

SCIENCE

2015 YEAR IN REVIEW

Plants are fundamental to life, from the air that we breathe to the food that we eat. Science is the foundation of botanic gardens, from understanding how to grow plants in the gardens to conserving biodiversity outside the gardens. Thus, plant science serves as a key programmatic element of Denver Botanic Gardens.



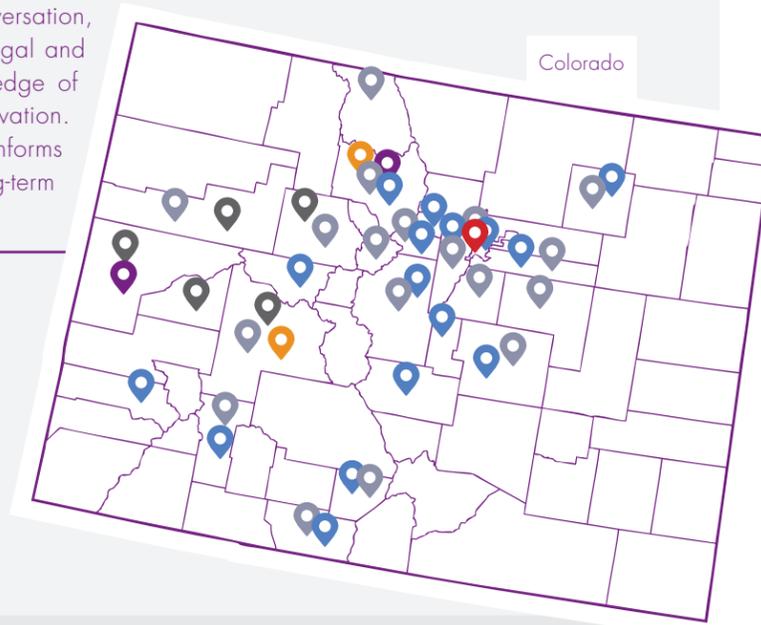
2015 WAS AN ACTIVE YEAR FOR FIELD, LAB AND COLLECTION ACTIVITIES

As a regional research center, we play a critical role in the conversation, preservation and documentation of Colorado's biodiversity. Plant, fungal and insect collections document species occurrence, deepen our knowledge of biodiversity, provide primary data for scientific studies and inform conservation. Field measurements and tissue samples build the body of data that informs protection decisions for plant species. Seed collections aid in long-term preservation.

Collected in 2015:

-  **48,548** rare and imperiled plant measurements
-  **2,926** seeds
-  **1,334** plant specimens
-  **319** fungal specimens
-  **141** insect specimens
-  **5** threatened and endangered species tissue samples

PLUS  **17** of the plant specimens collected in 2015 were new county records, expanding our knowledge of plant distributions.



Conservation Programs

Seed Conservation

Regional seed collecting, preservation and germination experiments support *ex situ* conservation of rare species and restoration efforts. In 2015, we collected 2,763 seeds of *Penstemon penlandii* (an endangered species) and 22 separate seed collections of *Sclerocactus brevispinus* (threatened), *Sclerocactus wellandicus* (threatened) and *Sclerocactus glaucus* (threatened). We grew threatened and endangered

species at Denver Botanic Gardens for display and educational purposes. For two of these species, *Ipomopsis polyantha* (endangered) and *Penstemon penlandii*, we conducted germination experiments to develop appropriate protocols for future reintroductions, if needed. The *P. penlandii* study supported our conservation genetics work of this species.



Ipomopsis polyantha, which is only found naturally in one locality worldwide, around Pagosa Springs, CO, on display in our conservation garden after a successful germination experiment.

Population Biology

As one of our longest running conservation programs, long-term demographic monitoring and niche modeling are used to assess threats to rare species and advise management strategies. 2015 marked our 21st year of long-term monitoring of *Astragalus microcymbus* (a candidate for listing), our 20th year for *Penstemon harringtonii* (a US Bureau of Land Management (BLM) and US Forest Service sensitive species) and our eighth year for *Sclerocactus glaucus*.



A volunteer and intern collect data on *Penstemon harringtonii* outside of Eagle, CO.

Conservation Programs (continued)

Conservation Genetics

Our conservation genetics program investigates population level diversity and patterns in some of our state's rarest species. Through collaboration with the BLM and the US Fish and Wildlife Service, we are addressing questions of species identity, genetic diversity and distribution, which incorporate both population genetics and phylogenetics, to inform management decisions. In 2015, we initiated a project examining genetic diversity across *in situ* populations and *ex situ* collections of *Penstemon penlandii*. Additional genetics work continued with *Sclerocactus* populations in Colorado and with the Dudley Bluffs mustards (*Physaria congesta*, *Physaria obcordata*, both threatened).

NEW PROGRAM Native Habitat Restoration

At Denver Botanic Gardens Chatfield Farms, we are restoring 5.5 acres of degraded riparian habitat. In 2015, we initiated the first phase of the Native Habitat Restoration Project which included a floristic survey. Currently, stream structures are being designed to improve hydrology. In 2016 plans will be developed for long-term monitoring of vegetation, invertebrates and water quality. This work is funded by the Borgen Family Foundation and the National Fish and Wildlife Foundation Five Star and Urban Waters Program.



Part of the 2015 efforts included protecting cottonwood trees along the creek from beaver damage by applying paint mixed with sand to the trunks. This texture discourages the beavers from chewing the trees.

Graduate Student Advising

We expanded our graduate student training, including a more formal partnership with the **Department of Integrative Biology at the University of Colorado Denver (UCD)** where several Gardens staff are affiliate faculty. Graduate students play a role at the Gardens through **Graduate Research Assistantships**. Currently, Rebecca Hufft, PhD, is the primary advisor of Carla DeMasters, a masters student at UCD, and Jennifer Neale, PhD, co-advises a doctoral student at the University of Denver. Additionally, these staff along with Melissa Islam, PhD, and Sarada Krishnan, PhD, serve on graduate committees at local universities.

Phenology

Partnering with the USA National Phenology Network (USA-NPN) and Project BudBurst, Gardens staff and volunteers make phenology observations of plants at our three locations: York Street, Chatfield Farms and Mount Goliath. All of these data are publicly available through our partners' websites.

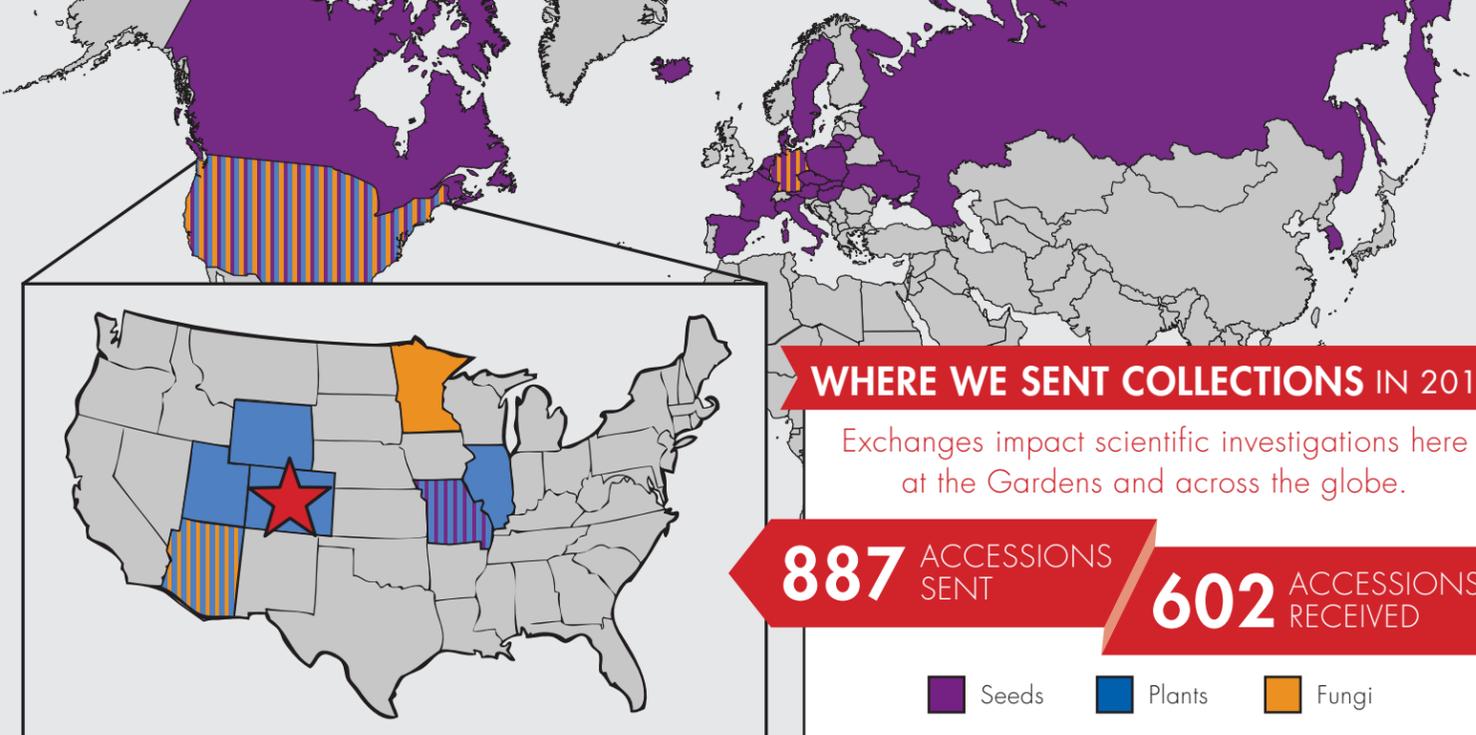
IN 2015 WE MADE

649
TOTAL
PHENOLOGY VISITS

over 76 days to 96 individual plants



Lilac phenology data have been formally collected in the United States since the 1950s and make up a large component of our phenology data.



WHERE WE SENT COLLECTIONS IN 2015

Exchanges impact scientific investigations here at the Gardens and across the globe.

887 ACCESSIONS SENT **602** ACCESSIONS RECEIVED

Seeds Plants Fungi

Our Collections

Denver Botanic Gardens is an American Alliance of Museums (AAM) accredited museum with two natural history collections (herbaria), seven living collections, art collections and a library.

Herbaria

Denver Botanic Gardens has two herbaria: The Kathryn Kalmbach Herbarium of Vascular Plants (KHD) and the Sam Mitchel Herbarium of Fungi (DBG). These collections document vascular plants and fungi throughout the Southern Rocky Mountain Region and include small ethnobotany and insect collections (DBGA). In 2015, Gardens' staff collected plants, fungi and insect specimens in 26 Colorado counties documenting under-collected areas of high biodiversity.

Living Collections

The living collections at Denver Botanic Gardens are one of the most diverse in North America with seven major collections identified: Alpine, Amenity, Aquatic, Cactus & Succulents, Native, Steppe and Tropical. Individual plants within these collections are grown for aesthetic purposes, education, research and/or conservation efforts. Plants are collected from the wild, received through exchanges and purchased from nurseries and garden centers.

Tissue Culture

Plants in our Living Collections that are difficult to propagate by traditional methods are expanded through tissue culture. In 2015, 13 species were produced and/or experimented in tissue culture, producing over 800 plantlets. These plantlets are supplied to our green industry partners.



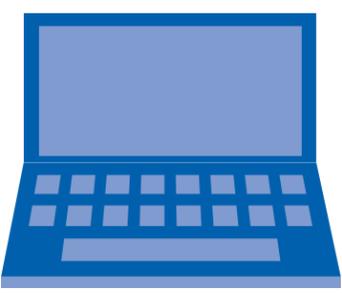
In August, our first corpse flower, *Amorphophallus titanum*, bloomed. When the male flowers matured, we harvested pollen and sent it to the Chicago Botanic Gardens to facilitate pollination of their corpse flower which bloomed later in 2015. Photo by Scott Dressel-Martin.

Our Collections (continued)



Helen Fowler Library

The Helen Fowler Library supports research through access to scientific literature. In 2015, researchers requested a diversity of literature, from recent publications in scientific journals to 200-year-old books held in the Waring Rare Book Room. Working together, library and herbaria staff curated and catalogued hundreds of general interest plant and fungal books stored in the herbarium.



SEARCH OUR COLLECTIONS

Our collection data are accessible **24/7** THROUGH DATA PORTALS

Herbaria collections are available through **SEINet** (swbiodiversity.org/seinet) for plants, **MycPortal** (mycoportal.org) for fungi, and **SCAN** (symbiota4.acis.ufl.edu/scan/portal) for insects.

Living collections can be searched through **Gardens Navigator** (navigate.botanicgardens.org). Collections are also searchable through **Botanic Gardens Conservation International** (bgci.org/plant_search.php), which includes data from 1,144 institutions.

Library resources can be accessed at www.botanicgardens.org/library.



An image of *Asclepias asperula*, collected in 2012 in Mesa County, CO. Over 57,000 specimens have been imaged and uploaded to SEINet for anyone to access.

NEW COLLECTION

Herbaria I Collection of Arthropods

In 2015 we started this collection to discover and document arthropod diversity within the Gardens and to educate about their role in the Gardens and wildlands.



TOTAL ACCESSIONS AS OF 12/31/2015

60,150 KHD (plants)

26,780 Living Collections

17,875 DBG (fungi)

141 DBGA (insects)



9 fungal species were found in Colorado for the first time in 2015 and are housed at the Sam Mitchel Herbarium of Fungi. They include:

60,000



Russula silvicola

50,000



Agaricus rubronanus

40,000



30,000

20,000

10,000



Outreach

	External scientific community engagement	Attended or presented at 16 conferences or workshops in 2015.
	Internal scientific community engagement	Hired and trained undergraduate and graduate students, interns and seasonals.
	External public engagement	Participated in the Exhibitor Lounge at TEDxYouth@MileHigh which was attended by 2,000+ middle- and high-schoolers.
	Internal public engagement	Conducted Science Chats in the Science Pyramid, interacting with over 2,500 visitors in 2015.
	External program support	Provided over 250 hours of lectures, interviews and workshops to local radio and TV programs, Garden Clubs, Fungal and Plant Societies and classrooms, as well as partnering with outside organizations to support initiatives.
	Internal program support	Provided research and education specimens to Gardens' staff to facilitate workshops, tours, classes and exhibits.

Publications

Bone, M., D. Johnson, P. Kelaidis, M. Kintgen, L. Vickerman. 2015. "Steppes: The Plants and Ecology of the World's Semi-arid Regions." Timber Press, Portland, OR.

Evenson, V.S. and Denver Botanic Gardens. 2015. "Mushrooms of the Rocky Mountain Region." Timber Press Field Guide: Portland, OR.

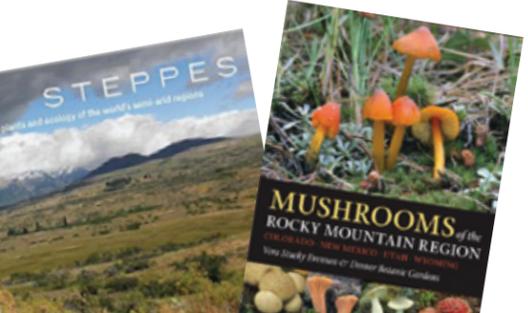
Faist, A.M., **J.M.R. Neale**, B. Mines and S.K. Collinge. 2015. Maintenance of Pollinator Function in Restored Vernal Pools: Gnats Filling the Role of Solitary Bees. *Ecological Restoration* 33: 51-60.

Islam, M.B. and R.P. Guralnick. 2015. Generic Placement of the Former *Condaliopsis* (Rhamnaceae) Species. *Phytotaxa* 236 (1): 25-39.

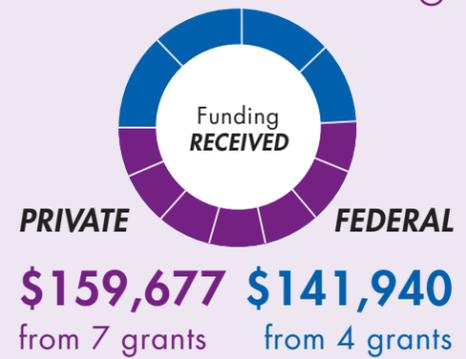
Krishnan, S., T. Ranker, A.P. Davis, and J.J. Rakotomalala. 2015. Current status of coffee genetic resources: Implications for conservation – Case study in Madagascar. *Acta Horticulturae* 1101: DOI 10.17660/ActaHortic.2015.1101.3.

Levy, R.A. and C.R. Nufio. 2015. Dispersal Potential Impacts Size Clines of Grasshoppers Across an Elevation Gradient. *Oikos* 124: 610-619.

Stevens, M.I., A.C. Clarke, F.M. Clarkson, **M. Goshorn.** 2015. Are Current Ecological Restoration Practices Capturing Natural Levels of Genetic Diversity? A New Zealand Case Study Using AFLP and ISSR Data from Mahoe. *New Zealand Journal of Ecology* 39 (2).



Grants & Funding



Presentations

Islam, M. Accessing CoNPS Field Trip Records on SEINet. Invited presentation. Colorado Native Plant Society Annual Meeting 2015, Golden, CO.

Islam, M. Recruiting and managing volunteers in small collections. Invited presentation. Small Collections Symposium, *The Contribution of Small Natural History Collections in the 21st Century*. Society for Preservation of Natural History Collections Annual Meeting 2015, Gainesville, FL.

Krishnan, S. Science and Culture of Coffee. Invited presentation to Bondurant High School as part of the World Food Prize lecture series. 2015. Des Moines, IA.

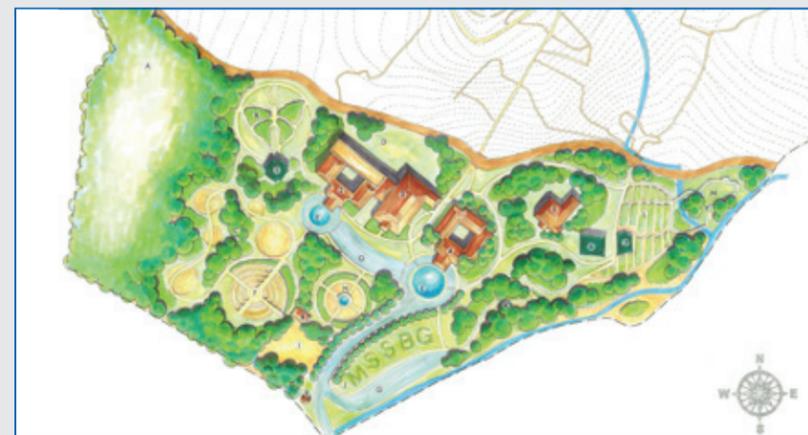
Manion, J.T., **J.R. Neale**, M. Westwood, J. Cruse-Sanders, J. Randall, P. Griffith. Growing and nurturing a plant conservation program – from roots to shoots. American Public Gardens Association Annual Meeting 2015, Minneapolis, MN.

Neale, J.R., M. Islam, M. DePrenger-Levin. Population genetic assessment of *Phacelia* in Northern Colorado. Center for Plant Conservation Annual Meeting 2015, Athens, GA.

Global Strategy for Plant Conservation

Denver Botanic Gardens utilizes the five objectives and 16 targets of the **Global Strategy for Plant Conservation (GSPC)** (www.cbd.int/gspc/programme/guide.shtml) as a guiding framework for conservation activities. Everything we do can be framed within a global context thus making our work relevant beyond our region.

- OBJECTIVE I** Plant diversity is well understood, documented and recognized
- Visited 43 field sites in Colorado in 2015 to collect and document plant and fungal diversity.
 - Published our data on the **Global Biodiversity Information Facility** (www.gbif.org) and **iDigBio** (www.idigbio.org/portal) portals to ensure our collections are available and accessible to a global audience.
- OBJECTIVE II** Plant diversity is urgently and effectively conserved
- Continued long-term monitoring of four rare Colorado species involving statistically rigorous, annual sampling of marked individuals *in situ* to guide management strategies.
 - Collected seeds from three species in two counties in collaboration with the Center for Plant Conservation.
 - Maintained representatives of more than 150 IUCN Red List species listed at vulnerable, endangered or critically endangered in our living plant collection.
- OBJECTIVE III** Plant diversity is used in a sustainable and equitable manner
- Provided assistance to complete the master plan for the M.S. Swaminathan Botanical Garden in India. This Garden will play a key role in addressing local agricultural heritage and conservation of crop genetics.
- OBJECTIVE IV** Education and awareness about plant diversity, its role in sustainable livelihoods and importance to all life on earth is promoted
- Spent over 100 hours in the Gardens' Science Pyramid educating visitors about Colorado flora.
 - Staff collaborated with two botanical illustrators, Benjamin Cardenas and Ikumi Kayama, to create illustrations for publications and to showcase Colorado's rarest species.
- OBJECTIVE V** The capacity and public engagement necessary to implement the Strategy have been developed
- Citizen scientists volunteered 289 hours with us through the Rare Plant Monitoring Steward program collecting data to protect rare and federally listed plants.
 - Helped organize the 2015 High Altitude Revegetation and Central Rockies Society for Ecological Restoration Conference and Workshop at Colorado State University in Fort Collins, CO



Master plan created by Denver Botanic Gardens for the M.S. Swaminathan Botanical Garden in Kalpetta, India located in the Western Ghats, one of the world's biodiversity hotspots.



Research Associate Mary Goshorn discussing phenology with visitors at a Science Chat in the Science Pyramid.



2015 floristic surveys found *Lewisia rediviva* in Garfield and Hinsdale counties, extending the documented southern edge of its known range by 225 km. Photo by Mike Kintgen.

Thank You to Our Funders

American Penstemon Society

Black Hills Exploration and Production

Borgen Family Foundation

Center for Plant Conservation

Colorado Native Plant Society, Marr Fund

Denver Botanic Gardens Guild

Institute of Museum and Library Services

National Fish and Wildlife Foundation
Five Star & Urban Waters Program

National Science Foundation

Stanley Smith Horticultural Trust

The Garden Club of Denver

US Bureau of Land Management

We gratefully acknowledge the many other individuals who provide financial support for our work throughout the year. Science at Denver Botanic Gardens is also supported with distributed income from Denver Botanic Gardens Endowment Funds. Denver Botanic Gardens is supported by the Scientific & Cultural Facilities District (SCFD).

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 www.botanicgardens.org and selecting "Research and Conservation."

Photos taken by Gardens staff unless otherwise noted.

DENVER BOTANIC
GARDENS

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