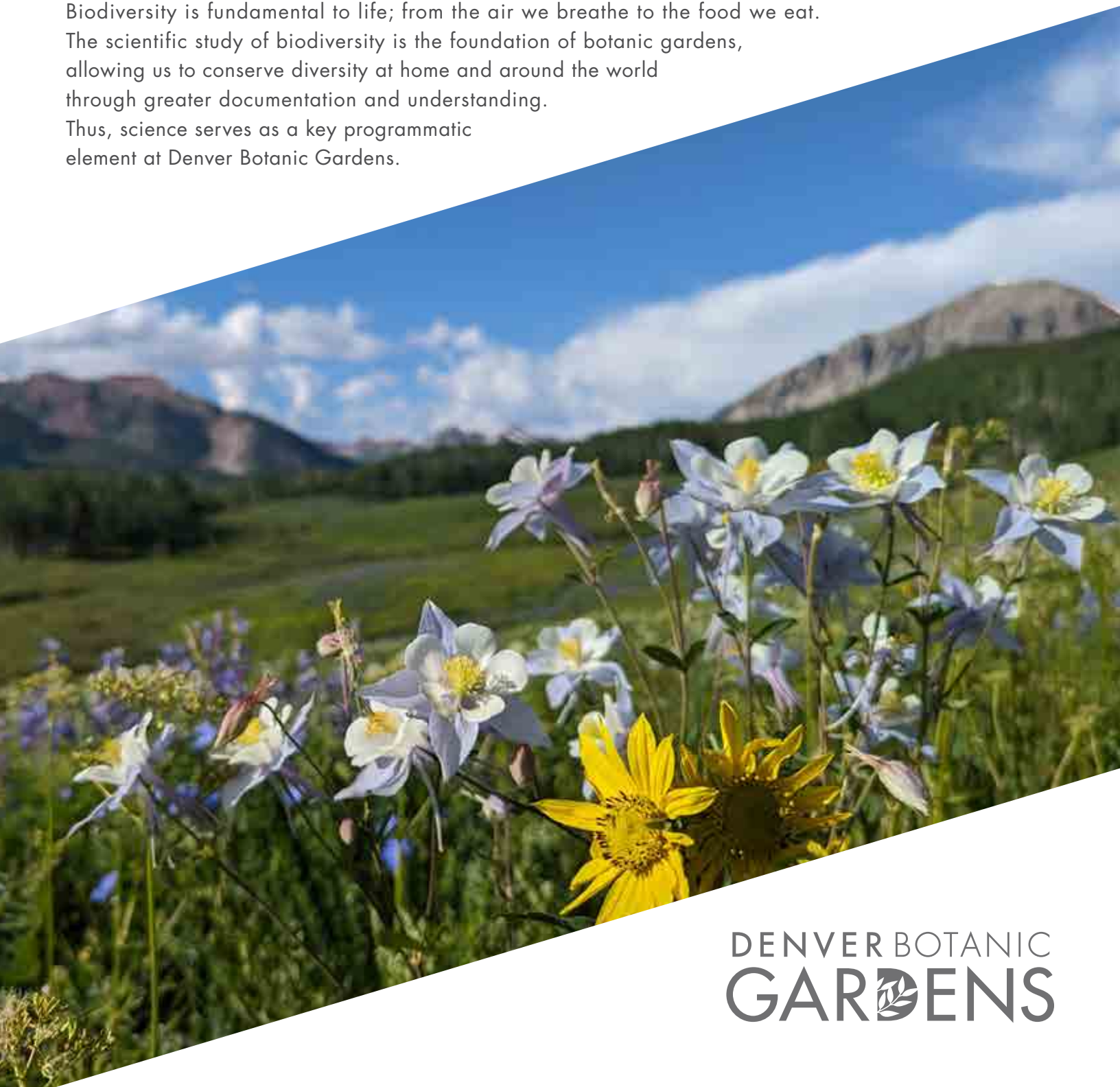


# SCIENCE

## 2023 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.





## Introduction

The 2023 Year In Review showcases our scientists' passion and dedication to seeking knowledge tied to biodiversity and our deep desire to understand patterns and processes in nature. Our diverse work spans not only a broad geographic area, but a variety of habitat types, focal taxa and driving questions.

We continue to pursue projects aimed at **ASSESSING TAXONOMIC DIVERSITY**, applying molecular genetic and morphological assessments to differentiate taxa across multiple branches of the tree of life. It is only through accurate taxonomy that we can design and conduct studies that help inform effective land management.

We continue to promote in situ and ex situ **CONSERVATION THROUGH COLLABORATIVE PROJECTS**. Long-term tracking of rare species helped contribute to the delisting of one endangered species and is informing evidence-based management strategies for others. With climate change threatening our alpine habitats, we're expanding our efforts to understand and conserve these fragile areas.

Within the urban environment, we continue to partner with government and local organizations to **UNDERSTAND THE BIODIVERSITY OF THE URBAN MATRIX**. Our projects aim to inform management of

urban green spaces. Whether it is assessing success and health of newly planted urban trees, green stormwater infrastructure or adding native species to a golf course, our local projects connect us to our community.

We continue to expand our **RESTORATION EXPERIMENTS** both through common garden and wildland projects aimed at assessing the most effective restoration seed mixes. Genetic data collected in this context furthers our ability to assess the best metrics of restoration success, thus expanding the capacity of our work to inform on-the-ground practice.

Graduate students, seasonal staff and interns all bolster our ability to ask deeper questions and collect meaningful data. In 2023 we added a full time **FLORISTIC AND OUTREACH COORDINATOR**. This role is focused on not only growing our collections by leading floristic surveys, but understanding the breadth and depth of the work we do so it can be shared with a wider audience.



## Cities Summit of the Americas

Botanic gardens play an essential role in connecting people to biodiversity. Gardens located in urban centers are key in forging and growing this connection. In conjunction with the Cities Summit of the Americas held in Denver in April 2023, the Gardens developed a symposium showcasing the role of public gardens in connecting people with nature in cities. The six panelists shared programs and ideas on how cities can understand and protect biodiversity in partnership with public gardens. We hosted more than **200 ATTENDEES REPRESENTING OVER A DOZEN COUNTRIES**.

## Volunteer Appreciation

We want to take a moment to acknowledge the extraordinary impact our volunteers make. Each task they undertake, no matter how small, plays an integral role in our mission to connect people with plants. They tirelessly process specimens, identify plants and fungi and assist in field work. This year,

we honor Loraine Yeatts, who has achieved a remarkable milestone: **55 YEARS OF DEDICATED SERVICE**. Loraine's unwavering commitment and boundless enthusiasm inspires us all and will serve as an example that will resonate for generations to come.



Volunteers and staff collecting plants on the eastern plains, Loraine Yeatts pictured on the left.

# Featured Projects

## Physaria Sleuthing

One taxon of conservation concern in the Denver foothills is referred to as *Physaria* X1, hypothesized to be a hybrid between the rare *Physaria bellii* (Bell's twinpod) and more widespread *P. vitulifera* (fiddleleaf twinpod). We collaborated with researchers and government and nonprofit agencies to determine if *Physaria* X1 deserves species recognition. Our results showed that *Physaria* X1 was not a unique species, but a phenotypically unusual *P. vitulifera*. Surprisingly though, one population of *P. vitulifera* was shown to be quite genetically and morphologically distinct. Our next step is to use additional samples to determine if this population represents an undescribed species.



Potential new species of *Physaria*

## Can Alpine Plants Take the Heat?

Rare alpine plants are some of the most at-risk species from climate change. Little information is known about how alpine endemics will respond to increases in temperature, reduction in snowpack and length of growing season, among other environmental factors. One such species that needs more research is *Physaria alpina* (Avery Peak twinpod), found only in high alpine areas of the central Colorado mountains. In 2023, we set up a long-term demography project at Horseshoe Mountain to understand how growth, reproduction and community composition will change over time in the species' natural habitat. This research will help inform future conservation action.



*Physaria alpina* at Horseshoe Mountain

## Delisting a Threatened Species

Through collaboration with the U.S. Bureau of Land Management and over a decade of studying population dynamics, Denver Botanic Gardens found that the federally listed cactus *Sclerocactus glaucus* (Colorado hookless cactus) is stable and resilient to both climate change and threats from energy development. These results led the U.S. Fish and Wildlife Service to recommend delisting, thus removing it from the list of threatened and endangered species under the Endangered Species Act. However, we will continue to monitor changes in population size and density, demographic response to the environment and seed dispersal. Combined, these analyses will prepare us to detect population declines in time to take appropriate conservation actions if needed.



Researchers collecting demographic data on *Sclerocactus glaucus*

## Quantifying Ecosystem and Climate Drivers of Fungal Reproduction

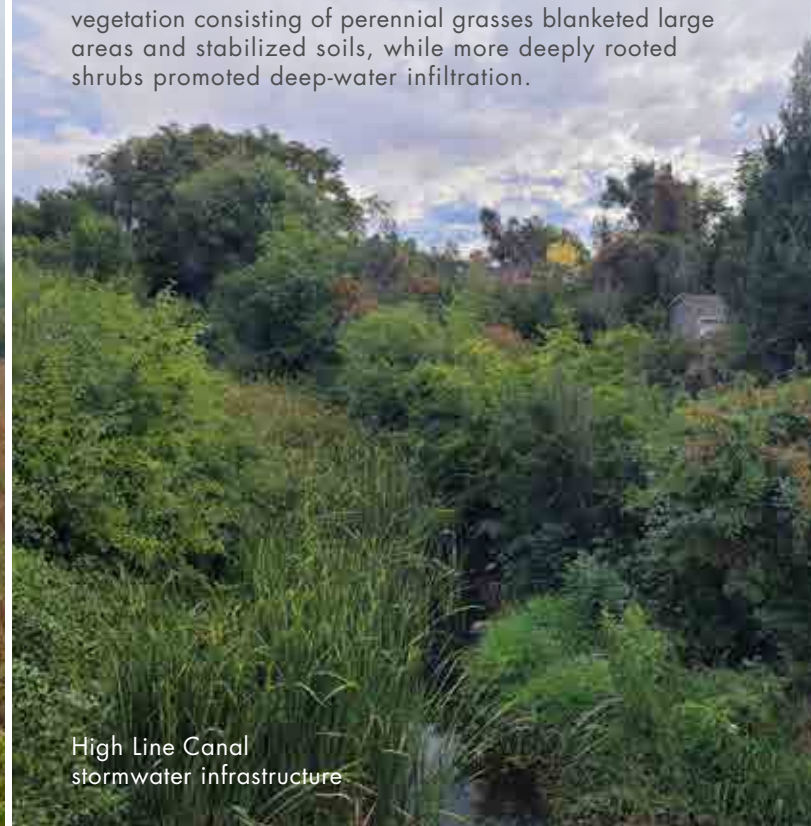
Mushrooms are intimately associated with plants. Our National Science Foundation supported project attempts to understand mushroom-plant relationships by looking for fungi in grassland, oak and conifer forest habitats. This summer, we traveled to Niwot Ridge in Colorado and the Konza Prairie Biological Station in Kansas to collect samples of plants (living and dead), soil, spores and mushrooms. In collaboration with a national team of researchers, DNA from these samples will reveal what fungi occur where. Our ultimate goal is to understand what environmental factors shape mushroom diversity and better predict how fungi respond to climate change alongside their plant partners.



Konza Prairie Biological Station sampling site

## Exploring Water Dynamics in an Urban Canal

Green stormwater infrastructure (GSI) makes use of natural features, namely vegetation and soil, to hold or move stormwater in ways that benefit both humans and the environment. While GSI is usually built with intentional plantings and amended or engineered soils, our pilot GSI project along the High Line Canal in Denver presents an opportunity to explore whether naturally occurring plant communities can slow, spread and sink water to achieve desired GSI function. Our initial results found that canal vegetation consisting of perennial grasses blanketed large areas and stabilized soils, while more deeply rooted shrubs promoted deep-water infiltration.



High Line Canal stormwater infrastructure

## Newly Described Species of Thistle

Recent research revealed an undescribed species of thistle endemic to the La Sal Mountains of Utah, *Cirsium tukuhnikivatizicum*, or the La Sal thistle. This newly described species was named for Mount Tukuhnikivatiz, part of the La Sal Mountain range and a prominent backdrop for the La Sal thistle. Tukuhnikivatiz is also the Ute word for "where the sun sets last," and thus the name also pays tribute to the legacy of use of the La Sal Mountains by Indigenous people.



Illustration of *Cirsium tukuhnikivatizicum* from the School of Botanical Art and Illustration at Denver Botanic Gardens

## Outreach Highlights

This year we provided several outreach opportunities for the community. We led hikes and volunteer outings and gave more than 50 herbarium tours. Through our monthly EcoQuests, we shared identification tips for plants and fungi and called on community members to post their findings on iNaturalist. During the City Nature Challenge, a global challenge between cities to record biodiversity and engage the community with nature, we coordinated participation efforts in the Denver-Boulder metro area. We even established the Native Plant Treasure Hunt, an ongoing pirate-themed scavenger hunt throughout the Gardens.



One of the plants you can find on the Native Plant Treasure Hunt

# Guardians of Nature: Strategies for Safeguarding Biodiversity in a Changing World

Conservation is a key driver of all our work. Conservation includes the preservation and protection of natural habitats and species. While conservation is still always our preferred option, restoration can help us improve systems that have been impacted through loss of ecosystem functions and biodiversity. Ecological restoration is the process of restoring degraded ecosystems, including species, habitats and ecosystem functions. The goal of such restoration is to put systems back on a path to function and recover fully on their own. We use both conservation and restoration management practices to support healthy ecosystems through a range of ongoing and new initiatives.

## Ethical Harvest: Navigating the Delicate Balance of Plant Collection and Movement for Conservation Purposes

One of our ongoing yearly initiatives is to preserve native plants through seed banking, one of the primary methods of ex situ plant conservation (or conservation outside of the natural habitat). Scientists at the Gardens collect and bank seeds of rare and common species in partnership with the Center for Plant Conservation and the U.S. Bureau of Land Management. Seed banking stores seeds at extremely low temperatures and humidity to preserve the viability of seeds for potentially up to hundreds of years. Common species are collected in large quantities and used for restoration efforts in the near-term. Seeds from rare plants are conserved for longer periods so that they can be used in reintroductions if the species were to go extinct or if a population were to be destroyed. This year we made 12 collections of rare plants from Colorado and Wyoming, totaling about 32,000 seeds. This includes 10 species, four of which are new species to our seed bank. One species from Colorado, *Astragalus rafaensis* (San Rafael milkvetch), had not been collected since 1987, and another species, *Phacelia submutica* (DeBeque phacelia), had not been collected since 2011. All the collections made this year add valuable genetic diversity to our seed bank collections and provide additional protections to these species outside of their natural habitat.

Often there are multiple land use needs, and it is not possible to protect all rare plants where they occur. Then, we must consider if it is more helpful to transplant individuals to safer spots out of harm's way within their natural habitat. In 2023, we began a new project in collaboration with our horticulture staff, a local utility entity and the federal government to study the effectiveness of transplanting a rare plant due to a road expansion. This road work is for an energy project in western Colorado where needed improvements to power lines threaten the endangered species *Penstemon penlandii* (Penland's beardtongue). We tested transplanting in the spring and fall from the road area that will potentially be impacted into existing occupied habitat. Over the next three years, we will monitor the survival and growth of our transplanted individuals relative to untransplanted individuals. This information will inform land management plans and help determine if this is a viable option for similar situations.

Collecting seeds of the rare *Ipomopsis globularis*



*Penstemon penlandii*, a federally endangered plant



Researchers at CommonGround golf course



Seedlings awaiting planting at Chatfield Farms



Collecting data on seedling emergence near Cañon City

## Improving Wildlife Habitat on Golf Courses

In 2022, we started working with the Colorado Golf Association at CommonGround Golf Course to help improve wildlife habitat on an urban golf course. After conducting a floristic inventory in 2022, we decided to work on increasing native wildflowers in the mostly non-native grass rough areas. We chose to use equipment already in use at CommonGround for site maintenance, including an aerator to create limited disturbance and a harrow to remove thatch. We hand-seeded a mix of native wildflowers last December before the first snow. This summer we found that a few of the species germinated in these areas. The biggest winner in this first year was *Coreopsis tinctoria* (plains coreopsis). All aerated plots showed a good density of this pollinator-loving yellow flower. In one of our three pilot plots, we also saw numerous *Cleome serrulata* (Rocky Mountain beeplant). We saw several other native forbs and are excited to see which of these species survive the winter and emerge next season. We have numerous ideas for exploring additional strategies, including various disturbance and planting methods, to further enhance urban wildlife areas.

## Adaptive Potential of Species Used in Restoration

Last year we also started a new project to assess genetic appropriateness of native species for large-scale restoration efforts, specifically focused on grasslands. We grew seed from six to 22 populations of four native species – *Artemisia frigida* (fringed sage), *Bouteloua gracilis* (blue grama), *Ericameria nauseosa* (rubber rabbitbrush) and *Penstemon virens* (Front Range beardtongue) – in a large common garden experiment at Chatfield Farms. The adaptive potential of species to respond to climate change was tested through warming and watering experiments. This year, we collected the second year of data on growth, survival, phenology and reproduction. We also began a new experiment to look at germination and emergence in the field. We are complementing these field performance measures with analyses to assess genetic variation among populations. Together, these data will help us understand the extent of local adaptation and the importance of genetic diversity when selecting seed for restoration and the ability of restored populations to adapt to future environmental change.

## Importance of Within-species Genetic Diversity to Restoration

This year we started collecting seedling emergence data in our new long-term restoration experimental plots near Cañon City, Colorado. This experiment was initiated in 2022 and takes place on two sites managed by the U.S. Bureau of Land Management. The experiment will test different seeding methods for ecological restoration. Specifically, we are looking at how varying levels of genetic diversity within species impacts plant performance. Using *Artemisia frigida* (fringed sage) as our focal species, we will measure key plant performance metrics over the next two to five years, such as seedling emergence, plant survival, timing of flowering and seed production.

# Natural History Collections

Natural history collections are snapshots in time, capturing the biodiversity of a particular place at a specific moment. Each specimen is a record of our natural world – documenting morphological, genetic and distributional information all in a single collection. Together, these specimens provide precious evidence of landscape, ecosystem and population change over time. As a museum, the Gardens' natural history collections support and engage all who are curious about the natural world. And as records of the past, they provide invaluable, irreplaceable resources for protecting our future.

## Searching for a Rare Plant on Comanche National Grassland

In collaboration with the Botanic Gardens Conservation International and the U.S. Forest Service, we traveled to the southeastern corner of the state to search for the rare *Solidago capulinensis* (Capulin goldenrod). Currently only known from one location on Comanche National Grassland, our goal was to find additional populations and then return to collect seed for conservation and revegetation. However, after an exhaustive search, we only found a single plant, from the same population that was documented in 1949. Although we only found one Capulin goldenrod, we were able to make collections of 10 plant species not previously housed in our herbarium.



*Solidago capulinensis* (Capulin goldenrod) on Comanche National Grassland

## Denver Metro Botanical Discoveries

You might not think there are many native or rare plants to document in the city of Denver. However, thanks to numerous green spaces and parks, the greater metro area harbors many plant species. This summer, our excursions throughout Denver yielded collections of over 100 unique plants. One of the most memorable we found was *Acorus calamus*, or sweet flag. Only known from a handful of locations along the Front Range, we were able to document five new occurrences. These new distributions will provide valuable information for tracking this rare species.



*Acorus calamus* (sweet flag) at a Denver metro park

## Sandsage Prairie Floristics at Ballyneal Golf Club

Staff from our research and horticulture departments collaborated to survey high-quality, historically untilled sandsage prairie at Ballyneal Golf Club on the eastern plains of Yuma County, Colorado. This presented an excellent opportunity to not only voucher plants in an under-documented area but also to assist the golf course in establishing best land-management practices. The spring and summer rain showers also resulted in a profusion of plants, including the purple-blue *Tradescantia occidentalis* (prairie spiderwort). Altogether, our botanical sleuthing produced specimens of over 100 species, including *Lithospermum carolinense* (Carolina puccoon), which reaches its westernmost North American extent in the sandy dunes of eastern Colorado.

Surveying plants at Ballyneal Golf Club



## 100,000<sup>th</sup> Accession

In 2023, we accessioned our 100,000th specimen into the natural history collections. Not just any specimen could fit the bill, so we chose the type collection of *Cirsium funkiae*, the funky thistle, for this great honor. We celebrated this momentous occasion with a gathering of staff and volunteers.



Accessioning the 100,000th specimen into the natural history collections

## Fantastic Fungal Finds

Every year we work with researchers and community scientists to collect hundreds of mushrooms for deposition in The Sam Mitchel Herbarium of Fungi. In 2023, volunteers and staff incorporated 860 fungal specimens. These include specimens from the Aspen Center for Environmental studies mushroom course, specimens collected as part of a collaborative grant-funded project in Kansas and Colorado, and specimens from the Telluride Mushroom Festival. In addition, we incorporated over 150 truffle specimens from a collection at Northern Arizona University. Continuously adding specimens such as these enriches our collections and enhances this important resource for future biodiversity research.



*Hydnellum caeruleum*, or blue tooth, collected for deposit in the Sam Mitchel Herbarium of Fungi

## Building a Reference Collection

Our reference collection of one representative specimen of every native plant species in the state is becoming more complete every year. Last summer, we targeted the northeastern plains in search of specimens to add to this collection. The eastern plains comprise nearly one third of the state yet have far fewer collections than our mountainous regions. With the extra rain this year we couldn't wait to see what was blooming. Our collection trip yielded over 100 specimens, 20 of which were county records.

Superbloom of *Thelesperma filifolium* (plains greenthread) on the eastern plains



# Graduate Training

The Research & 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.

**Megan Clark** successfully defended her master's thesis in spring 2023. She conducted research to assess the impacts of seed sourcing in a grassland restoration experiment.



**Tiffany Gentry** graduated in fall 2023 after successfully defending her master's thesis on the diploid progenitors of the allopolyploid *Eutrema edwardsii*.



**Alissa Iverson** graduated in spring 2023 after successfully defending her master's thesis on the plant community ecology of a section of the High Line Canal.



**Francis Anaya** is a second-year master's student working with the U.S. Bureau of Land Management to examine the efficacy of seeding as a post-wildfire management practice.



**Brielle Cerep-Funke** is a first-year master's student launching a common garden experiment at our Chatfield Farms location to test how native horticultural plants perform under increasing drought stress.



**Michelle DePrenger-Levin** is a Ph.D. candidate examining the use of life history to generalize extinction risk and methods to improve estimates of life history.



**My-Lan Le** is a first-year master's student planning to identify what variables influence rare plant abundance in alpine communities.



**Jessica Loeffler** is a first-year master's student interested in studying how the mixotrophic plant *Pyrola asarifolia's* dependence on mycorrhizal fungi changes with light availability.



**Justin Loucks** is a second-year master's student interested in DNA barcoding and phylogenetics to systematically examine the of taxa in the fungal family Bankeraceae within western North America.



**Roy Rutherford** is a first-year master's student interested in surveying, maintaining and improving biological diversity in urbanized settings that represent restoration and conservation challenges.



**Audrey Spencer** is a Ph.D. candidate researching the systematics and biogeography of *Physocarpus* or ninebark. The results of her research will provide important insight into the origins of the flora of the Southern Rocky Mountains.



## Peer-Reviewed Publications

**Ackerfield, J.R.** 2023. *Cirsium tukuhnikivatizicum*: A new species of thisle endemic to the La Sal Mountains of Utah. *Systematic Botany* 48(2): 354-362.

Bueno de Mesquita, C.P., Solon, A.J., Barfield, A., Mastrangelo, C.F., Tubman, A.J., Vincent, K., Porazinska, D.L., **Hufft, R.A.**, Shakelford, N., Suding, K.N., and S.K. Schmidt. 2023. Adverse impacts of Roundup on soil bacteria, soil chemistry, and mycorrhizal fungi during restoration of a Colorado grassland. *Applied Soil Ecology* 185 (2023) 104778 <https://doi.org/10.1016/j.apsoil.2022.104778>

Innes, P., **Goebel, A.M.**, Smith, C., Rosenberger, K., and N.C. Kane. 2023. Gene expression and alternative splicing contribute to adaptive divergence of ecotypes. *Heredity* doi: 10.1038/s41437-023-00665-y

Moreyra, L.D., Garcia-Jacas, N., Roquet, C., **Ackerfield, J.R.**, Arabaci, T., Blanco-Gavaldà, C., Brochmann, C., Calleja, J.A., Dirmenci, T., Fujikawa, K., and M. Galbany-Casals. 2023. African mountain thistles: three new genera in the *Carduus-Cirsium* group. *Plants* 12(17): 3083.

**Neale, J.R.** 2023. More than pretty places: botanic gardens take the lead on plant conservation and education. *Cactus and Succulent Journal* 95(3): 221-225.

Olds, C.G., Berta-Thompson, J.W., **Loucks, J.J.**, **Levy, R.A.**, and **A.W. Wilson.** 2023. Applying a modified metabarcoding approach for the sequencing of macrofungal specimens from fungarium collections. *Applications in Plant Sciences* 11(1): e11508.

**Sheik, M.** and A. Weeks. 2023. A floristic checklist of Shenandoah River State Park, Warren County, Virginia. *Castanea* 88(1): 138-154.

**Sheik, M.** 2023. The West Virginia Natural History Program herbarium is going global. *The Vasculum* 18(2): 12-13.

Siniscalchi, C.M., **Ackerfield, J.R.**, and R.A. Folk. 2023. Diversification and biogeography of North American thistles (*Cirsium*: Cardioideae: Compositae): drivers of a rapid continent-wide radiation. *International Journal of Plant Sciences* 184(5): 322-341.

**Wilson, A.W.**, Eberhardt, U., Nguyen, N., Noffsinger, C.R., Swenie, R.A., **Loucks, J.L.**, Perry, B.A., Herrera, M., Osmundson, T.W., DeLong-Duhon, S., Beker, H.J., and G.M. Mueller. 2023. Does One Size Fit All? Variations in the DNA Barcode Gaps of Macrofungal Genera. *Journal of Fungi* 9(8): 788.

## Select Presentations

**Ackerfield, J.** 2023. Biodiversity collections and activities in the Research & Conservation Department at Denver Botanic Gardens. Denver Master Gardner's Club. Denver, CO.

**Ackerfield, J.** 2023. A *Cirsium* story: Using phylogenomics to inform taxonomy and diversification patterns in a continent-wide radiation. University of Wyoming Biology Department Seminar Series. Laramie, WY.

**Ackerfield, J.** 2023. Collaboration is the key to documenting biodiversity Colorado Weed Management Association Winter Conference. Pueblo, CO.

**Ackerfield, J.** 2023. Flora of Colorado: Updates to taxonomy and identification tools. Colorado Native Plant Masters. Denver, CO.

**Ackerfield, J.** 2023. Floristic inventory of Axton Ranch Mountain Park. Botany Conference. Boise, ID.

**Ackerfield, J.** 2023. *Physaria* X1 update and *Solidago capulinensis* scouting. Colorado Native Plant Society Rare Plant Symposium. Alamosa, CO.

**Ackerfield, J.** 2023. Untapped Plant Select® potentials. Plant Select® Conference. Denver, CO.

**Alba, C.** 2023. Green gems in cities – with a reach beyond the garden walls. Cities Summit of the Americas. Urban Live Labs: Nature-Based Solutions in Cities. Denver, CO.

**Alba, C.** 2023. Measuring tree health along an urban greenway. The Park People. Denver, CO.

**Alba, C.** 2023. Plant diversity and ecological function on the High Line Canal. Littleton Garden Club. Denver, CO.

**Alba, C.** 2023. Potentially problematic plants at Denver Botanic Gardens. Alpine Curators Meeting. Denver, CO.

**Alba, C.** 2023. The role of microsite selection in shaping urban tree planting success. Ecological Society of America. Portland, OR.

**Alba, C.** 2023. Vegetation and soil in relation to GSI function on the High Line Canal. High Line Canal STEP Committee. Denver, CO.

**Clark, M.**, **Goebel, A.**, and **R. Hufft.** 2023. Common garden experiments of grassland species to inform seed sourcing decisions for ecological restoration. National Native Seed Conference. Alexandria, VA.

**DePrenger-Levin, M.** 2023. Data management, security, and quality. Rare Plant Citizen Science Network. Virtual.

**DePrenger-Levin, M.** 2023. Pace and mode of reproduction predict short-term persistence of small populations. Ecological Society of America. Portland, OR.

**Eldred, L.M.W.** and **J. Neale.** 2023. Interdisciplinary bilingual interpretation: Art meets science at Denver Botanic Gardens. American Alliance of Museums. Denver, CO.

**Gentry, T.**, Bruederle, L., and **J. Ackerfield.** 2023. Diploid progenitors of the allopolyploid *Eutrema edwardsii*. Botany Conference. Boise, ID.

**Goebel, A.** 2023. Diverse plant populations and robust ecological restoration. University of Colorado Denver, Department of Integrative Biology. Denver, CO.

**Goebel, A.** and **R. Hufft.** 2023. Genetic variation & local climate adaptation: Seed sourcing implications for grassland restoration, Society for Ecological Restoration, Darwin, Australia.

Honan, A., Branco, S., Mondo, S., Barry, K., **Wilson, A.W.**, Wangeline, A., Stewart, J., Talag, J., Quandt, C.A., Lofgren, L., and V.M. Bunting. 2023. Myco-Ed: Mycological Curriculum for Education and Discovery. Mycological Society of America. Flagstaff, AZ.

**Hufft, R.** 2023. Conservation of Golf Courses: Thinking Outside the Box. Colorado Weed Management Association Winter Training, Pueblo, CO.

**Hufft, R.** 2023. Improving wildlife habitats surrounding agricultural fields and regenerative farming techniques to improve soil and water quality for Nature-Based & Unconventional Water Management Solutions for Sustainable Agriculture, USDA-FAO International Climate Hub. Virtual.

**Hufft, R.**, **Murray, R.**, **Craft, H.**, and K. Peterson. 2023. Empowering Visitors to Engage in the Climate Crisis. American Alliance of Museums, Denver, CO.

**Hufft, R.**, **Vickerman, L.**, **Neale, J.**, and **E. Geyer.** 2023. Bringing together restoration and sustainable agriculture practices for improvements in soil health, biodiversity, and wildlife habitat. Society for Ecological Restoration, Darwin, Australia.

**Levy, R.** 2023. Digital Asset Management System Selection and Implementation at Denver Botanic Gardens. APGA Technology Innovation Professionals Symposium. Virtual.

**Levy, R.** 2023. Rapid and reproducible specimen data formatting. BioDigiCon. Virtual.

**Loucks, J.J.** and **A.W. Wilson.** 2023. Exploring Cryptic Diversity in Western North American Bankeraceae. Mycological Society of America. Flagstaff, AZ.

**Neale, J.** 2023. Beyond the Gardens: Research activities at Denver Botanic Gardens. Fort Lewis College. Durango, CO. Virtual.

**Neale, J.** 2023. Community science | garden-led programs. Cities of the Americas Summit Symposium: Urban Live Lab: Nature-Based Solutions in Cities. Denver, CO.

Olds, C.G., Berta-Thompson, J.W., and **A.W. Wilson.** 2023. Diversity in Russulaceae (*Lactarius* and *Russula*) of the Southern Rockies measured using MOTUs from nrITS2 sequence data. Mycological Society of America. Flagstaff, AZ.

**Seglias, A.** and **R. Hufft.** 2023. Can alpine species "bank" on conservation. National Native Seed Conference. Alexandria, VA.

**Spencer, A.**, Bruederle, L., and **J. Ackerfield.** 2023. Systematics of the eastern Asian-North American disjunct genus *Physocarpus* (Rosaceae). Botany Conference. Boise, ID.

**Wilson, A.W.** 2023. Daily Voucher Collections Report. North American Mycological Association Meeting. Hendersonville, NC.

**Wilson, A.W.** 2023. Elevating Fungal Diversity Research Through Molecular Barcoding of Fungarium Collections. Mycological Society of America. Flagstaff, AZ.

# Citations

**Wilson, A.W.** 2023. How many millions?!?! The existential problem of describing fungal diversity. Kansas State University Department of Biology Seminar. Manhattan, KS AND Sierra Nevada Field Campus Spring Fungi Seminar. Sierra City, CA.

## Technical Reports

**Ackerfield, J.** 2023. Floristic inventory of Axton Mountain Ranch. Technical Report prepared for Denver Mountain Parks and Denver Mountain Parks Foundation.

**Alba, C.** 2023. Monitoring of newly planted trees along the High Line Canal: An interim report. Technical Report prepared for High Line Canal Conservancy.

**Alba, C.**, **Kintgen, M.**, and **J. Toews.** 2023. Sandsage prairie floristics at Ballyneal Golf Club. Technical Report prepared for Ballyneal Golf Club.

**DePrenger-Levin, M.** 2023. Conservation of *Phacelia submutica*. Technical Report prepared for US Bureau of Land Management.

**DePrenger-Levin, M.** and **R. Hufft.** 2023. Demographic monitoring of *Sclerocactus glaucus* and *Sclerocactus dawsonii*, two endemic species of western Colorado. Technical Report prepared for US Bureau of Land Management.

**DePrenger-Levin, M.** and **R. Hufft.** 2023. Life history and demography of *Astragalus microcymbus* (Fabaceae). Technical Report prepared for US Bureau of Land Management.

**DePrenger-Levin, M.** and **R. Hufft.** 2023. Population monitoring of *Penstemon harringtonii* (Plantaginaceae), an Endemic Species of Colorado, USA. Technical Report prepared for US Bureau of Land Management.

**DePrenger-Levin, M.** 2023. Transplanting as a conservation strategy: Case study using *Penstemon penlandii*. Technical Report prepared for Tri-State generation and transmission Association, Inc.

**Goebel, A.**, **Melhem, T.**, **Emery, A.**, and **R. Hufft.** 2023. Experiments to inform seed source selection for ecological restoration in grasslands. Technical Report prepared for US Bureau of Land Management.

## Datasets

Kathryn Kalmbach Herbarium, Denver Botanic Gardens. 2023. Kathryn Kalmbach Herbarium Occurrence dataset. <https://doi.org/10.15468/axrelr>

Kathryn Kalmbach Herbarium, Denver Botanic Gardens. 2023. Denver Botanic Gardens Collection of Arthropods Occurrence dataset <https://doi.org/10.15468/tdocff>

Sam Mitchel Herbarium of Fungi, Denver Botanic Gardens. 2023. Denver Botanic Gardens, Sam Mitchel Herbarium of Fungi Occurrence dataset <https://doi.org/10.15468/kuqqug>



## Professional Service

Serving as a resource of scientific expertise is one of our strategic objectives. Professional service connects our scientific staff to peers and the broader community. By serving in leadership roles for professional societies and organizations we not only give back to those that support us, but we help shape the role of botanic gardens in connecting science to the public. Serving in editorial positions and as reviewers for scientific journals also keeps us up to speed with current research in our fields. Staying connected to our professional community makes our work stronger.

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Colorado Mycological Society

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DENVER BOTANIC  
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