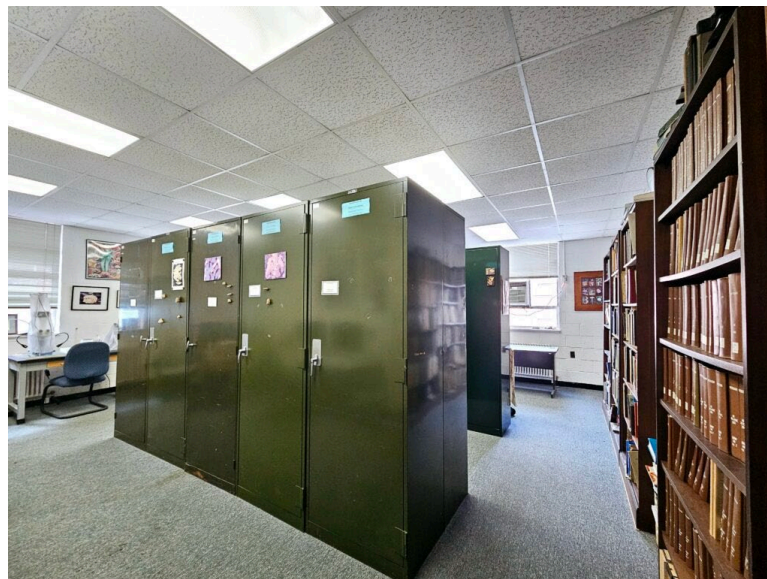


# Pressing Concerns: News from the Larry F. Grand Mycological Herbarium

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## An overview of the Larry F. Grand Mycological Herbarium

A mycological herbarium is a place where collections of preserved, dried, pressed (or boxed) specimens of fungi are housed. Important metadata for these specimens such as scientific species name; location and date of collection; habit, ecological habitat and substrate; microscopic and macroscopic characters; and collector name are recorded when the fungus is collected. The metadata are always recorded in a computer database as well as a printed paper specimen label associated with the specimen. When properly cared for, herbarium specimens can last for hundreds of years. As such, they serve as important historical vouchers, each of which “is an important record of a particular species growing in a particular place at a particular time” (Rob Huxley, the Natural History Museum, London). In this capacity, a mycological herbarium is similar to a natural history museum. However, because fungi lack hard tissues and are mostly composed of water, dried fungal specimens don’t preserve and display as well as the specimens we usually see on exhibit in natural history museums, i.e., animal (zoological) and fossil (paleontological) specimens. This is also the reason why fewer fungal fossils have been found than for animals and plants. Because most fungi are associated with plants, mycological herbaria can give us critical information about plants as well as fungi.



**The newly reorganized Larry F. Grand Mycological Herbarium, 3419 Gardner Hall, NC State University. Photo by Achintya Prathikantam.**

Mycological herbaria (plural) provide a critical infrastructure for answering key educational and scientific research questions. First, they serve as a reference for biodiversity research, a field of inquiry focused on accurate species identification. Comparison with herbarium specimens—to confirm one's own identifications—should be the final step in every biodiversity inventory. After identifications are confirmed in this way, representative voucher specimens from inventory research should be deposited in an herbarium to provide a reference for future scientists to verify the findings of one's inventory. Depositing voucher specimens allows for reproducibility of results, which is a major principle of the scientific method.

More modern, non-traditional uses of herbaria include tracking species of fungi and associated plants through time and space to provide evidence of climate and environmental change. For example, recent research conducted on historical herbarium voucher specimens suggests that some cold-loving, boreal species of fungi were more widespread in high-elevation habitats of the Southern Appalachians, but are now restricted to northern latitudes. In addition, increasing numbers of artists and historians are utilizing herbarium specimens to inspire artwork, or develop biographies of famous collectors. Another relatively new, innovative use for herbaria is mining preserved fungal specimens for DNA to study population genetics and reconstruct evolutionary relationships. Recent technological advances have made it much easier to extract, amplify and sequence DNA from herbarium specimens. Because of these advances, herbaria represent a goldmine of "ancient DNA" that is now being used to explore many interesting questions from tracking the spread and evolution of invasive species and plant diseases, to revealing new species and patterns of host specialization of plant pathogens (which is the current focus of NCSU's Bradshaw Lab; see article below).

Our herbarium, called the Larry F. Grand Mycological Herbarium (official herbarium designation: NCSLG), is currently housed in room 3419 Gardner Hall at North Carolina State University in Raleigh. The herbarium was established in 1970 by Professor Larry F. Grand and contains specimens collected from ecologically diverse habitats located in North Carolina, Georgia, South Carolina, Tennessee, and Virginia. Unique habitats in North Carolina represented in our herbarium include bald regions of the Southern Appalachian Mountains; and Nags Head Woods, a remnant Coastal Plain longleaf pine ecosystem that comprises the largest contiguous maritime forest on a barrier island in the eastern US. Our herbarium consists primarily of plant pathogenic (~5600 specimens) as well as wood decay (~2900 specimens) fungi—particularly those associated with species of woody plants found in forest ecosystems. The remaining specimens in the collection consist of mushrooms, cup fungi, and jelly fungi, totaling approximately 700 specimens. This collection has received painstaking attention to document and conserve its specimens, which are of ecological, economic and evolutionary importance to educators, scientists and the public. Recent specimen acquisitions from Germany and Japan, acquired by the newly appointed Director, Michael Bradshaw, will exponentially increase the number of powdery mildew holdings. The herbarium also houses a substantial library of mycology books, scientific journals and reprints.

A main priority for the herbarium is to improve accessibility. For example, how can we find a given fungus specimen in the collection in the least amount of time and improve engagement and visitation? And, by what means can remote users access and experience our specimens? To improve accessibility at NCSLG, one of our major objectives is to focus on digitizing our collections to provide specimen images and associated metadata to educators, scientists and the public, via the internet. Our digitization efforts include “georeferencing” the collections. This means that a latitude and longitude location are assigned to each digitized specimen, allowing them to be used in Geographic Information Systems (GIS) applications, creating a geographic range map for a given species. A substantial number of specimens in our collection were digitized from 2009-2014 as part of a National Science Foundation Biological Research Collections Program grant obtained by Drs. Larry Grand and Marc Cubeta. During this project, one high school (Max Larkin), 14 undergraduates, two graduate students, one visiting scientist (Henry Van Cotter), and research specialist Bryan Cody, contributed to the digitization efforts. Bryan was largely responsible for importing specimen data into the searchable online fungal database known as MyCoPortal ([www.mycportal.org](http://www.mycportal.org)). To browse only NCSLG’s collections in MyCoPortal, navigate from “Search Collections” on the left navigation section of the MyCoPortal website. “Deselect all Collections” and select “NCSLG” and click “Search” on the right or lower sections of the page.

Happy Fungus Hunting,

Scott A. LaGreca, Ph.D.  
Curator, Larry F. Grand Mycological Herbarium

Any questions, comments and feedback? please email me at [salagrec@ncsu.edu](mailto:salagrec@ncsu.edu)

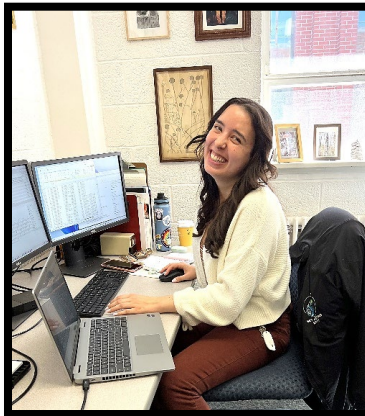
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## Meet our team



### **Dr. Michael Bradshaw, Director of the Mycological Herbarium**

Dr. Bradshaw is an Assistant Professor of Emerging Plant Diseases. He received his MSc and Ph.D. from the University of Washington. Before arriving at NC State last summer, Michael was a postdoctoral associate at both USDA headquarters in Beltsville, MD, and Harvard University. Michael is a PI on a new NSF (Division of Environmental Biology) funded project, “A North American monograph of the powdery mildews (Erysiphaceae)”. Using both molecular and morphological tools, this three-year project will allow more accurate identification of powdery mildews, as well as an understanding of how pathogens invade new substrates (namely, blueberries: *Vaccinium* spp.). For more information, visit the Bradshaw Lab website: <https://mbradshawlab.wordpress.ncsu.edu/>



### **Uma Crouch, Manager of the Bradshaw Lab**

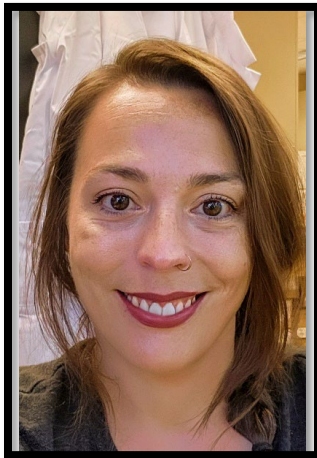
Uma is originally from California, where she completed her undergraduate degree at California State University, Monterey Bay and then worked for a year at the USDA-ARS in Salinas. She recently finished her MSc. at Pennsylvania State University, where she researched the fungal pathogen *Verticillium dahliae* in potato agroecosystems and its

endophytic colonization of various weed hosts. Uma's current research interests include molecular diagnostics, phylogeny and population genetics of fungi.



#### **Dr. Scott LaGrecia, Curator of the Mycological Herbarium**

Dr. LaGrecia is a lichenologist by training, but has a secret love of powdery mildews. He holds a Ph.D. in Botany from Duke University and has worked at four major herbaria (Harvard; the Natural History Museum, London; Cornell; and Duke) over the past 25 years. His research interests include the secondary chemistry and phylogeny of lichenized fungi, especially the genera *Lecanora* and *Ramalina*. Scott has done extensive fieldwork documenting the lichen flora of North Carolina.



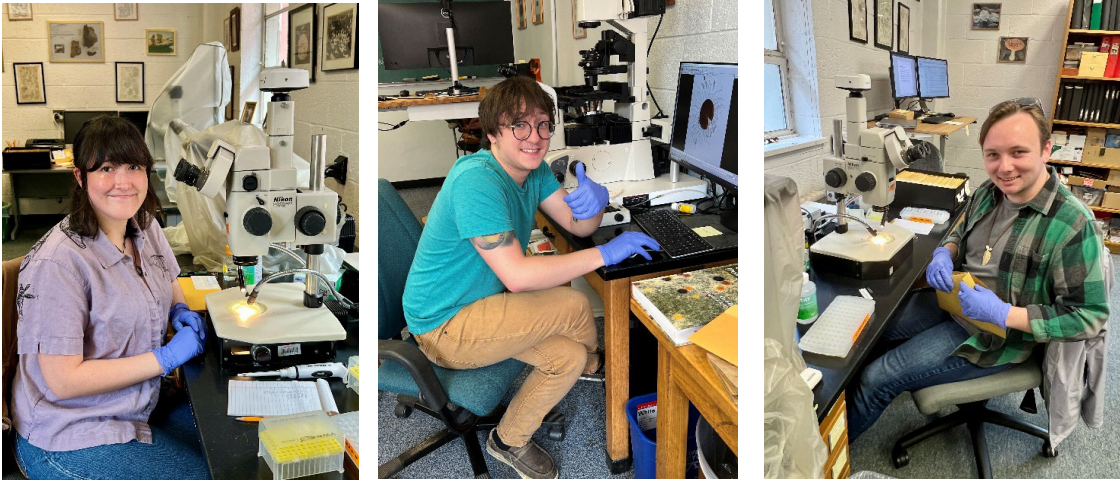
#### **Jackie Thomas, Postdoctoral Research Associate in the Bradshaw Lab**

Dr. Thomas obtained her BS and MSc. in Biology from the University of Central Arkansas. She then moved to South Carolina where she earned her Ph.D. in Genetics from Clemson University. Jackie's research passion plant-microbe interactions of all kinds—specifically, the molecular mechanisms underlying those interactions.



## Spring 2024 Herbarium Students

The start of 2024 saw our herbarium hopping with three amazing NC State undergraduates. Extracting DNA from hundreds of herbarium specimens, Nina, Jake and Christian were instrumental in kicking our NSF project on powdery mildews into high gear.



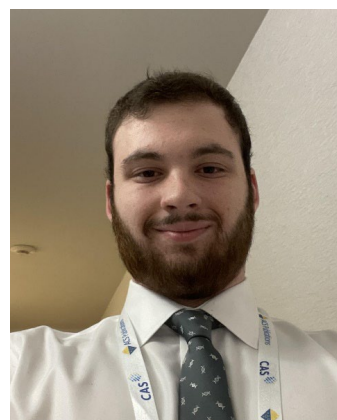
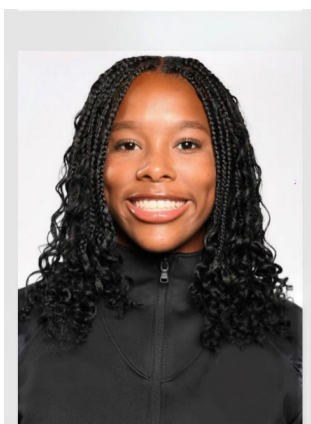
### **Our Spring undergraduates: Nina Esquerdo, Christian Shaw, and Jake Thompson**

**Nina** is a senior majoring in Fisheries, Wildlife, and Conservation Biology with a concentration in Wildlife Science and a minor in Plant Biology. Nina is originally from the Charlotte area and plans to return for graduate school to earn her Masters in Fisheries, Wildlife, and Conservation Biology.

**Christian** is a junior majoring in Microbiology. His research experience project, in the laboratory of Professor Kevin Garcia, is on ectomycorrhizal fungal associations with loblolly pines. Christian, originally from Forsyth County, is an active member of the NC State Student Mycology Club.

**Jake** is a senior Plant Biology major with minors in Entomology and Ecology. In addition to working in the mycological herbarium, Jake does curatorial work for Professor Alexander Krings downstairs in the vascular plant herbarium. This semester Jake is earning the Field Botany certificate. Originally hailing from Albemarle NC, Jake plans to pursue a career in plant biology. After his schooling Jake plans to work with native habitat restoration, and teach at the university level.

## Summer 2024 Herbarium Interns



### **Our Summer Interns: Lena Richardson, Andrew Paul, and Gabe Valenzano**

**Lena Richardson** is a sophomore at the University of South Carolina and a member of her university's Track and field team. She is a Biological Sciences major with a minor in business administration and loves all things biology. She will be working this summer in Dr. Bradshaw's lab, along with preparing events for her university's alliance for women in the STEM club in which she is the event coordinator. After completing undergrad, Lena plans to continue her education and pursue a Ph.D. in an undecided biological topic, which she will then use to pursue a career in research.

**Andrew Paul** is fourth year undergraduate with a double major in Plant Biology and Philosophy. In addition to his work in the herbarium, he does research on endophytes in wheat in the Hawkes Lab. He's also president of the NC State Mycology Club. Andrew is looking forward to graduating in the Fall and taking some time off before graduate school.

**Gabe Valenzano** is a junior Biochemistry major with a minor in Physics. Gabe has worked with Dr. Heather Miller, culturing MRSA and discovering the effects of antibiotic adjuvants at High Point University for the past 2 years. Originally from Saint Charles IL, Gabe intends to pursue a Ph.D. in Biochemistry to become a researcher while continuing to branch and explore different areas of science.

**Christian Shaw** is also interning with us this summer. He worked for us in Spring 2024; he is profiled above.

## News and Notes



### Funding opportunities

A small amount of funding (~\$500-\$1000) is available from the Larry F. Grand Mycological Foundation for students who plan on using the Mycological Herbarium collections for research. To be considered for an award, applicants should send a CV, cover letter and two-page research proposal (not including references) to Michael Bradshaw at [mbradshaw@ncsu.edu](mailto:mbradshaw@ncsu.edu).

### The Spring 2024 NC State Schenck Forest Foray

On the afternoon of April 13, 2024, 30 mycophiles—young and old alike—came together to explore the Spring mycoflora in NC State’s Schenck Research Forest. Despite dry conditions, we found polypores such as *Ganoderma* and *Trichaptum* spp.; some interesting *Hypoxyylon* spp.; *Pluteus* cf. *cervinus*; *Uromyces ari-triphylli* (a rust on Jack-in-the-Pulpit); *Xylophorus* sp.; and random lichens and LBM’s (= Little Brown Mushrooms). In addition, an interesting—potentially new—powdery mildew was collected on young leaves of ironwood (*Carpinus caroliniana*). The ITS locus will be sequenced for all specimens collected during the foray, which was organized by the Director of the Center for Integrated Fungal Research, Professor Marc Cubeta.



Spring 2024 Schenck Forest Foray “Team Mushroom”. Photo by Tom Cuffney.





## Register for the 2024 NC State DEPP Plant Patho-thon!

Please join us on July 13th and September 21st for the 2024 “Plant Patho-thon”—a series of local plant pathogens excursions to expand both our knowledge of local plant pathogens, and the holdings of the Larry F. Grand Mycological Herbarium. This year we will be visiting NC State’s J.C. Raulston Arboretum to collect a representative voucher specimen of all fungal plant pathogens we encounter! The ITS locus of each collected specimen will be sequenced, followed by accession of material into the herbarium. Please email Scott LaGreca at [salagrec@ncsu.edu](mailto:salagrec@ncsu.edu) for details, and to register.

## White Pines Preserve BioBlitz Planned

Save the date!: on Saturday, October 19th, there will be a mycological BioBlitz at White Pines Preserve in Sanford. A BioBlitz is a 24-hour survey of all taxa present in a particular area. Come help us update the last mycological inventory from 1972. This is part of the North Carolina Biodiversity Project’s year-long inventory of the Preserve. Please contact Marc Cubeta at [macubeta@ncsu.edu](mailto:macubeta@ncsu.edu) for details.

## Join the Triangle Mycological Society

The brand-new Triangle Mycological Society is dedicated to enhancing understanding and appreciation of fungi, with a special focus on mushrooms, across the Research Triangle area, which spans Durham, Orange, and Wake counties in North Carolina. Our activities are diverse and designed to engage members with the fungal world through monthly lectures, regular meetings, mushroom hunts, workshops on identifying fungi, as well as incorporating photography and arts, alongside in-depth evaluations of the latest fungal research. While we do not require membership fees, we encourage a yearly donation of \$20 to the Larry F. Grand Mycological Foundation. These contributions directly support our operations, including our

newsletter; the organization of foraging expeditions and lectures; funding a scholarship; and covering various other costs necessary to sustain the society. Additional donations beyond the suggested amount are warmly welcomed and greatly aid in our mission. For more information, and to join, go to: <https://ncslg.cals.ncsu.edu/triangle-mushroom-club/>

## Students: Join the NC State Mycology Club

Last Fall, NC State fourth year student and Summer Herbarium Intern Andrew Paul (profiled in this newsletter) wanted to bring students interested in fungi together. So he founded the NC State Mycology Club. Over the past year, the club has hosted guest lectures from NC State faculty, organized foraging trips, and held presentations on ethnomycology and mushroom identification. Interested? Follow them on Instagram, @ncsu\_mycology\_club, or contact Andrew at [ampaul@ncsu.edu](mailto:ampaul@ncsu.edu).

## Recent publications by herbarium staff

**Bradshaw M**, U Braun, L Quijada, DH Pfister. 2024. Phylogeny and taxonomy of the genera of Erysiphaceae, part 5: *Erysiphe* (the “Microsphaera lineage” part 1). *Mycologia* 116 (1): 106-147. doi:10.1080/00275514.2023.2252715. [*this paper used DNA from an NCSLG specimen*]

**Bradshaw MJ**, Aime MC, Rokas A, Maust A, Moparthi S, Jellings K, Pane AM, Hendricks D, Pandey B, Li Y, Pfister DH. 2023. Extensive intragenomic variation in the internal transcribed spacer region of fungi. *iScience*. 2023 Aug 18;26(8):107317. PubMed Central PMCID: [PMC10387565](https://pubmed.ncbi.nlm.nih.gov/37755416/).

**Bradshaw M**, Boufford D, Braun U, Moparthi S, Jellings K, Maust A, Pandey B, Slack S, Pfister D. 2023. An in-depth evaluation of powdery mildew hosts reveals one of the world’s most common and widespread groups of fungal plant pathogens. *Plant Dis*. 2023 Sep 27; PubMed PMID: [37755416](https://pubmed.ncbi.nlm.nih.gov/37755416/)

**Bradshaw M**, Braun U, Pfister DH. 2023. Phylogeny and taxonomy of the genera of Erysiphaceae, part 4, *Erysiphe* (the “Uncinula lineage”). *Mycologia* 115(6):871-903. doi:10.1080/00275514.2023.2230853. [*this paper used DNA from an NCSLG specimen*]

**Bradshaw M**, Braun U, Pfister DH. 2023. Phylogeny and taxonomy of the genera of Erysiphaceae, part 3: *Cystotheca*. *Mycologia*. 115(3):427–436. doi:10.1080/00275514.2023.2194172

**Bradshaw M**, U Braun, S Takamatsu, MZ Németh, D Seress, DH Pfister. 2023. The *Erysiphe alphitoides* complex (powdery mildews) – unravelling the phylogeny and taxonomy of an

intricate assemblage of species. New Zealand Journal of Botany, 1-17.  
doi:10.1080/0028825X.2023.2276913

**Bradshaw MJ**, Carey J, Liu M, Bartholomew HP, Jurick WM 2nd, Hambleton S, Hendricks D, Schnittler M, Scholler M. 2023. Genetic time traveling: sequencing old herbarium specimens, including the oldest herbarium specimen sequenced from kingdom Fungi, reveals the population structure of an agriculturally significant rust. New Phytol. 2023 Feb;237(4):1463-1473. PubMed PMID: [36385249](https://pubmed.ncbi.nlm.nih.gov/36385249/).

**LaGreca S**, Lewis-Gentry G, Briscoe L, Lendemer JC. 2024. Typification of the Lace Lichen, *Ramalina menziesii* Taylor—and its synonyms—reiterates the need for complete typification of names for well-known or iconic taxa. TAXON 73(2)  
[<https://doi.org/10.1002/tax.13164>]

**LaGreca S**. 2023. Chicita Francis Culberson (1931-2023). The Bryologist 126(3): 379-384.  
[<https://doi.org/10.1639/0007-2745-126.3.379>]

Paez CA, Kraistudomsook N, Smith JA, Loyd AL, Lindner DL, Smith ME. 2022. Revising the taxonomic placement of *Laetiporus persicinus* within the Laetiporaceae. Mycologia: DOI: 10.1080/00275514.2022.2139144/ [**this paper used DNA from an NCSLG specimen**]

Schnabel E, **Thomas J**, El-Hawaz R, Gao Y, Poehlman WL, Chavan S., ... & Frugoli J. 2023. Laser Capture Microdissection Transcriptome Reveals Spatiotemporal Tissue Gene Expression Patterns of *Medicago truncatula* Roots Responding to Rhizobia. Molecular Plant-Microbe Interactions, 36(12), 805-820.

**Thomas J**, Frugoli, J. 2024. Mutation of BAM2 rescues the sunn hypernodulation phenotype in *Medicago truncatula*, suggesting that a signaling pathway like CLV1/BAM in Arabidopsis affects nodule number. Frontiers in Plant Science, 14, 1334190.

**Thomas J**, Hiltenbrand, R., Bowman, M. J., Kim, H. R., Winn, M. E., Mukherjee, A. 2020. Time-course RNA-seq analysis provides an improved understanding of gene regulation during the formation of nodule-like structures in rice. Plant Molecular Biology, 103, 113-128.

Xu M, Liu Y, Möller E, **LaGreca S**, Moya P, Wang X, Timdal E, de Boer H, Barreno E, Wang L, Thüs H, Andrésón Ó, Magnússon KP, Ólafsdóttir ES, Heiðmarsson S. 2023. Mycobiont-specific primers facilitate the amplification of mitochondrial small subunit ribosomal DNA: a focus on the lichenized fungal genus *Melanelia* (Ascomycota, Parmeliaceae) in Iceland. MycoKeys 96: 57-75. [<https://doi.org/10.3897/mycokeys.96.100037>]

Wiggins G, **Thomas J**, Rahmatallah Y, Deen C, Haynes A, Degon Z, ... & Mukherjee A. 2022. Common gene expression patterns are observed in rice roots during associations with plant growth-promoting bacteria, *Herbaspirillum seropedicae* and *Azospirillum brasilense*. Scientific Reports, 12(1), 8827.