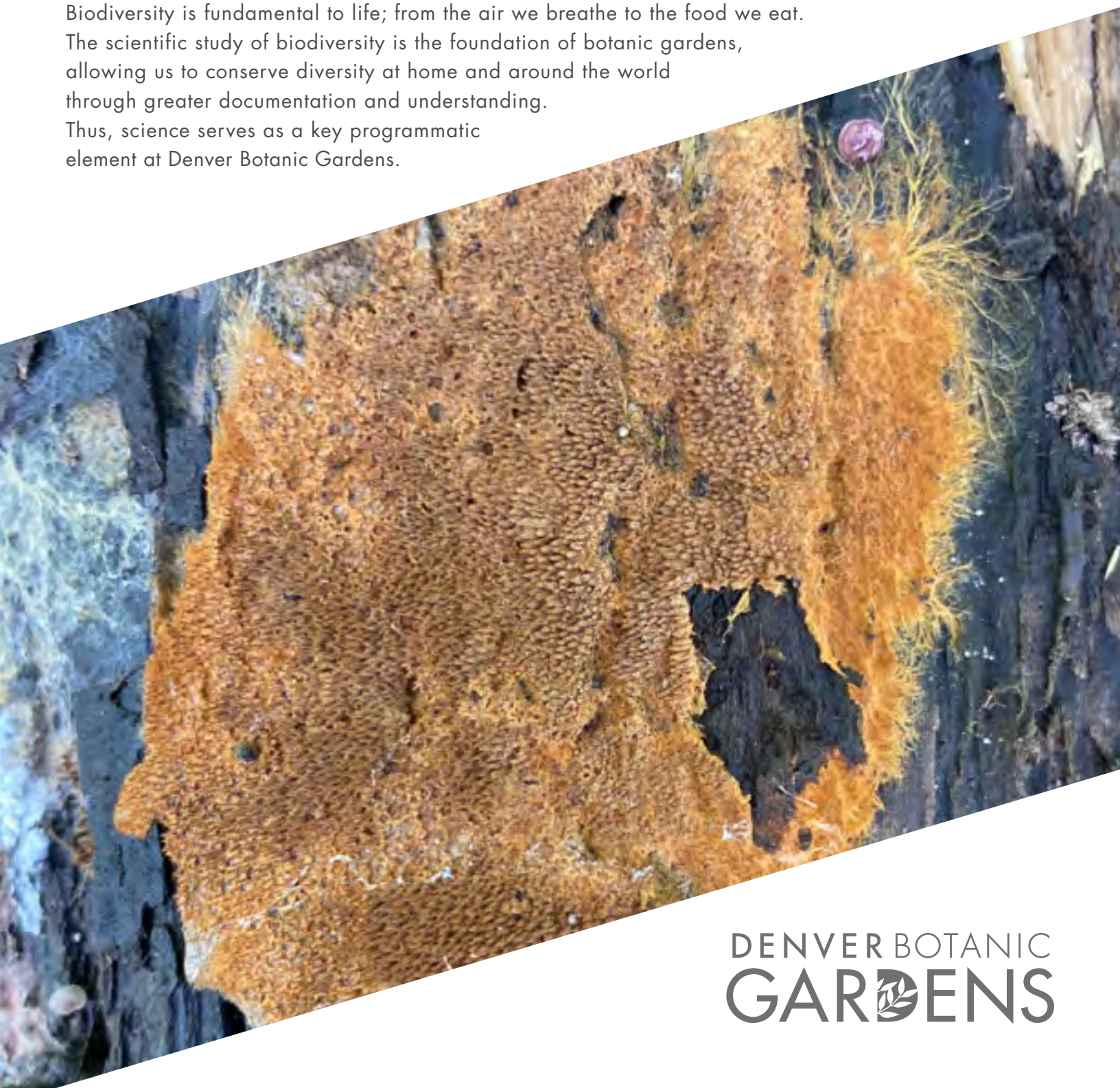
SCIENCE

2025 YEAR IN REVIEW

Biodiversity is fundamental to life; from the air we breathe to the food we eat. The scientific study of biodiversity is the foundation of botanic gardens, allowing us to conserve diversity at home and around the world through greater documentation and understanding. Thus, science serves as a key programmatic element at Denver Botanic Gardens.



DENVER BOTANIC GARDENS

On the cover:
Odontia ferruginea is a species of fungus that is rarely documented but likely abundant in our forest ecosystems. This species is believed to be a saprotrophic decomposer of plant materials like wood. Denver Botanic Gardens is pursuing documentation of these fungi in order to demystify their importance to Rocky Mountain ecosystems.

Science at the Gardens

Botanic gardens are essential to halting biodiversity loss and mitigating impacts of climate change on natural systems. In the Research and Conservation Department at Denver Botanic Gardens we frame our work in the context of the Kunming-Montreal Global Biodiversity Framework (GBF). This framework lays out targets ranging from managing areas to reduce biodiversity loss, to restoring 30% of degraded ecosystems, to ensuring that data are available and accessible for biodiversity action.

In addition to leading within the Gardens, our team contributes our time and expertise to larger collaborative conservation and collections planning and strategies. As a Patron Garden member of Botanic Gardens Conservation International (BGCI) and with Dr. Neale's service on the BGCI U.S. board of directors, we are directly involved in conversations on the establishment of tracking metrics for both the GBF and the next iteration of the Global Strategy for Plant Conservation (GSPC). Collaborative tracking of actions and metrics laid out in the GSPC will help us understand where we are succeeding and where we need to redouble our efforts to protect plants. Dr. DePrenger-Levin serves on the Ecological Society of America U.S. National Vegetation Classification Panel to improve definitions of ecosystems allowing for alignment in tracking conservation action and impact. Dr. Hufft continues to lead on the board of the Society for Conservation Biology North America. Matthew Sheik continues his role in advancing collaboration across biodiversity data users and providers through BioFair. Dr. Wilson is leading a national community of fungal curators and collections managers to address challenges facing fungal collections, proposing the development of a Mycological Society of America Collections Committee. In collaboration with the Colorado Natural Heritage Program and local mycologists, Dr. Wilson helped develop an assessment plan for documenting fungal rarity. We are also engaged in the national conversation around how federal funding and policy shifts are impacting our industry. Along with other botanic garden professionals, we will be developing a national plant conservation action plan in 2026.

These are just some of the ways the Gardens is expanding its role as a leader in plant and fungal biodiversity and conservation. Our work—whether it be local, regional, national or international—aids our global understanding of biodiversity and how to halt its loss. Our networks and broad engagement allow us to lead by example and show how a garden of any size can contribute to global conservation efforts.

Brian Vogt

1958 – 2025

In 2025, we lost one of the Gardens' most important champions, long-time CEO Brian Vogt. Under his leadership, our conservation and research programs grew both in scope and impact. A tireless advocate for biodiversity conservation, Brian championed our projects by bringing added visibility to our work.

Kunming–Montreal

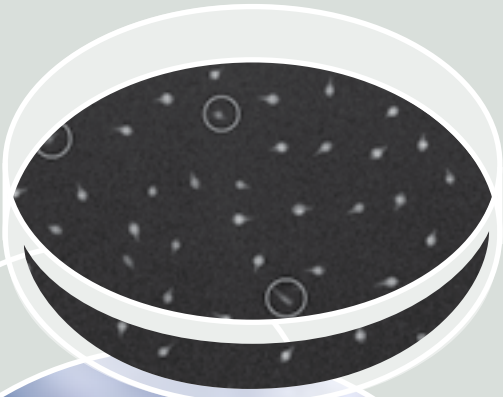
GLOBAL BIODIVERSITY FRAMEWORK

Design by The New Division

Dr. Molly Nepokroeff

We are thrilled to have Dr. Molly Nepokroeff join our team as head curator of natural history collections. Molly brings a background in herbarium management and systematic studies, as well as knowledge of Colorado flora. In her first six months Molly has gotten to know the Gardens' collections, volunteers and staff. She also launched a strategic planning process for the collections and has several collection opportunities lined up for 2026.

Featured Projects



Alpine Plant Conservation

The Research and Conservation Department was awarded a grant from the Institute of Museum and Library Services (IMLS) to advance **THE NORTH AMERICAN BOTANIC GARDEN STRATEGY FOR ALPINE PLANT CONSERVATION** (MA-255890-OMS-24). The Alpine Strategy is a blueprint for conserving alpine plants in North America through web portal development, increases in conservation seed collections and management of stored conservation collections. Successful management of conservation seed collections relies on understanding seed quality, of which the most efficient and least destructive way to assess is through x-ray imagery. The funding from IMLS allowed us to purchase an x-ray machine in 2025 to image our alpine seed collections. Using this technique, we found our seed collections are of good quality, with **87% OF THE COLLECTIONS HAVING ABOVE 70% FILLED SEEDS**.

Transplanting to Mitigate Habitat Loss

Conservation actions can take many forms. For the federally listed *Penstemon penlandii*, conservation looks like moving plants out of harm's way due to a road expansion project. The Gardens is uniquely suited to study the effectiveness of transplanting as mitigation. Research staff know how to set up an experiment and analyze data to measure success, and our horticulturists are experts at planting beautiful, thriving gardens in our ecoregion. The combination makes for an excellent collaboration for this project. Since 2023, we have studied how to **MAXIMIZE THE SURVIVAL OF TRANSPLANTED INDIVIDUALS WHILE MINIMIZING IMPACTS ON THE EXISTING POPULATION**. We have prevented the loss of individuals while also increasing our conservation seed collection to safeguard this species.

Genetic Diversity & Seed Sourcing for Restoration

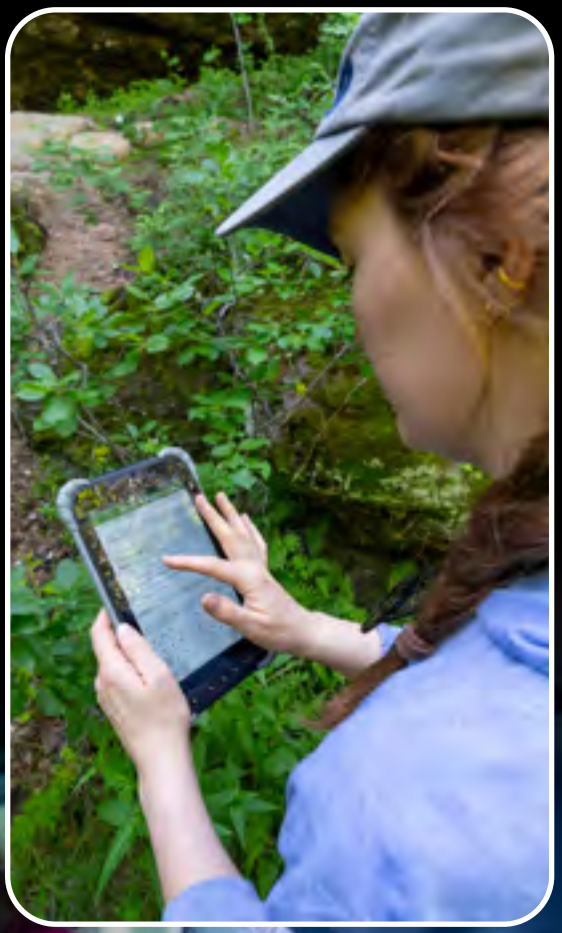
We have been conducting field experiments since 2021 to study the **IMPACT OF GENETIC DIVERSITY ON SEED SOURCE SELECTION FOR ECOLOGICAL RESTORATION OF DEGRADED WILDERNESS**. These experiments include common garden studies of native grassland plant species at Chatfield Farms and in southern Colorado on land managed by the U.S. Bureau of Land Management. We have begun sharing results at scientific conferences and reports to stakeholders. We have discovered that variation in performance traits and variation at the genome level of a species aligns with differences in geography, ecology and climate. This information will help us better source seeds for local restoration projects in Colorado and the arid West.

Penstemon Flowering Under Water Stress

This summer our team continued research started by graduate student exploring first-year **ESTABLISHMENT AND GROWTH OF SIX PENSTEMON SPECIES UNDER INCREASINGLY LIMITING WATER AVAILABILITY**. In the second year of the project we focused on how water stress affects flowering of these showy, native garden plants, which could in turn affect pollinator dynamics. We tracked the progression of flowering over the summer, estimating the peak timing of open flowers, total number of flowers and other metrics that will help us better understand resource availability to pollinators in a changing climate. We're crunching data now, so stay tuned for findings in 2026.

ArcGIS Usage, Survey 123

Research and Conservation Department staff attended the annual **ESRI USER CONFERENCE** in San Diego, California, to explore how new and improved geospatial technologies can aid biodiversity research. With that knowledge, we implemented more tools and methods that better capture data digitally in the field, manage information effectively and efficiently share the data with researchers and the public through open data platforms.



Community Outreach

From herbarium tours to Night at the Museums and City Nature Challenge, each year our team shares our passion for science with the local community. Our most anticipated event of 2025 was **INSECTS ILLUMINATED**, a nighttime outreach event that documents nocturnal insect biodiversity through community science. Using ultraviolet lights, we attract insects, record observations on iNaturalist and collect specimens for our natural history collections. We partnered with our community engagement team to welcome two Spanish-speaking groups to participate as community scientists. This event shows how **COMMUNITY SCIENCE CAN ADVANCE BIODIVERSITY RESEARCH** while deepening people's connection to the natural world.

Nature-Based Solutions for Climate Resilience

Denver Botanic Gardens is developing best practices for nature-based solutions for climate resilience. Initiatives tackle diverse issues from conservation of rare alpine plants to restoration of agricultural fields in the plains. As we work to conserve and restore wildlife and ecosystems, urban areas become progressively more important areas of focus.

Utilizing Native Plants for Climate Resilience Across Habitats

To improve appropriate plant selections and availability for restoration that are **RESILIENT TO CLIMATE CHANGE**, we are researching adaptation among plant populations to improve seed sourcing and have initiated a native plant materials production program to increase native seed supplies. We are also **DEVELOPING BEST PRACTICES** for site preparation, seeding and long-term maintenance for restoration projects to promote resilient ecosystems.

Diverse, native plants are also important for nature-based solutions to **IMPROVE CLIMATE RESILIENCE IN URBAN AREAS**. We are engaged in several projects to improve urban wildlife habitat and green infrastructure using native plants. These projects range from the installation of beaver dam analogs to reconnect the floodplain and improve native plant communities and wildlife habitat, to increasing biodiversity through grassland restoration on urban golf courses to developing best practices for native plantings to support stormwater management and urban streetscape habitat.

Expanding Partnerships to Improve Urban Wildlife Habitat

We have partnered with **THE COLORADO GOLF ASSOCIATION** to boost biodiversity on an urban golf course, CommonGround. Golf courses are one of the largest open spaces in urban areas. They provide wildlife habitats and corridors and present a partnership opportunity for public gardens **TO IMPROVE BIODIVERSITY AND STRENGTHEN CONSERVATION EFFORTS** while engaging with and educating new audiences.

While the golf course is already home to deer, coyotes, hawks and other wildlife, we aim to increase native plant diversity in these areas to create better habitats, especially for pollinators. Following a floristic inventory of the golf course in 2022, we trialed a seeding experiment in the rough areas to enhance plant diversity. We tested methods that utilize existing course equipment and can be easily implemented at other sites. Results suggest this low-impact approach is successfully promoting forb germination and persistence over multiple growing seasons. Even with minimal native forb growth in these plots, both **BEE ACTIVITY AND OVERALL POLLINATOR VISITATIONS ROSE**. We are continuing our partnership with a new experiment initiated this year to test site preparation and maintenance methods for native grassland restoration. We are developing methods that can be scaled up to other golf courses and urban areas. We have been sharing this work in both the conservation and golf communities, working to expand this work through partnerships with golf courses and gardens around the country.

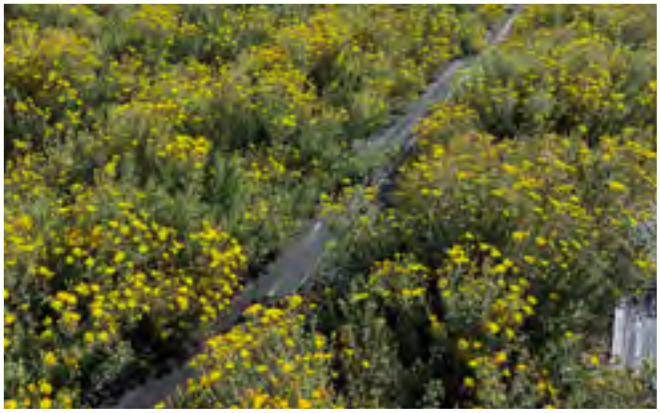
Cultivating an Increase in Native Seed

One promising step toward driving the overall effectiveness of **ECOLOGICAL RESTORATION EFFORTS** lies in working with native seeds. We have partnered with **THE BUREAU OF LAND MANAGEMENT** to grow out native plant species of interest to increase seed stock to support these efforts and create a cultivation protocol for large-scale seed production. This season, we worked with four native Colorado species: *Heterotheca villosa*, *Sphaeralcea coccinea*, *Phacelia crenulata* and *Stanleya pinnata*. By season's end, we managed to successfully establish all species in our field plots and produce a significant amount of seed stock.

An overview of our Seed Increase plots as we close the 2025 growing season.

Heterotheca villosa
(hairy false goldenaster)

Seed



Sphaeralcea coccinea
(scarlet globemallow)

Seed

Natural History Collections

Natural history collections are our world heritage collections; they provide a record of biodiversity in our area throughout time. Specimens provide physical records of species and populations, but in more recent years, they also provide tissue for genetic and functional trait data assessments. Knowledge of which species occur in an area is foundational to all other biodiversity science that can take place and our collections serve to document this most basic information. As our ecosystems in Colorado are increasingly imperiled, our natural history collections document the basis of these changes, whether it is above treeline in the alpine or right here in the city of Denver.

Fungal Collections

We continue to advance **FUNGAL BIODIVERSITY RESEARCH** in the Southern Rockies and surrounding region. Several events helped to provide meaningful collections this year. A foray held at Manitou Experimental Forest provided collections of the genera *Thelephora*, *Polyozellus* and *Odontia*. These represent extremely diverse but poorly known fungi and the collections help us understand their diversity and role in Rocky Mountain ecosystems. We are also wrapping up the National Science Foundation-funded CLIMUSH project which performed the first fungal survey of Konza Prairie Biological Station in eastern Kansas. Overall, the fungal collections grew by **279 SPECIMENS** with **51 NEW SCIENTIFIC NAMES** added to the Sam Mitchel Herbarium of Fungi.

Daniels Park Survey

This summer we conducted a floristic inventory at Daniels Park. This 1,001-acre Denver Mountain Park is home to a herd of bison as well as many historic sites. We collected approximately **250 PLANT SPECIMENS** and a few fungi throughout the growing season. This project is a collaboration with **DENVER ZOO CONSERVATION ALLIANCE (DZCA)**, who maintains the bison herd. Our inventory helps support their ecological studies, including exploring impacts of bison on plant ecology. Fieldwork this summer was an adventure, involving being on alert for bison quietly hiding in the oak scrub and navigating high heat and fast-approaching thunderstorms.

Updating Collections Nomenclature

To reflect current understanding of relationships among plant species, biodiversity researchers continuously revise and update scientific names for existing species. For example, from analyses of genetic, environmental and life history data, the species *Senecio multilobatus* (lobeleaf groundsel) was discovered to be more closely related to members of the genus *Packera*. Scientists have updated that name to *Packera multilobata*. We are assessing our **+85,000 VASCULAR PLANT SPECIMENS** to update species names that have been changed, a task not done in 60 years. This project ensures our collections reflect current understandings of plant diversity in Colorado and makes it possible for us to quickly find specimens we need in the herbarium.

Denver Urban Flora

Our local flora is changing through introduction of non-native species and climate-driven native species range shifts. We have been documenting **BIODIVERSITY IN THE DENVER METRO AREA** and in 2025 discovered several records of introduced species for the state, e.g. *Cardamine occulta*, an introduced species of bittercress from Asia, and *Anthriscus caucalis* (bur-chervil), an introduced member of the carrot family. Shown here is native *Solanum elaeagnifolium* (silverleaf nightshade), a new, northerly occurrence in Jefferson County, a range extension from the south.

Bryophyte Collection

Bryophytes are a small, low growing and ancient group of plants that include mosses, liverworts and hornworts. Gardens adjunct researcher Dr. Barbara Thiers, a world expert on bryophytes, has been collecting and curating a small but growing collection of bryophytes for our biodiversity collections. Bryophytes pose unique challenges to preservation, identification and digitization since they are collected in special packets and stored upright in boxes in the herbarium. Identification requires use of compound microscopes to examine tissue and cell structure. The Kathryn Kalmbach Herbarium now houses approximately **500 BRYOPHYTE COLLECTIONS**.

Most Wanted Species

We built a new web dashboard this year to aid in tracking "**KHD'S MOST WANTED**," a list of species known to occur in Colorado, but we have yet to collect and include in our herbarium. The dashboard will help us plan collecting trips, giving us a county-by-county list of species to target when conducting field work. This year we vouchered *Penstemon bleaklyi*, a "most wanted" Colorado native, new taxon for our herbarium and the first collection for this species held in a Colorado herbarium.

Graduate Training

The Research and Conservation Department is committed to training future and current scientists through immersive research opportunities. Partnering with the University of Colorado Denver, students work with a lead scientist at the Gardens to answer questions pertaining to ecology, biodiversity and conservation. This partnership helps us answer important biological questions while teaching students how to conduct research and contribute to science.

Audrey Spencer successfully earned her doctorate degree. Using systematics and biogeography, she is unraveling the evolutionary origins and taxonomic identity of ninebarks (Physocarpus) across the Southern Rockies. Beyond the Rockies, Audrey examined relationships among *Physocarpus* taxa from Asia and North America.

Justin Loucks defended his master's thesis documenting the biodiversity of the mushroom genus *Boletopsis* from western North America. He used DNA sequences and morphological data to assess the diversity of species in *Boletopisis*, resulting in the recognition of eleven species globally with at least two new species.

Jess Loeffler defended her master's thesis examining how mycoheterotrophy (when plants steal nutrients from fungi) shapes fungal communities. She collected specimens of *Pyrola asarifolia* and *Chimaphila umbelata* to understand more about the dynamics of fungal-plant associations and the potential of fungi to support plant communities.

Roy Rutherford defended their master's thesis exploring mosquito diversity and distribution along an urban canal and recreational greenway near Denver to better understand their habitat preferences. This is the first assessment of mosquitos along this highly used corridor, providing data to inform management decisions.

Brielle Cerep-Funke defended her master's thesis exploring how increasing water stress affects first-year establishment and growth of six native *Penstemon* species that are often used in horticulture. Her work sheds light on drought resilience in a range of species while helping to refine recommended irrigation levels in Colorado gardens.

My-Lan Le defended her master's thesis studying the reproductive biology and ecology of the rare alpine twinpod, *Physaria alpina*. Her findings inform targeted conservation strategies for this Colorado endemic plant.

Ashlee Kerber is a second-year master's student studying the systematics of sky pilot (*Polemonium* spp.) in Colorado. She is using population genomics methods, morphology and volatile scent studies in the field to characterize a closely related species complex in the Colorado alpine.

Meredith Prentice is a second-year master's student studying how fire severity impacts above and belowground understory community composition in Colorado's Front Range. She is interested in how severe fire events influence the successional trajectory of vegetative communities adapted to frequent, low to moderate severity fire.

Franki Anaya is a master's student interested in forest vegetation recovery post-high severity wildfires. Her research uses Bureau of Land Management data to determine if aerial seeding of the Beaver Creek (Colorado) burn scar aided native vegetation regeneration and surface stabilization. She works for the Natural Resources Conservation Service.

Citations

Peer-reviewed Publications

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Branco, S., ..., **Wilson, A. W.**, et al. [16 authors]. 2025. Myco-Ed: Mycological Curriculum for Education and Discovery. PLOS Pathogens 21(10): e1013625. https://doi.org/10.1371/journal.ppat.1013303

Caiafa, M. V., ..., **Wilson, A. W.**, et al. [31 authors]. 2025. Think globally, barcode locally: nine years of macrofungi sampling reveals extensive biodiversity at the Ordway-Swisher Biological Station, a subtropical site in Florida. Fungal Biology 129 (7). https://doi.org/10.1016/j.funbio.2025.101643

Herrera, M., **Wilson, A. W.**, and Mueller, G. M. 2025. Fungal diversity in the Neotropics: Update on the Diversity and Taxonomy of Hydnaceae in Costa Rica. Mycologia 117(4), 725-748. https://doi.org/10.1080/00275514.2025.2491289

Singer, H., ..., **Wilson, A.**, et al. [13 authors]. 2025. From Field to FASTA: Onsite DNA Barcoding the Mushrooms of the 2024 NAMA Foray. bioRxiv, 2025-07. https://doi.org/10.1101/2025.07.16.664919

Walters, C., Hill, L. M., Heineman, K. D., ... **Seglias, A.**, et al. [34 authors]. Assessing viability of seeds from rare, wild plants native to the US: the D.E.A.D paradigm. Applications in Plant Science 13(6): e70035. https://doi.org/10.1002/aps3.70035

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Alba C. 2025. Vegetation Survey of the Preserve at 70 Ranch. Report to Denver Zoo Conservation Alliance.

DePrenger-Levin, M. 2025. North Sand Hills: A comparison of active dunes in North Park, Colorado. Report to Ducks Unlimited, Inc.

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DePrenger-Levin, M. and **Hufft, R.** 2025. Demographic monitoring of *Sclerocactus glaucus* and *Sclerocactus dawsoniae*, two endemic species of western Colorado. Report to Bureau of Land Management.

DePrenger-Levin, M. and **Hufft, R.** 2025. Life History and Demography of *Astragalus microcymbus* Barneby (Fabaceae). Report to Bureau of Land Management.

DePrenger-Levin, M. and **Hufft, R.** 2025. Population Monitoring of *Penstemon harringtonii* (Plantaginaceae), an Endemic Species of Colorado, USA. Report to Bureau of Land Management.

Goebl, A.M., Bardsley, K., Wheeler, L., **Hufft, R.A.** 2025. Informing seed source selection for several western North America grassland species for use in ecological restoration. Report to Bureau of Land Management.

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Datasets

Kathryn Kalmbach Herbarium, Denver Botanic Gardens. 2025. Denver Botanic Gardens Collection of Arthropods. Occurrence dataset. https://doi.org/10.15468/tdocff

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Sam Mitchel Herbarium of Fungi, Denver Botanic Gardens. 2025. Denver Botanic Gardens, Sam Mitchel Herbarium of Fungi. Occurrence dataset. https://doi.org/10.15468/kuqgug

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Alba, C. and Iverson, A. 2025. Retrofitting a (sub) urban canal to function as green stormwater infrastructure. Ecological Society of America Annual Meeting (ESA), Baltimore, MD.

Alba, C. 2025. Watching the trees grow: What shapes tree planting success along an urban Front Range Greenway? Tree Diversity Symposium, Denver Botanic Gardens.

DePrenger-Levin, M. 2025. Distance sampling for plants. ESA.

DePrenger-Levin, M. and **Neale, J.R.** 2025. Strategies for providing the best available knowledge on population trends. Global Partnership for Plant Conservation, St. Louis, MO.

Goebl, A. and **Hufft R.** 2025. Comparing seeding approaches for restoration: benefits and drawbacks of increasing within-species genetic diversity for climate change adaptation. National Native Seed Conference. Tucson, AZ

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Seglias, A. 2025. 30, flirty, and thriving... and evolving: New approaches to demography studies after three decades. Center for Plant Conservation. St. Louis, MO.

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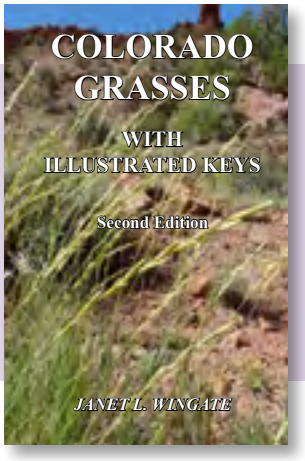

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Colorado State Mushroom

In 2025, the Colorado state legislature declared *Agaricus julius* as the official state mushroom with Dr. Andrew Wilson serving on the expert committee advising state representatives on the proclamation. The state mushroom designation was awarded on geographic relevance, recognizability, charisma, biological relevance and whether the mushroom tells a compelling story among other factors. *Agaricus julius*, also known as the emperor mushroom, was previously mistaken as "The Prince" mushroom (*Agaricus augustus*) in Colorado, but when researchers sequenced its DNA we learned that it was a new species. After this, Dr. Richard Kerrigan made the cheeky comment in his book on Agaricus of North America, "...perhaps now it will become the Emperor formerly known as Prince." From the discovery of this species in Colorado, to the fact that it sometimes grows with the state tree, the Colorado blue spruce, *Agaricus julius* is an exceptional choice to represent Colorado's state mushroom.

Thank You to Our Funders

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Colorado Golf Association
Colorado Mycological Society
Denver Zoo Conservation Alliance
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To keep up to date with science at Denver Botanic Gardens, you can sign up for the quarterly science e-newsletter by clicking "Subscribe" at the bottom of botanicgardens.org and selecting "Science."

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DENVER BOTANIC GARDENS

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