

CITIZEN SCIENTISTS TO THE RESCUE THE PAST, PRESENT AND FUTURE OF THE NORTH AMERICAN MYCOFLORA PROJECT

By Bill Sheehan, Joanne Schwartz and Sigrid Jakob

The [North American Mycoflora Project](#) (“NAMP”) was launched into the world at the annual meeting of the American Mycological Society at Yale University on July 14, 2012. It was born from an audacious vision: to create a complete ‘funga’ for North America – a comprehensive list of the continent’s fungi, supplemented by maps, images, voucher specimens and sequences for every single species. It would have been a step far beyond the incomplete and often unreliable patchwork of foray lists, monographs and herbarium inventories that currently makes up our understanding of the fungi of North America.

This ambitious enterprise never got out of the starting gate, mainly because it would have required hundreds of mycologists and millions of dollars in funding, dollars that no institution was able to provide.

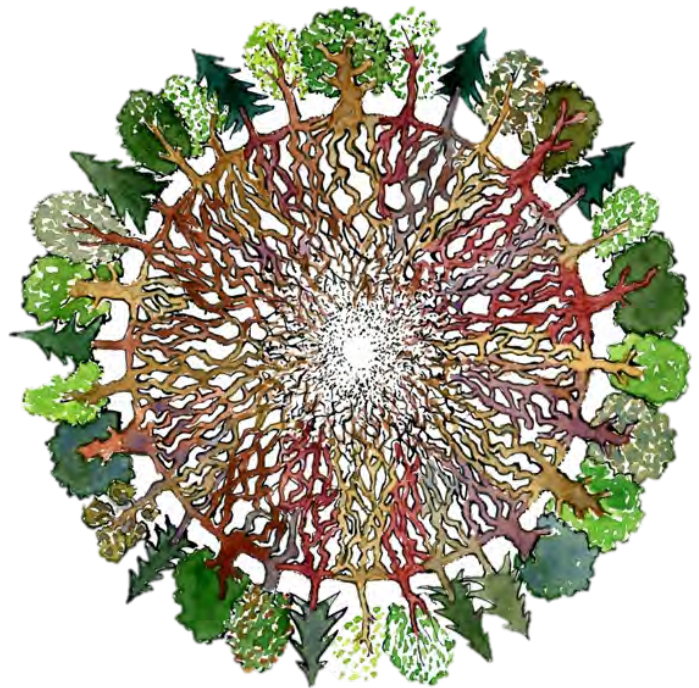
And so the idea lay dormant, waiting for its moment.

The launch of a movement

By 2017, the world had changed. The “molecular revolution” had transformed mycology; DNA sequencing of fungi shed new light on relationships among genera, revealed their history, and allowed for a more confident identification of specimens beyond the murkiness of morphological characteristics. But even then, this powerful tool was still only available to the very few.

The vision propelling this new incarnation of NAMP as a newly incorporated nonprofit organization was just as bold as its predecessor – but also more realistic and inclusive. Instead of relying on a small cadre of overworked and underfunded mycologists to document the continent’s fungi, it would harness the efforts of the thousands of mushroom enthusiasts who already spend their weekends surveying America’s forests and wetlands, reserves and parks. We believed that, equipped with the right

protocols, these citizen scientists could do the collecting and vouchering and we could get their collections sequenced. Together, we could vastly expand the knowledge of our native fungi.



Artist's depiction of a Wood Wide Web of fungi
Credit: Frits Ahlefeldt-Laurvig, Hiking Artist

And so, in 2018, the [North American Mycoflora Project](#) was reborn thanks to the perseverance and dedication of a few volunteers, coupled with the support of generous sponsors and donors, including the [North American Mycological Association](#). In just two years, over 160 projects have seen the light of day. These projects span a broad geographic range, from Alaska to Puerto Rico, and Hawaii all the way to Greenland. Projects range in scale from local and regional to continent-wide, and include forays and taxon-focused projects (such as *Cortinarius*, *Inocybe*, *Russula*, Boletales, Bankeraceae, polypores, crust fungi and others).



Eight-headed *Amanita ocreata* found by Macro Fungi of the Channel Islands (CA) project. Credit: Joanne Schwartz

While most projects are led by unaffiliated mycophiles, a good percentage are connected to mushroom clubs, civic organizations (such as the Great Plains Nature Center, Potter Valley Tribe), educational institutions (such as Valdosta State University, Glen Urquhart School), government organizations (such as Northwest Territories, Florida Department of Agriculture and Consumer Services) and national parks (such as Boston Harbor Islands, Glacier National Park). There's even a project that aims to find and sequence mushrooms described by Charles McIlvaine around Philadelphia more than a century ago.

Almost 4,300 specimens have been sequenced to date from the various individual projects, with results posted on [MycoMap](#) and some also on [MyCoPortal](#) and [Genbank](#). Among these are very rare species like *Lachnum halesiae* found on *Halesia carolina*; an undescribed species in the family Hymenogastraceae; an undescribed *Callistosporium*; and undescribed species in *Amanita* such as *Amanita sp-N68* and in *Russula*, including *Russula sp-IN58* and *Russula sp-IN99*.

NAMP data has also helped clarify species: for example, Jean Lodge, University of Georgia and NAMP board member, is working with members of two NAMP projects (South Sound, WA and Long Island, NY) to sort out three species of *Chromosera* formerly thought to be one. These species includes *Mycena lilacifolia* Peck, which will be resurrected in the genus *Chromosera* and taken out of synonymy with *Chromosera cyanophylla*.

Other species that have been taken out of synonymy thanks to NAMP data include *Calvatia lilacina* (which we now know is not same as *C. cyathiformis*); *Bolbitius variicolor* taken out of synonymy with *B. titubans*; and *Amanita pantherinoides*, which has been discovered to be a valid American species and not a synonym of *A. pantherina*.

In addition, two Continental Mycoblitzes – “virtual” forays open to anyone with an iNaturalist account – have resulted in 5,285 observations of 1,165 species, by 220 participants. Almost 600 sequences have been posted so far and more will be processed once the Aime Lab at Purdue University resumes working after the COVID-19 lockdown.

Beyond the numbers, NAMP has made its mark in other ways: it has allowed regular mycophiles and mushroom clubs access to tools previously reserved for scientists. It has inspired them to become better citizen scientists, to learn new skills and come to a deeper understanding of this very special kingdom.



98 dried project specimens from one collecting trip
Credit: Joanne Schwartz

Learning as we go

As was to be expected, the ambitious enterprise of democratizing molecular analysis and engaging hundreds of citizen scientists in the process was not without teething pains: the labs that did our sequencing weren't always able to accommodate our idiosyncratic workflow, our participants didn't always follow protocols on how to submit their specimens, and not all sequences are easy to

interpret by nonscientists, to name but a few of our most prevalent issues. By the end of 2019, we had to ask our participants to hold off on sending any more specimen tubes; we were officially on hiatus. This forced break, while frustrating, proved to be a blessing in disguise. While we were busy having conversations and a round of sequence and data-flow tests with a potential sequencing partner, we also did some soul searching. We were proud of what we had achieved in just two years, but we wondered, was there an opportunity to make an even greater impact?

In talking to enthusiastic amateurs, we often heard that they found us intimidating. And we'll admit that it takes a certain amount of dedication to document a collection, dry the specimen, send it in for sequencing, make sense of the results, and send it to a fungarium. This means our participants are a relatively small but dedicated group, self-selected for their willingness to engage with our protocols. On the other hand, platforms like iNaturalist and Mushroom Observer have demonstrated that there are tens of thousands of people passionate about fungi, people who are willing and able to create records of their finds. We accepted the challenge to make NAMP accessible and inviting to more participants.

Fungi under attack

The other question we asked ourselves was about our impact in the world. Participants love that sequencing has the power to resolve thorny ID questions and help put a name to a mysterious find. But to see NAMP purely as a tool for identification is vastly to underestimate its potential.

Today, fungi are under threat like never before. Habitat destruction, pollution and climate change mean that fungi are going extinct or changing distribution faster than humans can document. Underfunded mycology departments and a loss of “[alphataxonomists](#)” mean there are fewer individuals with the time and expertise to catalog and map. And, because institutions and the general public don't understand the critical contribution of fungi to ecosystems, these manifold threats will not change anytime soon.

However, these threats do create an opportunity and an urgent need to put NAMP into the service of conservation as a tool to help document and even protect rare and endangered species, or

a way of tracking species that are harbingers of climate change. These data could support plans and policies for land management and habitat restoration, as well as Red List species submissions. We might help connect clubs and individuals with organizations needing fungal surveys for threatened habitats. We could partner with scientists doing research on rare or threatened species or the impact of climate change on the natural world, and supply an army of foot soldiers to collect and document them.



Fungi are a hyper-diverse kingdom.
Credit: Wikimedia Commons

A new organization for a new world

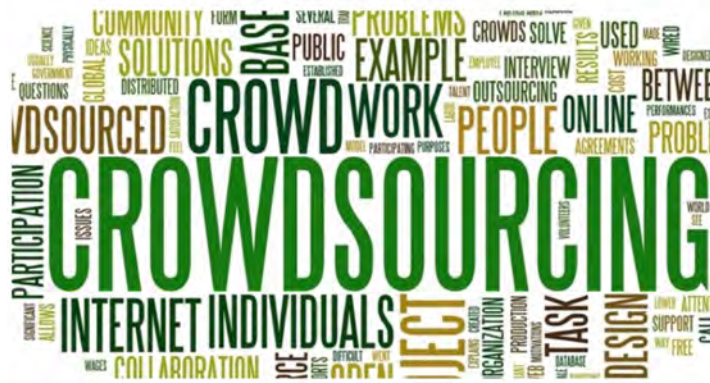
It is clear that there is an opportunity for NAMP to engage more people and make a greater impact in the world. But tweaks to our current organization wouldn't be enough to make this happen. That's why we took this hiatus, as an opportunity fundamentally to rethink who we are and how we operate – a complete reboot, if you will.

The new NAMP will relaunch in early August 2020.

Our mission will be expansive and inclusive: to equip citizen and professional scientists with the tools to document the diversity and distribution of fungi across North America.

For a start, we're ditching our name. Having the botanical term "flora" in our name is directly at odds with our desire to be champions of our very own kingdom, Fungi, so it had to go. We'll reveal our new name on our relaunch day, but suffice to say it reflects our mission.

We have a new sequencing partner in the Barcode of Life Data System ("BOLD"), based at the Center for Biodiversity Genomics at the University of Guelph, Ontario, Canada. BOLD is able to analyze high volumes at low cost with a predictable turnaround time. This partnership will clear the DNA-sequencing bottlenecks and offer other advantages, such as easy GenBank submission.



Credit: International Institute of Information Technology, Hyderabad

We will also be making it easier to participate in NAMP. We believe that every enthusiastic member can contribute good data, even if they are not yet ready to voucher and sequence. If thousands of citizen scientists learned to take and post quality geo-tagged field photos, not only would we be building an important body of ecological and taxonomic data, we would also be creating a pool of individuals who will want to learn more about science and move up to the next level. Our goal is to engage many more people, especially young people, in what we're calling **Level 1 activities**, and then provide resources and encouragement to those who want to do the more complex activities of sequencing and vouchering (Levels 2 and 3 respectively).

Come participate!

So if you're already participating in a NAMP project, welcome back! You'll be hearing from us soon about all that is new, as well as what to do with your samples.



And if you're merely curious, and would like to find out more, sign up for our Funga Decoded eNewsletter (<https://mycoflora.org/email-list>) and Deep Funga Blog (<https://mycoflora.org/index.php/resources/blog>), and follow us on Facebook at <https://www.facebook.com/mycoflora> and Instagram at https://www.instagram.com/na_mycoflora/. We have all kinds of exciting announcements to make. We'll be opening a new round of sequencing grants to help more projects sequence even more specimens.

Participating has never been easier – or more important. We look forward to a world in which citizen scientists of every experience level come together to collect valuable data to increase awareness of the critical role of fungi in the health of our ecosystems, allowing us better to protect them in a world of rapid climate change and habitat loss.

About the authors

Bill Sheehan is the President of the North American Mycoflora Project. He's a recovering entomologist who discovered fungi seven years ago after starting and running national environmental policy nonprofit organizations. He's leader of the Northeast Georgia Funga NAMP project.

Joanne Schwartz is Vice President of the North American Mycoflora Project. As a naturalist who has studied fungi for over 50 years, she leads the Macro Fungi of the Channel Islands (CA) NAMP project.

Sigrid Jakob is an amateur mycologist, citizen scientist and NAMP project leader for Fungi of NYC, with a particular interest in coprophilous fungi.