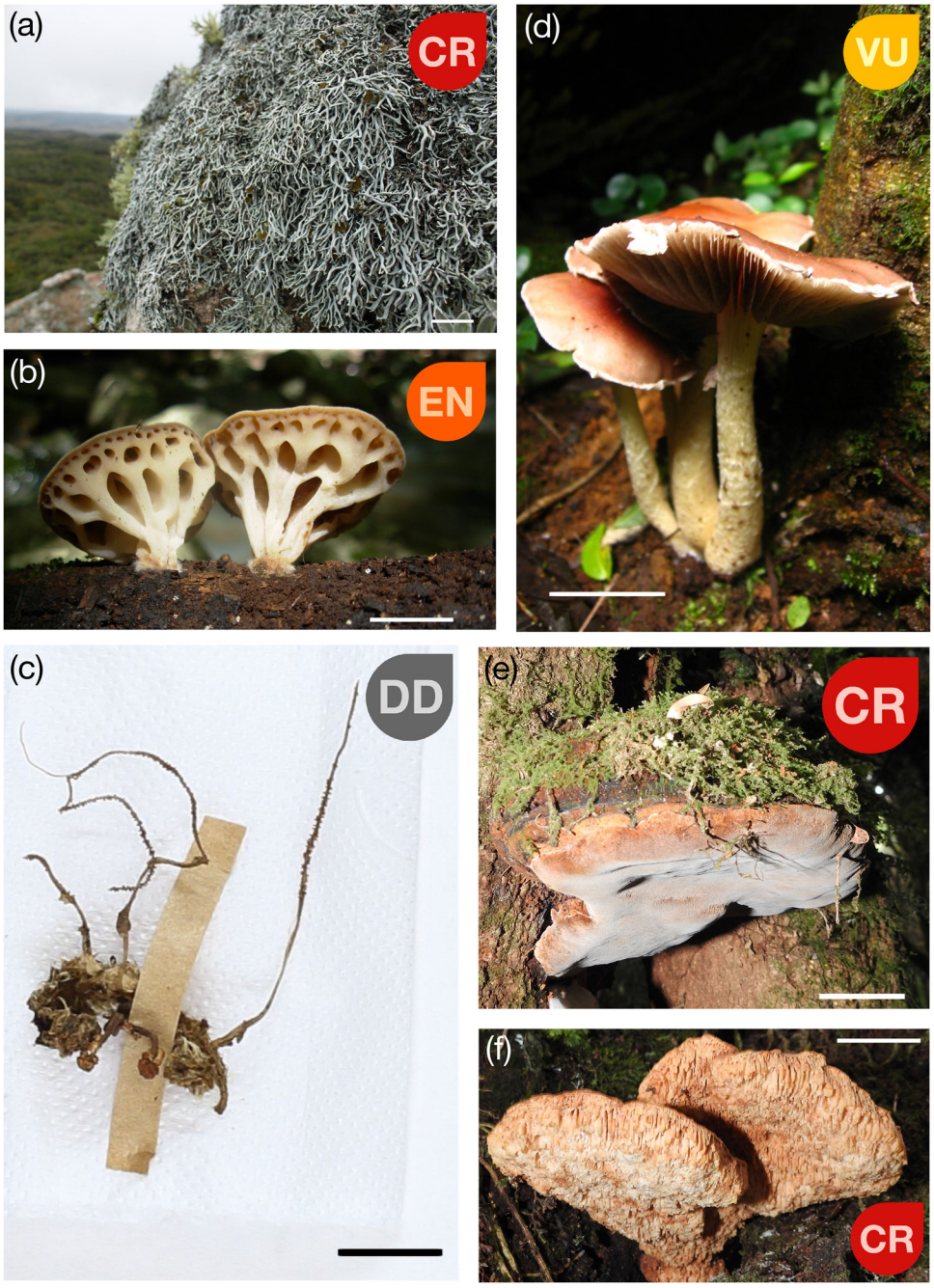

Fig. 3. Brazilian threatened fungal species (including lichens). *Parmotrema pachydermum* (Hue) O. Blanco, A. Crespo, Divakar, Elix & Lumbsch. Photo by A.A. Spielmann (a). *Rickiella edulis* (Speg.) Pfister. Photo by G. Robledo (b). *Ophiocordyceps ainictos* (Möller) G.H. Sung, J.M. Sung, Hywel-Jones & Spatafora. Photo by Felipe Bittencourt (c). *Stropharia venusta* P.S. Silva, Cortez & R.M. Silveira. Photo by P.S. Silva (d). *Fomitiporia nubicola* Alves-Silva, Bittencourt & Drechsler-Santos. Photo by Kelmer Martins-Cunha (e). *Bondarzewia loguerciae* Salvador-Mont., Rajchenb., Kossmann, Bittencourt & Drechsler-Santos. Photo by Kelmer Martins-Cunha (f). Species categories are indicated within each image. Images without indicated credits are from the author's personal archive. Scales: (a) = 10 cm; (b) = 2 cm; (c) = 2 cm; (d) = 2 cm; (e) = 5 cm; (f) = 10 cm.

globally assessed fungal species began increasing after 2015 (Mueller et al., 2022). Most assessed species are non-lichenized (i.e. only 4.9% of species are within the order Lecanorales, Fig. 2a) and belong to Basidiomycota (90.2%), reflecting a knowledge gap for other fungal phyla rather than an accurate ratio of threatened species belonging to the group. This bias influences species selection for assessments and underscores the urgent need for more mycologists and lichenologists involved in conservation, especially for lichens and non-lichenized Ascomycota. There is also an unbalanced distribution of conservation efforts within Basidiomycota, with Cantharellales, Agaricales, Polyporales, and Russulales representing ca. 70% of assessed species (Fig. 2a), highlighting the strong bias towards certain known and more conspicuous groups of fungi. So far, there has been no effort to evaluate the conservation status of arbuscular mycorrhizal fungi in Brazil, despite the country's ecosystems harboring ecosystems high predicted richness and rarity of AMF, and following the global trend, the majority of this diversity is not in protected areas (Van Nuland et al., 2025).

Half of the assessed Brazilian fungal species are considered threatened if Near Threatened species (which are considered species of conservation interest) are included (Fig. 2b), while ca. 54% of assessed species are endemic. Among the assessed species, the highest number are classified as Vulnerable (36), followed by Data Deficient (31) and Least Concern (30). The combined threatened categories (CR, EN, VU) account for 50 species (Fig. 3). While current assessments are biased towards rare and endemic species, ongoing efforts may hold or even increase the percentage of assessed species that are endemic, given Brazil's status as a major hotspot for fungal diversity and endemism (Tedersoo et al., 2022).

The primary threat clusters cited in IUCN Red List assessments are agriculture and residential and commercial development, while climate change and severe weather are cited in 14% of assessments (Fig. 4). Additionally, biological resource use, natural system modifications, and pollution account for 26% of the listed threats to Brazilian fungi. Naturally, the conservation action clusters related to land protection and law & policy are heavily cited in assessments, accounting for 67.8% of significant conservation action cluster occurrences (Fig. 5). These threats and conservation actions directly reflect expert opinion about which key factors are pressuring assessed Brazilian fungal species, and which actions can be taken to actively revert processes endangering these species. Therefore, despite the low number of assessed species when compared with our estimates, we anticipate that there is already a clear pattern of urgent need to include fungal species into the existing legal framework for species conservation in Brazil, while also integrating the protection of their habitats.

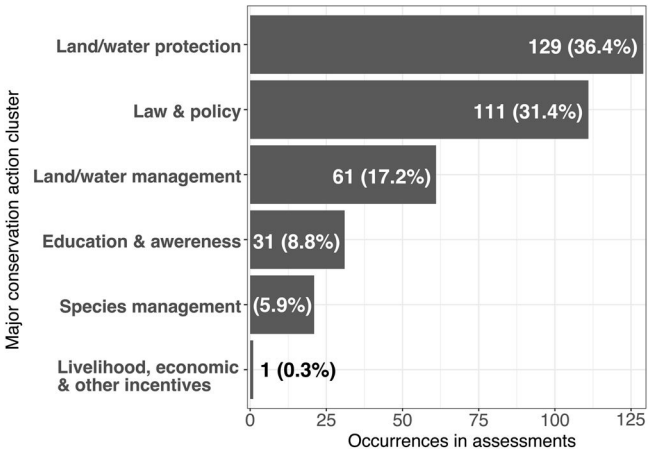

Fig. 5. Major conservation action clusters cited in the global assessments of threatened Brazilian fungal species. Each displayed type represents a major conservation action cluster defined by IUCN in the conservation actions classification scheme (from 1 to 6) within the IUCN Red List guidelines. Note that for some clusters the number of occurrences exceeds the number of assessments for fungi occurring in Brazil (123 assessments) due to more than one associated conservation action sub category being indicated within assessments.

Legal frameworks and actions for fungal conservation in Brazil

To protect Brazilian biodiversity, a set of policies, decrees, resolutions, and other guidelines have been implemented at the federal, state, and municipal levels. While these measures are crucial, their effectiveness depends on proper implementation and enforcement (Nunes et al., 2024). Several key legal instruments safeguard the environment in Brazil. Law No. 9.605/1998, known as the Environmental Crimes Law, establishes penalties for individuals or companies responsible for environmental damage. Law No. 9.985/2000 outlines criteria for creating, implementing, and managing protected areas, such as National Parks, under the National System of Nature Conservation Units (SNUC). MMA Ordinance No. 43/2014 introduced the National Program for the Conservation of Threatened Species (Pró-Espécies), which aims to minimize threats and prevent species extinction through conservation and management actions. This ordinance is reinforced by MMA Ordinance No. 162/2016, which establishes guidelines for the preparation and publication of Red Lists, as well as Ordinances No. 444/2014 (fauna), No. 443/2014 (flora), and, more recently, No. 148/2022, which officially recognize Brazilian species threatened with extinction.

Within this regulatory framework, threatened species receive

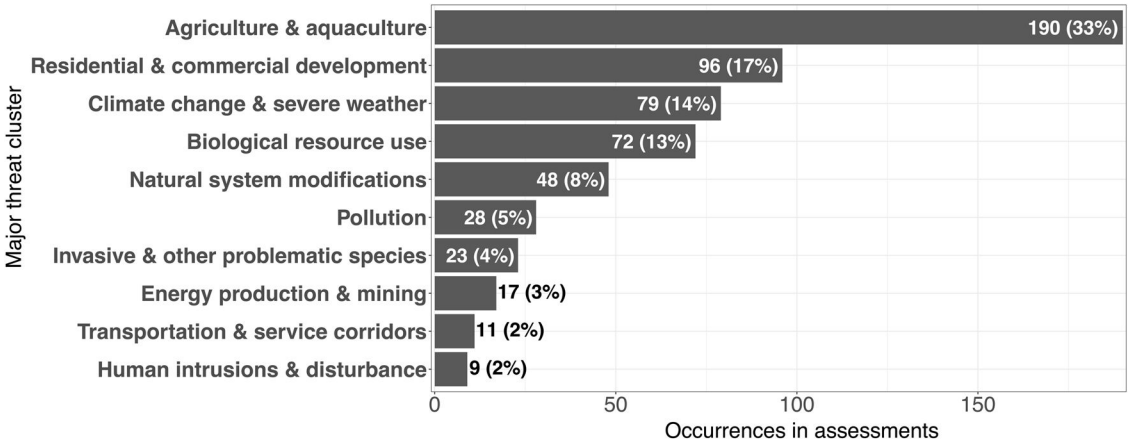

Fig. 4. Major threats clusters cited in the global assessments of threatened Brazilian fungal species. Each displayed type represents a major threat cluster defined by IUCN in the threat classification scheme (from 1 to 12) within the IUCN Red List guidelines. Note that for some clusters the number of occurrences exceeds the number of assessments for fungi occurring in Brazil (123 assessments) due to more than one associated threat sub category being indicated within assessments.

heightened protection. Crimes against these species are considered more serious than those against non-threatened species (Articles 15 and 29 of Law No. 9.605/1998). Additionally, threatened species are prioritized in conservation strategies such as the *Planos de Ação Nacionais para Conservação de Espécies Ameaçadas de Extinção* (PAN, "National Action Plans for the Conservation of Threatened Species"; MMA, 2024). These plans outline *in situ* and *ex situ* conservation measures (Article 3 of MMA Ordinance No. 43/2014). In the context of the Pró-Espécies, the *Planos de Ação Territoriais para Conservação de Espécies Ameaçadas de Extinção* (PAT, "Territorial Action Plans for the Conservation of Threatened Species"), managed by state environmental agencies, focus conservation efforts on Critically Endangered species that are not protected by any other conservation strategies.

However, for a long time, the exclusion of fungi from conservation policies and strategies, which were historically focused on plants and animals, represented a critical gap in Brazilian conservation law. Brazilian Red Lists, at both national and state levels, were previously restricted to fauna and flora, leaving funga without the conservation protections or actions available to threatened species of animals and plants. The recently enacted Decree No. 12.137/2024, has broadened this framework by officially including fungi in Brazilian environmental legislation, marking a significant step toward a more comprehensive conservation strategy. Recognizing fungi is essential for adopting a more holistic conservation approach that prioritizes the protection of entire ecosystems, rather than focusing solely on particular plant and animal species, fostering resilience against biodiversity loss and climate change while supporting food security.

The IUCN SSC established the BrazFunSG in 2023 to advance fungal conservation in Brazil (Drechsler-Santos et al., 2023a). This group has coordinated several initiatives to integrate fungi into conservation programs, environmental legislation, public policy, ecosystem management, and science outreach. For example, in 2023, to the best of our knowledge, the MMA officially acknowledged fungi for the first time in government documents and recommended that the Federation States collaborate with BrazFunSG to develop fungal Red Lists (Subirá, 2023). Further progress includes agreements with the *Instituto do Meio Ambiente* (IMA) of Santa Catarina and the *Secretaria Estadual do Meio Ambiente* (SEMA) of Rio Grande do Sul to incorporate threatened fungal species as beneficiary under the Territorial Action Plans for the Conservation of Threatened Species of the Southern Plateau (acronym in Portuguese PAT Planalto Sul). Also, internationally funded projects are supporting the preservation of fungal genetic diversity and advancing research on the biology of threatened species. The Brazilian Threatened Fungi Collection - Coleção de Fungos Ameaçados do Brasil (CFAB, MIND.Funga, 2024) marks the country's first *ex situ* conservation initiative for threatened fungi.

Despite the historical neglect of fungi in national conservation programs, the published Decree No. 12.137/2024 opens new horizons for the directives governing the effective fungal conservation in Brazil. Involvement from society and government is crucial to completing the Species Conservation Cycle—Assess, Plan, Act, Network, and Communicate (Rodríguez et al., 2022). Therefore, the formal recognition of funga in Brazilian legislation, including the establishment of an official national Red List, represents an essential step in advancing government policies and fungal conservation.

Together, these legal frameworks and recent institutional efforts reveal that Brazil now possesses the essential regulatory infrastructure to support fungal conservation—something that was historically absent. The inclusion of fungi in national legislation through Decree No. 12.137/2024, the integration into public policies such as the PATs, and the recognition of funga in strategic conservation tools like Red Lists together forms a legal and operational foundation capable of enabling impactful conservation outcomes. However, legal recognition alone is not enough. Turning legislation into action requires political will, continued scientific collaboration, funding, and societal engagement. The consolidation of this emerging framework marks not only a turning point for fungal conservation in Brazil but also establishes a valuable reference for other megadiverse countries seeking to adopt more inclusive and ecosystem-based conservation strategies.

Concluding remarks and future perspectives

Guidelines for effective fungal conservation have been widely discussed (e.g. Dahlberg et al., 2010; Gryzenhout et al., 2010; Allen and Lendemer, 2015; Pasailiuk et al., 2022; Yahr et al., 2024). Although fungi have historically faced challenges in gaining protection in Brazil, the growing awareness of their conservation represents a positive step toward safeguarding this large yet overlooked component of biodiversity. Efforts are now effectively underway to include threatened fungal species in conservation initiatives following formal legal recognition under Decree No. 12.137/2024.

The integration of fungal conservation into public policies and its translation into effective actions represent an urgent need. In this context, the efforts of the mycological community are increasingly focused on consolidating a comprehensive species list, aiming to systematize knowledge on fungal diversity within the official biodiversity platform Flora e Funga do Brasil. This database serves as the official taxonomic backbone adopted by the Brazilian authority responsible for the Red List — the CNCFlora/JBRJ — for conducting extinction risk assessments, as established by MMA Ordinance No. 1,070 of May 22, 2024, and JBRJ Normative Instruction No. 1 of December 10, 2021.

As a significant milestone, following the publication of Decree No. 12,137/2024, a formal proposal has been submitted to the MMA for the official recognition of 24 endemic species, paving the way for the formulation of the first Official National Red List of Brazilian Funga. In this timeline — where species are first catalogued in the Flora e Funga do Brasil platform, then assessed for extinction risk by CNCFlora/JBRJ, and subsequently submitted to the MMA for official recognition — the inclusion of threatened fungal species in other official conservation strategies and public policies becomes a tangible possibility. This integration aligns with the targets set forth in the National Biodiversity Strategy and Action Plan (NBSAP) and with Brazil's commitments under the CBD.

The official recognition of the Red List of Brazilian funga therefore represents a crucial step toward strengthening the integration of fungi into national conservation strategies, such as the PANs, PATs, and the Biodiversity Impact Reduction Plans. Some initiatives are already underway, including the incorporation of threatened fungal species in the PAT Planalto Sul, offering important opportunities for their protection. In addition, ten other PATs are currently being implemented across at least 12 Brazilian states, and new opportunities for including fungi are emerging in PANs under development. Another strategic initiative is the inclusion of funga into spatial prioritization analyses conducted by CNCFlora/JBRJ, which are aimed at updating the Priority Areas for the Conservation and Restoration of Ecosystems for Threatened Brazilian Flora and Funga.

Efforts for fungal conservation in Brazil should also target the largely overlooked microscopic fungal diversity, particularly arbuscular mycorrhizal fungi. Assessing their conservation status using IUCN criteria is challenging and may even be considered unfeasible according to the IUCN Guidelines, as microorganisms are excluded from assessment (Stewart et al., 2025). However, whether fungi, including those traditionally classified as microfungi, should be regarded as microorganisms is debatable, since their somatic bodies can span several meters. Moreover, species typically considered microfungi have already been assessed and included in the IUCN Red List (e.g., Branco Rocha et al., 2024). Until standardized methodology enabling individual species conservation assessments for these organisms are better established, their short-term protection could rely on safeguarding areas with high known or predicted richness, identified through eDNA (Van Nuland et al., 2025) and/or traditional sampling, prioritizing potentially endemic or rare species whenever possible. We are also aware of

initiatives led by international authorities in fungal conservation, such as the IUCN SSC Fungal Conservation Committee, that aim to introduce flexible and feasible criteria to overcome the limitations applicable to microscopic groups. Although these measures have not yet been published or implemented, they are promising and offer a broad, inclusive perspective for addressing this current challenge.

Brazil is often characterized by its widespread mycophobia and negative cultural perceptions of fungi (Góes-Neto and Bandeira, 2003). To address this, it is crucial to promote positive communication about fungi, linking scientific research with public understanding and informing effective public policies (Costa-Rezende et al., 2022; Calaça et al., 2023; Trierveiler-Pereira et al., 2022; Drechsler-Santos et al., 2023b).

As more fungal species are recognized as threatened, research is needed to develop concrete plans and actions to combat their decline. Thus, additional funding and scientists are needed for mycological conservation. Currently, there are funded projects dedicated to collecting data to understand what is needed to protect fungal species, including their biology, distribution, and specific environmental quality required for their survival. The recognition of funga as a vital and threatened biodiversity component in national policies and official Red Lists can drive projects and funding to fill important knowledge and spatial gaps regarding their diversity, biology, and distribution, allowing the understanding of large spatial patterns that can serve to their conservation and sustainable management (Runnel et al., 2021).

Key knowledge gaps in fungal conservation include habitat distribution and quality modeling. To address these gaps, involving students in conservation science and creating a collaborative network of citizen scientists for data collection and monitoring are essential for achieving the scale and speed seen in other countries (Lindsay et al., 2013; Irga et al., 2018; Heilmann-Clausen et al., 2019; Sheehan et al., 2021; Drechsler-Santos et al., 2023b; Haelewaters et al., 2024). Expanding and mobilizing human, institutional, and financial resources, along with engaging socio-political, national, and local governments, is necessary. Building on expert networks and collaborating with local institutions is needed for implementing strategic, science-based actions that enhance national conservation efforts. Brazil's recent legal and institutional advancements provide fertile ground for a national fungal conservation strategy — but realizing its full potential will require continued political commitment, funding, and coordinated action across sectors.

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Data availability

All data supporting this article is public and can be consulted in the sources cited in the text.

CRediT authorship contribution statement

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

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