

# SCIENCE

## 2022 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.



# Where in the world was the Research & Conservation Department?

In-person activity resumed in 2022 after two quiet years due to COVID-19. We traveled to conferences, presented our research, hosted meetings, visited collaborators, launched new projects and expanded existing ones. Volunteers and visitors returned to our collections and the labs. Our programs grew, furthering our impact on connecting people with plants.

Jennifer Ackerfield and Chrissy Alba attended the **Botany Conference** in Anchorage, Alaska, land of the midnight sun. They presented their research, saw *Botrychium* (moonworts) and explored the arctic flora.



Michelle DePrenger-Levin and April Goebel attended the **Ecological Society of America Conference** in Montreal, Quebec, Canada. Michelle presented her work and helped develop a strategic restoration plan with the U.S. National Vegetation Panel. April presented her work modeling extinction risk of the Colorado endemic, *Eriogonum brandegeii*.



Becky Hufft attended the **North American Congress for Conservation Biology** in Reno, Nevada. She presented on our urban ecology research and participated in the board meeting for the Society for Conservation Biology North America.



We hosted the **Center for Plant Conservation** National meeting in Denver, Colorado. There were several presentations on advances in conservation practices and the work being done to save imperiled plants.



Andy Wilson attended the Mycological Society of America's **"Mycology in the Swamp"** meeting in Gainesville, Florida. He presented research on macrofungi and specimen vouchering projects.



## Honoring 45 years of service

This year we said a heartfelt thank you to **Vera Evenson**, our emeritus curator of the Sam Mitchel Herbarium of Fungi. Vera retired after 45 years of service to the Gardens. She began her involvement as an inquisitive volunteer in 1977. Her knowledge of and care for the collection grew under the guidance of our founder, Dr. D. H. "Sam" Mitchel, and she was offered employment in the collection in 1990. Vera's contributions to the collection and the Gardens are immeasurable. Beyond the more than 5,000 specimens she collected, she was always willing to share her knowledge with a kind and patient smile. Vera educated countless staff, volunteers and visitors in the role that fungi play in the environment and the wonders of their diversity. Vera is not only a local expert and author of two editions of reference books on the mushrooms of Colorado and the Southern Rocky Mountains, but she shared her knowledge with peers through scientific publications.



She collaborated with mycologists from across the globe and graciously hosted many at the herbarium during the Colorado Mycological Society's annual Mushroom Fair where she would tap into their expertise to confirm identifications within our collections, enhancing their scientific value. Mycology holds a special place at the Gardens thanks to Vera's dedication and persistence. We are forever in debt to her for her invaluable contributions. Fungi forever belong at the Gardens, and we all know, without fungi, there are no plants.

Margo Yousse attended the **Society for the Preservation of Natural History Collections meeting** in Edinburgh, Scotland. Margo presented on the development of a herbarium toolkit and moving our collections into the Freyer – Newman Center.



Alex Seglias travelled to Norway to meet with scientists at the University of Bergen to learn about their **research on the effects of climate change on alpine plants**.



Jenny Neale attended the **7th Global Botanic Garden Congress** in Melbourne, Australia. She presented on our Chatfield Farms restoration as part of an Ecological Restoration Symposium and the North American Alpine Strategy.



Rick Levy attended the **Biodiversity Information Standards conference** in Sofia, Bulgaria. He presented an application he developed to improve genetic sequence publication while learning about new methods and evolving data standards.



# Featured Projects

## Mystery of the Misidentified Mustard

A collaboration among several organizations, including the Colorado Natural Heritage Program, Denver Botanic Gardens, Jefferson County Open Space, Ken Caryl Open Space and the University of Northern Colorado hopes to answer an important question: Is this mystery mustard a new species? For many years, this mustard, known only as *Physaria* X1, has been unidentifiable and therefore misidentified, not truly fitting any currently described species. Last summer, we visited several locations to take leaf and soil samples of the mystery *Physaria* and closely related species, *Physaria bellii* and *P. vitulifera*. Using morphological, soil and genetic data, we aim to unravel the mystery of the misidentified mustard.



*Physaria* X1 – is it a new species?

## High Line Canal Tree Study

The High Line Canal greenway is a unique place in semi-arid Colorado where stately cottonwoods and willows thrive in an urban setting. Since the 1970s, the Canal corridor has evolved from its intended use in irrigation to a beloved 71-mile recreational corridor that beckons thousands of people to its shady banks each year. As the originally established trees age out, and as water scarcity issues become more pressing in the West, managers are planning (and planting!) for the future. We are supporting this effort by assessing how hundreds of newly planted trees, representing species with different stress tolerances, perform in relationship to their planting locations.



A young Catalpa sapling soaks up the sun



Grassland restoration study site



Researchers collecting plant samples at CommonGround Golf Course



One of the species included in this modeling analysis, the rare cactus *Sclerocactus glaucus*

## Grassland Restoration Study

In collaboration with the Bureau of Land Management, we are continuing our long-term ecological restoration research. This year we established three sites to study the impact of seed source on restoration outcomes. Restoration of degraded landscapes using wild-collected seed is the preferred approach for restoring wildlife habitat and conserving ecosystem function. However, successful restoration can be challenging. Using six common species native to grasslands of western North America, we are investigating the importance of past climate and current genetic diversity in shaping the performance of restored plant communities.

## CommonGround Golf Course

Urban areas are increasingly important in conservation. Our newest partner in better understanding the biodiversity in Denver and surrounding areas is the Colorado Golf Association, owners of CommonGround Golf Course. The property encompasses 337 acres, including 100 acres of wetland open space, 71 acres of native grass areas within the golf course and 115 acres of golf course turfgrass. While the golf course is already home to deer, coyotes, hawks and other wildlife, we hope to increase native plant diversity in these areas and make them better wildlife habitat, especially for pollinators. This summer we conducted a floristic inventory as a first step in working together to restore areas to increase biodiversity and improve habitat connectivity.

## Extinction Risk by Life History Traits

What is the risk of extinction for a given plant species? Surprisingly, we can't answer this question well. A species' risk of extinction depends on its mode and rate of reproduction. Using models to generalize plant responses to environmental variability by life history traits from long-term monitoring data, we aim to discover which species are at the greatest risk of extinction. Ultimately, this research will increase our understanding of the potential for species to expand their range or persist in place and help guide appropriate seed harvesting rates for conservation efforts.

# Printing Press

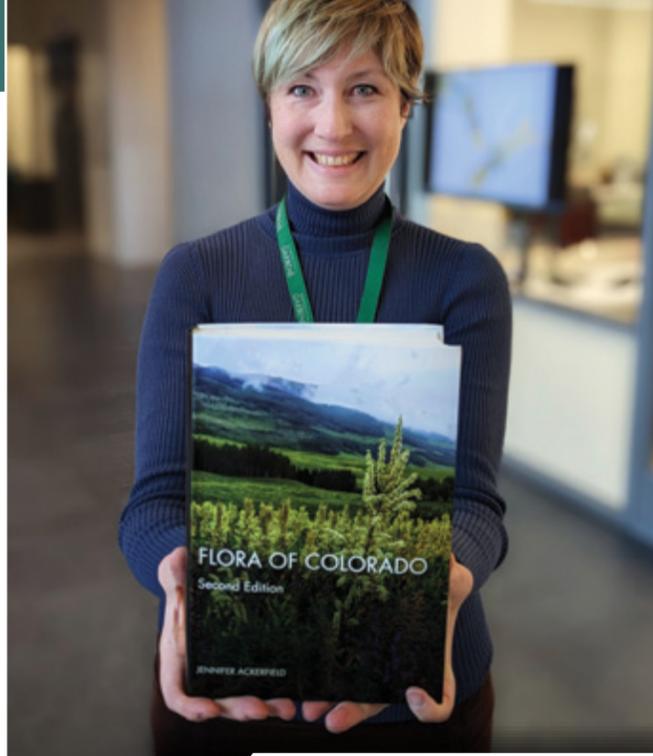
Publishing floras, keys and peer-reviewed journal articles is an important part of knowledge dissemination. Through these publications, our expertise and research findings are conveyed to the broader scientific and public communities. This allows others to evaluate our findings, initiate collaborations and creates new directions for future research. Ultimately, publishing builds upon the larger body of knowledge in taxonomy, systematics, conservation and ecology.

## Flora of Colorado, Second Edition

“The Flora of Colorado, Second Edition” is now available! This is the ultimate reference for all plant species present in Colorado, both native and introduced. The main purpose of the book is to provide dichotomous keys that enable the user to determine what plant species they have via a series of couplets. Each couplet is comprised of two choices consisting of contrasting morphological features, each with their own possible outcome. Choose correctly, and you will arrive at your species name in no time.

In addition to these keys, you will find numerous tools to help you in your identification journey including descriptions, elevation ranges and dot-distribution maps for every species, an introduction detailing the plant zones of Colorado, an illustrated glossary and numerous color photographs.

In fact, nearly 1,300 color photographs representing over 40% of the flora are included in the second edition. Photographs comparing difficult groups such as *Cirsium* (thistles), *Mentzelia* (blazingstars) and *Astragalus* (milkvetch) are especially useful – a description is helpful, but a picture is worth a thousand words. Black and white photos of seeds and fruit are also included for groups in which identification relies heavily on these microscopic characters, such as for the Amaranthaceae (amaranth), Boraginaceae (borage) and Nyctaginaceae (four-o'clock) families.

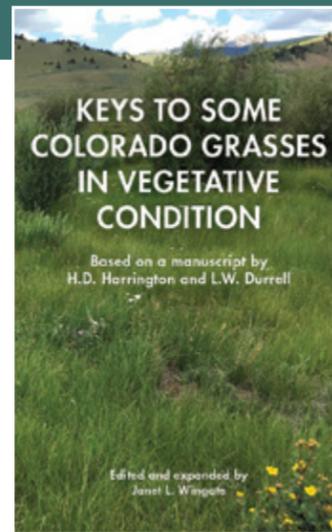


Author Dr. Jennifer Ackerfield

The second edition relies heavily on digitized and databased herbarium specimens for the range, locality and elevation information of each species. Compiling this information for the first edition was incomplete as some herbaria were not yet available online or only partially databased. But, thanks to the efforts of herbaria throughout the Rocky Mountains and Intermountain West, nearly complete specimen information is now readily available via online biodiversity portals. By examining this specimen data, over 120 new species were added to this edition – the result of range extensions, new invasive species or species inadvertently excluded from the first edition.

Some nomenclatural updates were also necessary. All scientific names used in the first edition were checked against the Global Biodiversity Information Facility (GBIF [gbif.org](http://gbif.org)) taxonomic backbone. Then, every single nomenclatural change was double checked in the literature to verify that the name changes made adhered to the species concept followed in the book, thus ensuring taxonomic consistency. There were even 10 species new to science described since the first edition that are in the second edition.

In looking to the future, we encourage you to record the plants observed on your hikes and adventures with [iNaturalist](https://www.inaturalist.org/). These observations will then be used to make even more detailed distribution maps for the third edition. And who knows, maybe you will even find a new species for Colorado.



## Keys to Some Colorado Grasses in Vegetative Condition

Identifying grasses in flower can be difficult. Identifying grasses when only the vegetative parts are present can be downright impossible. With Janet Wingate’s revision of “Keys to Some Colorado Grasses in Vegetative Condition,” this task will be much easier. Illustrations accompany the couplets, aiding the user in their identifications.

## Hiding in Plain Sight: Two new species of alpine thistles from the southern Rocky Mountains

Sometimes, new plant species are hiding right in plain sight. This [scientific publication](#) by Jennifer Ackerfield describes two new species that were doing just that – *Cirsium funkiae* (funky thistle) and *Cirsium culebraense* (Culebra Range thistle). These findings were the result of in-depth morphological and phylogenetic studies that determined these to be distinct entities from *Cirsium scopulorum* (mountain thistle).



*Cirsium funkiae*, the funky thistle



## Using Biological Invasions to Improve Plant Defense Theory

Introduced plants experience marked changes in herbivore communities in their new ranges, making them excellent systems for studying rapid evolution of chemical defenses. This [scientific publication](#) by Chrissy Alba reviews a decade of defense evolution research on *Verbascum thapsus*, then distills the findings to pose a new framework for studying how plants optimally defend themselves against a diversity of herbivores.

*Verbascum thapsus*, mullein

## Increasing Within-species Genetic Variation for Native Plant Restoration

Actively planting seed of native species can be an important step in restoring ecological function and conserving biodiversity following landscape disturbance. However, deciding where to source seed for such restoration projects can be challenging. A [scientific publication](#) led by April Goebel demonstrates that, for a species of annual sunflower, seeds with increased genetic diversity can positively impact certain aspects of plant performance and can buffer plant populations against environmental variability.

Plot of sunflower plants



## Can Alpine Species “Bank” on Conservation?

Alpine plant species are particularly at risk from climate change. One way to conserve plant species is through seed banking. However, some studies have shown that alpine seeds are shorter lived in -20°C storage than low-elevation species. Alex Seglias studied seeds from alpine species in Colorado and found that they exhibit a similar pattern. This [scientific publication](#) contributes toward optimal seed collection and storage protocols.

Rare alpine plant *Saussurea weberi*

# 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 permanent record of our natural world – documenting morphological, genetic and distributional information all in a single collection. Together, these collections provide precious evidence of how landscapes, ecosystems and populations change over time. As a museum, the Gardens' natural history collections support and engage all who are curious about the natural world, including scientists, artists and activists. And as permanent records of the past, these collections provide invaluable and irreplaceable resources for protecting our future.

## Konza Prairie and Niwot Ridge Mushroom Collections

What makes mushrooms mushroom? This is a question in fungal biology that the National Science Foundation-funded CLIMUSH project is attempting to explore. Reproduction in fungi can be influenced by plant diversity, environmental disturbances such as fire and other variation between habitats. This year, we have been sampling vegetation, soil samples, spores and mushrooms from Niwot Ridge in Colorado and Konza Prairie Biological Station in Kansas. In collaboration with mycologists from across North America, DNA sequence data from these samples will be compared to others across multiple sites to study the environmental influences on mushroom production in fungi. Thanks to projects such as this, we now currently house approximately 22,715 fungal specimens in the Sam Mitchel Herbarium of Fungi.

Konza Prairie Biological Station in Kansas

## Axton Mountain Ranch Floristic Study

This summer wrapped up our floristic inventory of a new Denver Mountain Park, Axton Mountain Ranch. Over the course of two summers, we collected approximately 415 unique species of vascular plants, representing about 13% of the flora of Colorado. Our inventory even included six different species of orchids! Through this project, we were able to provide six high school students with immersive, hands-on experience in the sciences. These students accompanied professional botanists on plant collection trips, learning how to make natural history collections and the importance of biodiversity research. This experience was so impactful that two of these students are now pursuing college degrees in the natural resources.



Researchers and interns jump for joy at the beginning of collecting season at Axton Mountain Ranch



Collecting specimens for the reference collection at Canyons of the Ancients

## Building a Reference Collection One Botanical Expedition at a Time

We have a goal at the Kathryn Kalmbach Herbarium – a collection of every plant species occurring in Colorado. To fill in gaps for this, we journeyed to Canyons of the Ancients Monument in Montezuma County. We made 75 collections, of which 20 represented species for which we had no previous collections. During our expedition, we even discovered a new species for the state – *Aphyllon franciscanum* (yellow clustered broomrape). While hunting for plants, we also saw pottery shards, ancient dwellings tucked into canyon alcoves and rock art. We look forward to more botanical expeditions across Colorado as we continue to build our reference collection.

## Roadside Botany on the Eastern Plains of Colorado

An important goal of the herbarium is to build the collection from all areas of Colorado. The eastern plains comprise over a third of the state, but account for a small fraction of collections when compared to mountainous areas. Last summer, we made three trips, visiting four counties – Kit Carson, Cheyenne, Elbert and Washington – to collect plants along roadsides. The sandy areas of Elbert and Washington Counties were particularly fruitful. These trips yielded nearly 250 specimens, 30 county records and even one state record, *Gossypium hirsutum* (cotton). Thanks to efforts such as this, we now house approximately 69,100 specimens of vascular plants in the Kathryn Kalmbach Herbarium.



Scouting for plants along a county roadside on the eastern plains

EcoFlora nature hike on Green Mountain

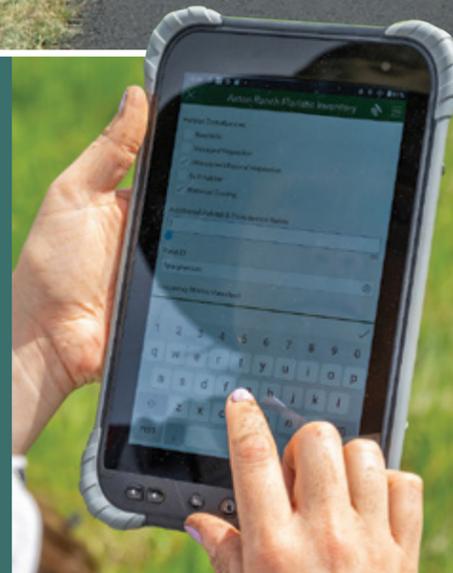
## Denver EcoFlora Outreach Highlights

The [Denver EcoFlora Project](#) made great strides in connecting the local community with plants. Staff and three high school interns led several nature hikes in the Denver metro area, teaching people about the plants in their own backyards. On these hikes, we instructed people on how to contribute to science by making their own observations of plants for [iNaturalist](#). We also sent out monthly EcoQuests, challenging people to go on scavenger hunts for specific plants. Through these efforts, we engaged with over 100 people in person. On iNaturalist, we now have 239,185 observations of plants for the Denver-Boulder metro area, for a total of 3,760 different species.

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## Digital Field Notebooks

Data are the fundamental units of discovery. Together they allow scientists to tell stories that guide decisions that impact every one of us. Denver Botanic Gardens is laser focused on collecting the best and most robust data that describe the plants and fungi of Colorado. Whether it's a genetic sequence unique to a species of mushroom or a description of the soil and habitat where a rare cactus calls home, we are expanding the use of digital tools to better document our research. In turn we create linked data and make it freely available online for this and future generations to explore and learn from. This year, we began the use of digital field notebooks to streamline specimen collections and ensure that the data collected are of the highest standards.



The Research & Conservation Department is committed to training future and current scientists through immersive research opportunities. Students pair with a lead scientist at the Gardens to answer questions pertaining to ecology, biodiversity and conservation. Research opportunities not only help us answer these important questions, but also teach students how to conduct research and contribute to science.

## Emily Orr

Emily successfully defended her Master's thesis in the fall. She studied population genetic structure and patterns in the rare milkvetch *Astragalus microcymbus*. The species is of conservation concern for conservation professionals. Emily's data show that there is moderate genetic diversity in the species and it is broadly distributed across the species' range. The lack of geographic structuring indicates either historic or current gene flow among the known locations. Emily moved to Saint Louis and has finished her degree remotely while full-time as a Biologist.



## Francis Anaya

Franki is a Master's student looking at the efficacy of seeding as a post-wildfire management practice. She is working with the Bureau of Land Management and using their Assessment, Inventory and Monitoring data to determine if seeding the Beaver Creek burn scar in Jackson County, Colorado has resulted in native vegetation regeneration or surface stabilization.



## Megan Clark

Megan is a Master's student broadly interested in conservation and plant community ecology. Her research focuses on the use of locally-sourced seed in restoration and how the movement of seed across regions impacts restoration success. With her research, she hopes to improve restoration techniques used in the Front Range.



## Justin Loucks

Justin is a master's student broadly interested in fungal diversity and ecology, and enjoys traveling and documenting rare and unique fungi. His research employs DNA barcoding and phylogenetics to systematically examine the diversity and distributions of taxa in the fungal family *Bankeraceae* within western North America.



## Michelle DePrenger-Levin

Michelle is a PhD candidate exploring biological traits that predispose a species to extinction. She is interested in how life history traits and variation in response to environmental forces impact the persistence of a species across its range and is examining available methods to detect declines in population size or range that increase extinction risk.



## Tiffany Gentry

Tiffany is a Master's student interested in the processes of evolution and speciation. Her research involves using molecular DNA sequencing to determine the closest living relatives of the rare Colorado endemic, *Eutrema penlandii*. She is also exploring how chromosome duplication contributes to within-genus diversification.



## Alissa Iverson

Alissa is a Master's student examining the composition of the plant community and soil seed bank of an urban canal undergoing hydrologic change. By uncovering what species of plants have seeds in the soil, she can make comparisons to the above-ground vegetation and determine the capacity of the habitat to respond to change.



## Audrey Spencer

Audrey is a Ph.D. student interested in the origins of the flora of the Southern Rocky Mountains and the biogeographical history of disjunct distribution patterns. Her research will use a combination of phylogenetics, morphology and geography to clarify the taxonomic relationships as well as the biogeographic history of *Physocarpus* (ninebark).



## Select Publications

**Ackerfield, J.** 2022. Flora of Colorado, Second Edition. Bot. Res. Inst. Texas. 861 pp.

**Ackerfield, J.** 2022. Hiding in plain sight: Two new species of alpine thistles, *Cirsium culebraense* and *C. funkiae* (Cardueae) from the southern Rocky Mountains (United States). The International Compositae Alliance 1(2): 1-15.

Baur, A., English, C.T., **Alba, C.**, **Spencer, A.**, and **L.P. Bruederle.** 2022. Facultative outcrossing inferred from pollen-ovule ratios in *Penstemon degeneri* (Plantaginaceae), a rare Colorado endemic. The Southwestern Naturalist 66(2): 175-179

Endriss, S., **Alba, C.**, and R.A. Huffbauer. 2022. Using biological invasions to improve plant defense theory. Entomologia Experimentalis et Applicata. Special Issue: Insect-Plant Relationships. 170:632-645. DOI: 10.1111/eea.13195

Finch, J., **Seglias, A.E.**, Kramer, A.T., and K. Havens. 2022. Recruitment varies among milkweed seed sources for habitat specialist but not generalist. Restoration Ecology <https://doi.org/10.1111/rec.13725>

**Goebel, A.M.**, Doak, D.F., and N.C. Kane. 2022. Empirical test of increasing genetic variation via inter-population crossing for native plant restoration in variable environments. Restoration Ecology 30(8) p. e13648

**Goebel, A.M.**, Kane, N.C., Doak, D.F., Rieseberg, L.H., and K.L. Ostevik. 2022. Adaptation to distinct habitats is maintained by contrasting selection at different life stages in sunflower ecotypes. Molecular Ecology <https://doi.org/10.1111/mec.16785>

Kucera, K.F., Fant, J.B. Jensen, S., Landeen, M., **Orr, E.** and A.T. Kramer. 2022. Genetic variation and structure change when producing and using mixed-source seed lots for restoration. Restoration Ecology 30(3) e13521. <https://doi.org/10.1111/rec.13521>

**Meluso, A.**, **Neale, J.**, and B. Boom. 2022. EcoFlorAs: Fostering community and biodiversity discovery. Public Garden Magazine 37(3) pp 8-11.

Philpott, M., Pence, V.C., Bassüner, B., Clayton, A.S., Coffey, E.E. D., Downing, J.L., Edwards, C.E., Folgado, R., Ligon, J.J., Powell, C., Ree, J.F., **Seglias, A.E.**, Suggi, N., Zale, P.J., and J. Zeldin. 2022. Harnessing the power of botanical gardens: Evaluating the costs and resources needed for exceptional plant conservation. Applications in Plant Sciences 10(5): e11493. <https://doi.org/10.1002/aps3.11493>

**Seglias, A.E.** 2022. Can alpine plant species "bank" on conservation?: Using artificial aging to understand seed longevity. Applications in Plant Sciences 10(5): e11493. <https://doi.org/10.1002/aps3.11493>

Warner, B.P. and **A. Meluso.** 2022. We are fingers of a hand that make a fist: Working class alliances in Colorado River water protests in the Mexicali Valley, Mexico. Water Alternatives 15(2): 193-214

**Wingate, J.** 2022. Keys to some Colorado grasses in vegetative condition. Wingate Publishing. Denver, CO.

Zhang, R., Shi, X.F., Liu, P.G., **Wilson, A.W.**, and G.M. Mueller. 2022. Host shift speciation of the ectomycorrhizal genus *Suillus* (Suillineae, Boletales) and biogeographic comparison with its host Pinaceae. Frontiers in Microbiology 13: 831450

## Select Presentations

**Ackerfield, J.** 2022. Diversification of *Cirsium* (thistles) in North America: drivers of a continent-wide radiation. Botanical Society of America Conference. Anchorage, AK.

**Ackerfield, J.** 2022. EcoFlorAs elucidate lessons learned from biodiversity data. Botanical Society of America Conference. Anchorage, AK.

**Ackerfield, J.** 2022. History of the herbaria at Denver Botanic Gardens. Council on Botanical and Horticultural Libraries Conference. Denver, CO.

**Ackerfield, J.** 2022. Taxonomy of flowering plants - why do these darn names keep changing? Colorado Native Plant Society. Denver, CO.

**Ackerfield, J.** 2022. The Denver EcoFlora Project: Highlights and overview. Denver EcoFlora Conference. Denver, CO.

**Ackerfield, J.** 2022. The story of the funky thistle: How to transform your research into a newsworthy story. Botanical Society of America Conference. Anchorage, AK.

**Ackerfield, J.** 2022. Wildflowers of Colorado: A rock garden perspective. North American Rock Garden Society Annual Banquet. Denver, CO.

**Alba, C.**, **DePrenger-Levin, M.**, and **R. Hufft.** 2022. Cheatgrass control with Rejuvra®: Its potential role in shaping vegetation response to fire. Botanical Society of America. Anchorage, AK AND Ecological Society of America. Montreal, Quebec, Canada.

**Alba, C.**, **DePrenger-Levin, M.**, and **R. Hufft.** 2022. How management of cheatgrass shapes plant community response to fire in Front Range foothills grasslands. Colorado Native Plant Society. Fort Collins, CO.

**Alba, C.**, **DePrenger-Levin, M.**, and **R. Hufft.** 2022. Incorporation of indaziflam (Rejuvra®) into weed management regimens in natural areas: A post-fire assessment. High Altitude Revegetation Committee – Society for Ecological Restoration – Rocky Mountains Chapter (HAR/SER-RM). Fort Collins, CO.

Delevich, C.A., Roy, B.A., Diez, J.M., McGuire, K., Conery, J., Frey, S.D., Smith, M.E., Kennedy, P.G., Arnold, A.E., U'Ren, J., **Wilson, A.W.**, and D.J. Jean Lodge. 2022. Distributions of macrofungi: quantifying ecosystem and climate drivers of fungal reproduction. Mycological Society of America Annual Meeting. Gainesville, FL.

**DePrenger-Levin, M.** 2022. Adaptive capacity of *Sclerocactus glaucus*. Center for Plant Conservation National Meeting. Denver, CO.

**DePrenger-Levin, M.** 2022. The role of life history traits in population dynamics in a changing environment. Ecological Society of America. Montreal, Quebec, Canada.

**Goebel, A.** 2022. Assessing local adaptation & evolutionary potential in common grassland species to inform seed selection for restoration. HAR/SER-RM. Fort Collins, CO.

**Goebel, A.** 2022. Optimizing the use of demographic data for viability analysis of threatened species when there are planned or unplanned missing data: The case of *Eriogonum brandegeei*. Ecological Society of America. Montreal, Quebec, Canada.

Herrera, M., Mueller, G.M., and **A.W. Wilson.** 2022. Preliminary results of the diversity and taxonomy of family Hydnaceae in Costa Rica. Mycological Society of America Annual Meeting. Gainesville, FL.

**Hufft, R.**, **Alba, C.**, and R. Levy. 2022. Monitoring biodiversity in urban wildlife corridors. North American Congress for Conservation Biology 2022, Reno, NV.

**Iverson, A.** and **C. Alba.** 2022. Soil seed bank of an urban canal undergoing hydrologic disturbance. Poster. HAR/SER-RM. Fort Collins, CO AND Natural Areas Association (NAA). Duluth, MN.

Leacock, P., Gaswick, W., Filialuna, O., and **A.W. Wilson.** 2022. The NAMA Voucher Collection Project and its twenty-five years of public and professional research, outreach, and training in macrofungal diversity. Mycological Society of America Annual Meetings. Gainesville, FL.

**Levy, R.** 2022. Arc Online for born digital data: Our experience six months in. Biodiversity Digitization Conference.

**Levy R.**, **Berta-Thompson J.**, **Olds, G.**, and **A.W. Wilson.** 2022. Specimods: A web-based tool for producing Genbank submission files for sequenced museum specimens. Biodiversity Information Science Standards. Sofia, Bulgaria AND Mycological Society of America Annual Meetings. Gainesville, FL.

**Levy, R.** 2022. The Data Underpinning Biodiversity Research. Café Botanique. Denver, CO.

**MacDonald, R.** 2022. Denver EcoFlora Project: Highlights from two years of outreach. Denver EcoFlora Conference. Denver, CO.

**Neale, J.** 2022. EcoFlora for everyone: Engaging your community in observing nature. Friends of the Chico State Herbarium. Chico, CA.

**Neale, J.**, **Hufft, R.A.**, **Goebel, A.**, and **L. Vickerman.** 2022. Environmental stewardship through riparian and meadow restoration. 7th Global Botanic Garden Congress, Melbourne, Australia.

**Neale, J.**, Ripley, N., Griffoul, E., and **M. Kintgen.** 2022. Conserving the North American alpine: from tiny seeds to big collaborations. 7th Global Botanic Garden Congress, Melbourne, Australia.

Paradiso, L., Lichtenberger, R., **Neale, J.**, **Meluso, A.**, Davis, J., and C. Arnold. 2022. Fostering Community and Discovery with EcoFlora. American Public Garden Association National Meeting. Portland, OR.

**Seglias, A.** 2022. Can alpine plant species "bank" on conservation. Society for Ecological Restoration High Altitude Revegetation Committee – Society for Ecological Restoration – Rocky Mountains Chapter. Fort Collins, CO.

**Wilson, A.W.** 2022. From soil to museum specimens: using DNA metabarcoding to study the diversity of macrofungi. UC Anschutz Medical Campus. Aurora, CO.

**Wilson, A.W.** 2022. Fungi in alpine ecosystems. Sierra Nevada Field Campus Spring Fungi Course. Sierra City, CA.

**Wilson, A.W.** 2022. Fungi of the Plains: Do the plants of the steppe need fungi? Steppe Symposium. Denver, CO.

**Wilson, A.W.** 2022. Introduction to the mushrooms of the Rockies: the power of voucher. Telluride Mushroom Festival. Telluride, CO.

**Yousse, M.**, **Levy, R.**, and **J. Ackerfield.** 2022. Herbarium processing toolkit. Society for the Preservation of Natural History Collections. Edinburgh, UK.

**Yousse, M.** and **J. Neale.** 2022. Moving collections in a pandemic? No problem! How planning and preparation saved the day. Society for the Preservation of Natural History Collections. Edinburgh, UK.

## Technical Reports

**Ackerfield, J.** and **C. Alba.** 2022. Rocky Mountain National Park *Erythranthe gemmipera* survey. Technical Report submitted to the National Park Service.

**Alba, C.**, 2022. How might vegetation and soil characteristics affect the function of green stormwater infrastructure on an urban greenway? An exploration using Reach 30 of the High Line Canal in Denver, Colorado. Technical Report submitted to High Line Canal Conservancy.

**Alba, C.** and **M. DePrenger-Levin.** 2022. Incorporation of indaziflam (Rejuvra®) into Boulder County Parks and Open Space Weed Management: A Post Fire Assessment. Technical Report submitted to Boulder County Parks and Open Space. Available at <https://bouldercountyopenspace.org/i/research/>

**DePrenger-Levin, M** and **R. Hufft.** 2022. Demographic monitoring of *Sclerocactus glaucus*, an endemic species of western Colorado. Technical Report submitted to Colorado Bureau of Land Management.

**DePrenger-Levin, M** and **R. Hufft.** 2022. *Eriogonum brandegeei* Demographic monitoring study 2004-2020. Technical Report submitted to Colorado Bureau of Land Management.

**DePrenger-Levin, M** and **R. Hufft.** 2022. Life history and demography of *Astragalus microcymbus* Barneby (Fabaceae). Technical Report submitted to Colorado Bureau of Land Management.

## Data Sets

Kathryn Kalmbach Herbarium (Denver Botanic Gardens). 2022. Kathryn Kalmbach Herbarium. Occurrence dataset <https://doi.org/10.15468/axrelr>

Kathryn Kalmbach Herbarium (Denver Botanic Gardens). 2022. Denver Botanic Gardens Collection of Arthropods. Occurrence dataset <https://doi.org/10.15468/tdocff>

Sam Mitchel Herbarium of Fungi (Denver Botanic Gardens). 2022. Denver Botanic Gardens, Sam Mitchel Herbarium of Fungi. Occurrence dataset <https://doi.org/10.15468/kuagg>



## Engaging in the Global Conservation Conversation

We traveled to the United Nations COP15 in Montreal, Quebec, Canada to participate in the 7th Summit for Subnational Governments and Cities. Mayors, governors and city governments across the globe are already taking action to protect biodiversity in their cities. As representatives of the Gardens, we spent three days at COP15 listening and observing how the negotiations on the Global Biodiversity Framework proceeded and gathered ideas on how to enhance the impact and influence of the Gardens in our community.

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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](http://botanicgardens.org) and selecting “Science.”

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DENVER BOTANIC  
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