

Citizen Science in Mycology

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The label “science” is normally restricted to scientific knowledge that is produced by paid credentialed professionals using sophisticated equipment. Other forms of knowledge are relegated to the status of “unscientific” and often ignored by professionals.² This trend has changed in mycology and elsewhere. Amateur mycologists and other “grassroots scientists” have challenged this conventional image. Whilst amateur scientists are far less dependent on formal training, they can and do, as educational ambassadors, create a vital nexus between science and the public.

I am a First Class Honours graduate trained classically in the field of Infectious Diseases and Immunology. I was appointed Head of the Department of Infectious Diseases at the University of Sydney from 1993–2000. My major teaching commitments to medical, dental and science students are undertaken at both undergraduate and postgraduate levels. During my extended seven-year period as Head of the Department, I also devoted much of my academic time to designing the new Graduate Medical Program at the Sydney University. I was personally responsible for the template on which the program today is based. I retired from the University of Sydney in December, 2006. My wife, Elma, and I, as amateur mycologists and executive members of the Sydney Fungal Studies Group, Inc., (SFSGI) for over 20 years, were responsible, for example, for the listing, under the Conservation & Endangered Species Act of NSW, of a community of fungi for the first time in Australia. The habitat - the Lane Cove Bushland Park (LCBP) - was gazetted with its listing on the Register of the National Estate. From the view of a mycology enthusiast, this essay is an insider’s perspective of citizen science.

This article comments briefly on the history of citizen science in Australian mycology giving examples of specific groups and individuals who, in their spare time, have made outstanding contributions. Some have achieved landmark legislations in fungal conservation. What is an “expert”? Should science not be occupied by paid scientists only? How might citizen scientists become active in social movements to bring about change for a sustainable world? What factors limit citizen mycology, and what are the future challenges in closing the gap between mycology and the general public? The paper argues for the importance of citizen-based Australian mycology and conservation.

Citizen science: what is it?

Pre-twentieth century, mycology in Australia began when expert fungal enthusiasts sent their collections to taxonomic mycologists in the UK.³ Such inconvenience soon became an impetus to produce our “home-grown” taxonomic

mycologists whose amateur fungal curiosity blossomed into expertise of international standing. Such luminaries came from different educational and occupational backgrounds and included John Cleland (medical pathologist), Leonard Rodway (botanist), Gordon Beaton (motor mechanic), Curtis Lloyd (pharmacist), Gordon Cunningham (various jobs including in charge of camel trains) and many more.

John Burton Cleland (1878–1971) studied medicine and in 1920 became Professor of Pathology at Adelaide University, a position he held until 1948. He had a lifelong interest in anthropology, ornithology and botany. Cleland collected widely and published numerous papers. As a mycology enthusiast, he made outstanding contributions to the study of Australian fungi and described over 200 new species. In 1934 and 1935 Cleland published his two-part monograph *Toadstools and Mushrooms and other Larger Fungi of South Australia*, which remained the only major Australian mycological work for several decades. His records, based on observations in the field, gave authenticity to his descriptions of species. In his spare time, as a passionate field naturalist, he collected nearly 30,000 plants including almost 60 new species. As an amateur ornithologist he collected over 1,000 bird skins of which a number became type specimens. He was a key instigator of the founding of the Flora and Fauna Handbooks Committee of South Australia and became its chairman.⁴ His research into Australian Aboriginal people led to activism and strong general comments about the negativity of colonisation by European Australians.⁵ Sir John Cleland is an outstanding example of how a motivated person can contribute, with distinction, as a part-time citizen scientist and collector outside his occupation or particular professional field.

“Citizen science” is an old method of integrating community outreach and scientific data collection, locally, regionally and often across large geographic scales. Fungimap, Inc., is a non-profit organisation of mainly citizen scientists and is another example of community-based science in action, dependent on amateur mycologists to supply data of macrofungi from across Australia.⁶ Over 700 citizen collectors contribute to the National Australian Fungimap Database providing information for research, conservation and policy. In SFSGI, volunteers of all ages use hand lenses and professional descriptive keys to identify common fungi. Though amateur mycologists play a role in data collection, citizen science can be, is and should be, much more than that.

Such gathering of field data is not new. The world’s longest-running uninterrupted bird census, the Audubon’s Christmas Bird Count, has depended upon citizen scientists who are vital to conservation.⁷ Others include Waterwatch – an Australian national community water monitoring program to protect waterways.⁸ Frogwatch is an example of community-based group in contact with scientists to protect amphibians and their habitats.⁹ Native orchid societies are dedicated to the study of native orchids.¹⁰ Such volunteer organisations aim to create a diverse, engaged and dynamic community of curious learners, collectors and mentors. In SFSGI, citizen mycologists allow a few taxonomic mycologists to be in many places at one time. Expertly collecting and classifying fungi are among the extraordinary things citizen mycologists do. They provide a much larger workforce than by any academic department.

How do citizen scientists advance knowledge?

For over 20 years many truly skillful and dedicated amateur mycologists in SFSGI have voluntarily worked in the shadows. Occasionally they gain a glint of notice from their professional peers but, for the most part, they do remarkable and often distinguished work in obscurity. Their efforts are done without recourse to institutional resources that professional mycologists, an endangered species, often take for granted.

They are our volunteer “citizen scientists” or “field mycologists” who help monitor conditions and trends, detect early indicators of change and provide information and advice to resource managers. The future of citizen science lies in the resistance to professionalisation.

Within SFSGI, experienced volunteer citizen scientists, with passion and enthusiasm, continue to generate new knowledge of fungal species and biodiversity generally. Not all members of the SFSGI are interested in taxonomy but are satisfied to learn to recognise specific species and enjoy the membership’s camaraderie. Expanding the number of citizen mycologists significantly improves the public’s understanding of the kingdom Fungi.

Much of the recording work essential for conservation is done by citizen scientists. For instance, SFSGI’s website is managed by a voluntary citizen scientist.¹¹ This hugely important contribution has been emphasised in recent articles.^{12,13} In addition, dedicated SFSGI citizen scientists conduct a series of public educational “talks and walks” annually fulfilling an aim of SFSGI “to educate people at all stages of skill and knowledge in the science of mycology”. By acting as mycology ambassadors, they help the public to understand the vital importance of fungi in our ecosystems and their conservation. Such mentoring fulfills another of SFSGI’s aims “to interact with groups and societies having mycological or closely related interests” including the popular Fungi Festival at Mt. Tomah Botanic Gardens. Some of the group’s amateur mycologists are the sole sources of critical information pertaining to listed endangered fungi.¹⁴

By integrating community outreach and scientific data-collection protocols, amateur mycologists do improve the public’s mycology literacy, keenness of observation and originality of ideas to create new frontiers in sustainability. These citizen mycologists commonly have local knowledge of particular ecosystems to help bushland managers to understand the broader social, economic and political context of changes occurring in ecosystems. For example, one of the most controversial changes to the threatened species laws of NSW is the introduction of “biodiversity banking” (Biobanking).^{15,16}

SFSGI citizen scientists have made successful representation to NSW Government to ensure biobanking does not allow a developer to build on a site near a habitat of an endangered ecological fungal community.¹⁷ If a development threatens a species in need of protection, construction can go ahead if the developer can find another area of land – a biobank – supporting the same species or ecological community. The developer looks after that land or pays someone else to do it. The conservation work is turned into credits and traded between developers.

Such advocacy by mycology enthusiasts and the dissemination of information have broadened public engagement in bushland management and fungal ecosystem stewardship. Effective fungi conservation requires better information about changing habitat character. Citizen volunteers can help monitor conditions and trends, detect early indicators of change and advise resource managers accordingly. For example, Lane Cove Council (LCC) and Hunters Hill Council (HCC) have taken such advice and implemented measures so that bush regenerators do not disturb sites of endangered fungi.¹⁸ Such measures have included installing fencing to protect sensitive fungal sites from trampling. Dogs are prohibited from being off a leash whilst in LCBP. Bush regenerators are given specific instructions of sites of endangered fungi and to undertake care in weeding. Special walkways have been installed to ensure walkers stay on the tracks. LCC has successfully imposed on-the-spot fines for unlawful behaviour and has prosecuted offenders in the NSW Land and Environment Court.

Specific achievements of citizen scientists in the SFSGI

In May, 2011, the SFSGI was the joint recipient of the Innovation Award by the Sydney Metropolitan Catchment Management Authority. Based wholly or partly on contributions to fungi conservation, member amateur mycologists have been recipients of such awards as citizenship awards, Citizen of the Year award, Prime Minister's Centenary Medal, a NSW finalist in Australian of the Year award and Order of Australia Day award.

The listing of a Hygrocybeae community and its holotype species under NSW State and Federal Legislations is another achievement of SFSGI. Lane Cove Bushland Park (LCBP) is a warm-temperate wet sclerophyll forest and measures approximately 800 metres long and about 300 metres wide. It joins Osborne Park (OP). LCBP is evergreen, hygrophilous in character in the upper portion and rich in lianes. Epiphytes are relatively common on tree trunks, especially in the upper tributary of Gore Creek, which empties into Sydney Harbour. LCBP/OP is the location of at least 35 species (previously 27) in the tribe Hygrocybeae (Waxcaps). Arising from the Application by SFSGI members, Ray and Elma Kearney, this ecological Hygrocybeae Community has been legislated (March, 2000) under the NSW Threatened Species Conservation Act, 1995 as endangered along with nine holotype taxa as either endangered or vulnerable. Because of its mycological assemblage, LCBP/OP has been listed on the Register of the National Estate by the Commonwealth Heritage Commission. This endangered fungal community is now ranked of International Significance (Rald's Classification).¹⁹

These successful prototype initiatives have depended upon the collaborative efforts involving amateur mycology enthusiasts and a professional taxonomic mycologist Dr. Tony Young as well as LCC.²⁰ This synergy of initiative, originality of ideas and keenness of observation achieved landmark decisions for legislative conservation of fungi in Australia.²¹ On 23rd July, 1999, a precedent was set in the NSW Land and Environment Court where a developer/company (\$8750) and foreman (\$1750) on site were fined for allowing building spoil to enter the Gore Creek tributary of LCBP. This successful case by LCC was based upon a "Preliminary Determination" to list the community of fungi as "endangered" and set a precedent in law-enforced fungal conservation in NSW.

SFSGI has also contributed to the *Atlas of NSW Wildlife* and the *Atlas of Living Australia*. Rigorous records of fungi field studies, in the greater Sydney Region, by SFSGI are used for conservation purposes by various Municipal Councils. Such lists also accompany the Group's application for renewal of the Scientific Licence(s) by the NSW Parks and Wildlife Service (NPWS). The licence is issued under section 132C of the NSW National Parks and Wildlife Act to authorise the collection of fungi for scientific, educational or conservation purposes. NPWS through NSW Office of Environment and Heritage pass the species-data to *Atlas of Living Australia* and *Atlas of NSW Wildlife*.^{22, 23}

Citizen scientists contribute to an understanding of the interdependency of species involving truffles. The SFSGI citizen mycologists offer their expertise freely. Two amateur mycologists recently discovered three species of truffles and a bandicoot's truffle midden or cache, after a bushfire in Lane Cove National Park (LCNP). This led to a collaborative partnership with visiting Professor Jim Trappe – an international truffle expert. These findings were reported to the Area Manager and Environmental Officers of LCNP. Truffles in Sydney's bushland are rarely recorded. These observations relate to the complexity of the general ecology involving mycorrhizal truffles and dispersal of truffle spores by forager-bandicoots. Fox baiting was found to lead to an increase in numbers of ticks which parasitise bandicoots and are correlated to increased incidence of tick allergies confirmed by clinical allergists. Management decisions (e.g., fox baiting), regarding natural resources are enhanced by this collaborative teamwork. Also

noteworthy is a new species of beetle which feeds on truffles. The beetle was discovered in the LCNP by these amateur mycologists who isolated, from the beetle's gut, two new species of yeast and a bacterial species with amazing communication mechanisms akin to quorum sensing.²⁴

Citizen scientists promote conservation education. Amateur mycologists have implemented many diverse outreach programs to expand public awareness of fungi and their conservation by good stewardship. For example, Fungimap, Inc., and its citizen scientists have a deep concern for our natural environments. Talented members continue to conduct many fungi ecology workshops and seminars across Victoria.²⁵ Photographs of fungi, by SFSGI citizen scientists, in the Sydney Region were compiled into a CD and distributed to public libraries – “to educate people at all stages of skill and knowledge in the science of mycology”.²⁶

Limitations experienced by citizen scientists

Whilst disconnects do occasionally exist between citizens and scientists, all taxonomic mycologists will concede their research has benefited directly from amateur mycologists. However, within the labyrinth of conservation politics and the bias towards stasis or do nothing, citizen scientists do encounter the in-built professional self-interests, the regional and state jealousies, personal fiefdoms and the immense power of special-interest lobbyists (e.g., developers, mining corporations and land-grabbers).^{27,28} Occasionally, professionals have sought to increase their status by strategically playing down amateur science as superficial, unacademic, provincial – in short, inferior to the work of professional scientists in every respect. Such petty antagonism was common in the 19th century.²⁹ An amateur in science came to mean a lower status, more often a mere oddity to be kept at a distance from “serious” science. This was basically the narrative told by authors such as Dorothy Stimson in her 1948 book on the history of the Royal Society, aptly called *Scientists and Amateurs*.³⁰

Observer reliability has been raised as an issue but taxonomic mycologists are not faultless. Names of species in the Northern and Southern Hemisphere do not always correspond. Closing the gap between mycology and the general public for mutual benefit is the only way to rapidly unlock the data and information that mycology desperately needs. Excellent photographic field guides help to dispel the mystery and fear as well as extol the beauty and importance of fungi – even though many remain unnamed. The rise of public participation in field studies does increase the public's scientific literacy. Such outcomes are conditional upon maintenance of ethics, scientific standards and credible mycological experience being sustainable. Several other factors may limit citizen scientists in Australian mycology.

Responsibility for research, teaching and post-graduate training in mycology should be embedded in the academic, tertiary universities and associated biological institutes. However, Australian universities are in decline and mycology is a Cinderella discipline – for many reasons.³¹ There is reported to be only one taxonomic mycologist in Queensland, suggesting that expert knowledge in identification of higher fungi, is scarce.³² Yet the membership of the active Queensland Mycological Society that is open to anyone with an interest in macro-fungi highlights the importance of citizen mycologists.³³

While amateurs can be involved in co-producing science with professionals, the latter still might resist and protect their independence. For most university staff members, research is a profession and publishing papers is a means for personal and professional development and advancement. Some do feel having citizen scientists as “scientific collaborators” weakens the professional's contribution and status. Conversely, for voluntary amateur scientists, practicing science is largely a leisure

activity while professionals spend working time, for example, in the field, although these boundaries are not always clear.³⁴

Among amateur scientific collaborators there are people from all kinds of backgrounds: a clinical allergist interested in collecting fungi and plants; a school teacher, such as Edith Coleman (1874–1951), interested in native orchids and their pollination by pseudo-copulating wasps.³⁵ Science in most museums originates from a close cooperation between specialised people and laypersons but usually sees the latter as marginal to “proper” science. For example, Edith Coleman’s original observation of pseudo-copulation by male wasps of certain species of ground orchids was rejected by an august Royal Society in London. Her subsequent series of papers in the *Victorian Naturalist* from 1927 to 1933 “created enormous world interest” to this day.³⁶

Amateur and professional scientists do similar things: they publish articles, do fieldwork and present talks and posters at conferences. Some come to belong – at least partially – to the world of the professional. Lay scientists are not always welcome members of some professional societies. Years ago the general public was prohibited to enter medical libraries. Today open access to the internet allows easy connection to much knowledge. However, many journals are subscription only thereby limiting access to the lay person. There now seems agreement that science has to occupy more open space and not by scientists only.³⁷

This may challenge the notions of “expertise”. What is it about our modern world that celebrity-status invites “expertise” when there is none on so many topics? The study of expertise needs to be developed.³⁸ In SFSGI there are lay persons with extraordinary skills and knowledge in classifying specimens of higher fungi. This co-production in mycology between amateur and professional can foster new ways of thinking about and engaging with science. However, what seems commonplace is that what demarcates science from non-science is a matter of power and authority.³⁹ Occasionally, on a field study, an unusual mushroom is quickly sequestered by a rival professional who evidently seeks control over a contested domain. Amateur scientists are more often than professional scientists, members of different scientific societies and active in several scientific fields at the same time.⁴⁰ A major challenge confronting the citizen scientist is that the partial connections with the professional are commonly fragile but can also exhibit certain strengths. How to motivate citizen scientists and to keep them going can involve “nursing and caring” of the collaborators. These connections are often neither permanent nor strong, but rather partial and fragile. These are among the challenges of the citizen scientist in mycology which currently lacks transforming academic leadership in Australia. The principal limit for volunteers is “the difficulty of finding time”. When they do science, where they do science, how they do science and with what tools they do science seems to differentiate amateurs from professionals.⁴¹

The coupling of citizen science with philosophy and activism

An activist is a person who feels strongly about a cause and who is also willing to dedicate time and energy towards advancing and realising this cause. Activism consists of efforts to bring about change and can take a wide range of forms. Activism, at least in some contexts (e.g., conservation and anti-war), is a moral responsibility. There is nothing wrong with differences of opinion except when diversity becomes polarising and groups compete with or reject each other causing the entire project to lose its original value.⁴²

Serious activism, like history itself, is ongoing. It cannot be worn and then conveniently removed like a pair of shoes. Today it would seem some have been programmed to disconnect from others and the Earth. Physical possessions and the

accumulation of wealth and power appear more important than humanity itself and its life-support systems. Thus the essence of our humanity and the living planet are pillaged and lost. Citizen scientists tend not to lose sight of our intrinsic human value and of the living art of nature. Many citizen activists refuse to be shaped into various forms and figures by those whose aim in life is to kill as they pillage and destroy our precious earth. The serious activist understands that she or he is a part of an ongoing, often strenuous struggle – seeking to find creative ways to collectively save ourselves, each other and this planet – without giving up.⁴³

The media seldom reports objectively on the exemplary activism taking place all around the country, for example, opposition to “fracking” for coal seam gas. Social movements typically have a core of activists (professionals, volunteers or both), a wider group of occasional participants and passive supporters. Social movements are natural homes to grassroots or citizen science, especially when a movement challenges an establishment (e.g., on environmental and health issues) with backing of professional science.⁴⁴ We all desire cleaner air, healthier food, safer water and greener parks. Real solutions do not generally involve corporations or governments but rather involves real public education.

According to new information by teams of citizen scientists and experts, the Earth is now entering the sixth mass extinction event in its four billion-year history. This die-off is the only such event precipitated by human beings. Data by over 10,000 amateur scientists and professionals in the International Union for Conservation of Nature show that currently 51 percent of known reptiles, 52 percent of known insects and 73 percent of known flowering plants are in danger.^{45,46} So too are species of fungi already listed as protected under NSW State legislation.

SFSGI mycology enthusiasts, Elma and Ray Kearney, recently brought to the attention of LCC an alarming malformation referred to as “rosecomb” (abnormal gills caused by diesel toxicity) in protected *Hygrocybe reesiae* and other endangered fungi.⁴⁷ This new mushroom, originally found in LCBP by the Kearneys, was listed (2000) under the NSW Threatened Species Conservation Act of 1995. For the first time, “rosecomb” in protected waxcaps (*Hygrocybe* fungi) in LCBP was recorded. *H. reesiae* rosecomb is not a genetic mutation but rather genetic instability coupled with an exogenous factor (e.g., diesel fumes to induce abnormal morphogenesis of gills), late in development of the fruiting structure. The analogy is thalidomide teratology. Thalidomide was a widely used drug in the late 1950s and early 1960s for the treatment of nausea in pregnant women. It became apparent in the 1960s that thalidomide treatment resulted in severe birth defects (teratology) in thousands of children. Extinction may occur if threats remain, especially at 16°C. What is also relevant is that the World Health Organization (WHO) declared in June 2012 that diesel fumes are a Level-1 human carcinogen (i.e., proven evidence of carcinogenicity in human beings).⁴⁸ Is *H. reesiae* rosecomb a wake-up call as another marker of an environmental epigenetic toxin harmful to people?

On the basis of these observations, an application made to the NSW Scientific Committee, appointed under the NSW Threatened Species and Conservation Act, have made a Preliminary Determination to raise the level of threat to the LCBP ecological fungal community from “Endangered” to “Critically Endangered”. The observation of “rosecomb” has also been reported to the 2013 Federal Senate Committee Inquiry into *The Impacts on Health of Air Quality in Australia* in an effort to bring about change to make the world a healthier place.⁴⁹

A motivating force behind this activism is that the preamble to the WHO’s constitution declares that it is one of the fundamental rights of every human being to enjoy “the highest attainable standard of health”.^{50,51} However, Australia continues to breach *The Universal Declaration of Human Rights* (Article 25) by allowing its citizens to

be exposed to the carcinogenic fumes of diesel, despite the government knowing the dangers.⁵² The United Nations further defined the right to health in Article 12 of the *International Covenant on Economic, Social and Cultural Rights* in 1966.⁵³ The *Covenant* guarantees the “right of everyone to the enjoyment of the highest attainable standard of health”. Article 12.2(b) comprises for example, “the prevention and reduction of the population's exposure to harmful substances such as radiation and harmful chemicals or other detrimental environmental conditions that directly or indirectly impact upon human health”. Petroleum may power our cars and heat our homes, but it also contributes to birth defects and disorders like asthma, emphysema and cancer as well as deformities in other species including protected fungi. Why is this so? Terry Tamminen claims: “Oil and car industries have acted again and again to deceive regulators about the hazards of their products and have used their wealth to hamstring attempts by state and federal legislators to make laws that address such threats/hazards”.⁵⁴

Indeed, the 2009 documentary *The Idiot Cycle* claims that certain chemical manufacturers, including oil cartels, are profiting from the production of cancer-causing products and then some of the same companies are investing in profitable cancer treatments – making pollution itself a cash cow. Public health experts fear global trade agreements and powerful transnational companies continue to create a boom industry in death and disease.

“Globalisation” is too often confused with a beneficial notion of genuine mutual interdependence and cooperation between nation states – but in reality it clearly is not. In an effort to maintain profit margins, here and abroad public assets are plundered, human life trampled upon and the environment destroyed. In secret negotiations behind closed doors, the Trans-Pacific Partnership will allow corporations to sue nations if laws such as those protecting the environment interfere with corporate profits. Activism will not see our biodiversity hollowed out. National and international regulatory mechanisms, based on evidence, must be put in place. Enter the citizen scientist.

Data collected by citizen scientists clearly show that extinction rates have dramatically increased several hundred times beyond historical levels over the last few decades. The causes of such biocide are human environmental poisons. Are there ways to help prevent what many experts believe is a coming worldwide bio-collapse? It begins with citizen scientists holding meetings, educating others and developing plans to reduce the defined threats. As with so many other issues, people must both protest what they oppose and build new systems of replacement. It all begins at the grassroots level involving mainly the citizen scientists.

At the time of Rachel Carson's seminal work *Silent Spring*, published in 1962, there was virtually no environmental movement in Australia. Conservation was not taken seriously by governments or the public. However, *Silent Spring* changed public and government awareness of a serious threat to both human beings and the environment. Her impassioned plea arose from her understanding of the fragile relationship of the ecosystem that we, and all other living things, rely upon. Here was individual activism in operation.

Today, when ordinary citizen scientists and others rise up in anger and hope, they have power to defy governments and focus debate by politicians. Such moments are upon us now to bring change for good. In the words of Max Ehrmann who in 1927 wrote “Desiderata” (Latin for “desired things”): “You are a child of the universe no less than the trees and the stars; you have a right to live”.⁵⁵ The poem is a list of things desirable in life – technically, things considered necessary or highly desirable or something lacking and wanted. The poem's simplicity and affirmation of life resonate more than ever. Applied to activism, such wisdom coupled with collective defiance and

its subsequent disruption, has always been essential to the preservation of democracy and of our life-support systems.

The future and what further steps to be taken

Whilst species lists (with photos) in grassroots mycology are of some value in mapping occurrence, such lists do not provide sufficient scientific evidence for most species in a prescribed location. It is now imperative that the annual, two-hour collections must be linked to basic ecological data-sets to include grid/satellite location and habitat substrate. This ecological approach to conservation seems missing today. Preservation of specimens provides an archival record for future reference as classification will change with evolving concepts of species. Such preservations will place demands on limited funding and resources to maintain such herbaria.

The application of nucleic acid sequencing is now obligatory for meaningful taxonomy. In a field study, undertaken by members of SFSGI, eleven specimens of fungi in one genus were classified as one species by a specialist taxonomic mycologist but, when subjected to molecular analysis by citizen scientists and a specialist pharmacologist, three distinct species were identified. Objective analysis of such complex mimics by sequence analysis has only just begun.

Citizen science does need a home preferably within a university or research institute. Restricted access to scientific journals limits the taxonomic treatments by citizen scientists, who in some cases are daunted by the complex process of describing a new species, often requiring examining material on loan from herbaria. Such taxonomic pursuits require an affiliation with a university or similar institution. Today, however, with little or no funding for mycology and when taxonomic mycologists are critically endangered, much of the collecting and identifications are made by experienced citizen scientists. Attempts must be undertaken to improve the connections between the remnant professional mycologists and enthusiastic citizen scientists. Without such collaboration, the work of field studies, voucher collections and sequencing will cease.

Notes

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