



NATURAL HISTORY COLLECTIONS MANAGEMENT PLAN

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Natural History Collection Plan Contents

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I. Purpose of the Plan

The Natural History Collections Management Plan provides historical overview, content and scope, and collection assessment to assist in stewarding, expanding, and developing the collections.

II. Review and Revision of the Plan

The Collections Plan will be reviewed as needed at a minimum of every five years to assess the success of the activities described herein and determine measures to overcome challenges. Review will be undertaken by managers of the collection and revisions will then be routed through the Board-level Gardens & Conservation Committee and the Nominating and Governance committee with ultimate recommendation to the full Board of Trustees.

III. Ethics Regarding Collections

Denver Botanic Gardens acknowledges that it holds collections in public trust to serve as a resource for a wide community and to preserve this inheritance for posterity. To this end, the Gardens and those who govern it (board, staff, volunteers), adhere to the American Alliance of Museums' Code of Ethics for Museums (2000). As articulated there, "the distinctive character of museum ethics derives from the

ownership, care and use of objects, specimens, and living collections representing the world's natural and cultural common wealth. This stewardship of collections entails the highest public trust and carries with it the presumption of rightful ownership, permanence, care, documentation, accessibility and responsible disposal.” Denver Botanic Gardens’ institutional code of ethics is included in its Employee Guidelines (2017 or as amended), to which Board of Trustees members also adhere. Additional ethics considerations can be found within individual collection policies.

IV. History of the Natural History Collections

Together, the Kathryn Kalmbach Herbarium of Vascular Plants (KHD), the Sam Mitchel Herbarium of Fungi (DBG) and the Denver Botanic Gardens Arthropod Collection (DBGA) make up the natural history collections at Denver Botanic Gardens. These collections reside in the Research & Conservation Department. The Department including the natural history collections serves as a center of biodiversity research connecting scientists, land managers, and citizen scientists to regionally relevant research. Together the collections house 82,000 specimens, which document vascular plant, fungal and arthropod diversity and distribution in the Southern Rocky Mountain Region. In Colorado, the Gardens’ herbaria (KHD and DBG) are the third largest in the state by total number of specimens after University of Colorado-Boulder and Colorado State University and the largest in number fleshy fungi specimens. The arthropod collection is a unique collection focused on documenting arthropod diversity at Denver Botanic Gardens.

The collections were acquired through active collecting by staff and volunteers to document species diversity and distribution in the region. In addition to Gardens driven studies, specimens were acquired through gifts and exchanges with regional herbaria, biologists, and citizen scientists. Of particular note, the plant collection holds two smaller herbaria, University of Denver Herbarium and University of Colorado-Denver Herbarium, which were gifted to the Gardens. A small satellite collection is on long-term loan to the University of Colorado-Denver Department of Integrative Biology for use in education.

Until 2000, the collections were physically separated and continued to be managed separately with little integration of collection management (with the exception of adopting BG-Base to catalog the specimens) until 2011. From the founding of the fungal herbarium, specimens were cataloged and accessioned in accession books with each specimen given a unique number. Each specimen also includes a physical card stored separately from the specimen with information related to collection event – date, locality, and collector – duplicating the information held with the specimen. Physical cards often also include detailed

notes and illustrations related to identification. The plant collection was never cataloged, but each specimen was assigned an accession number.

In the 1990s, databasing the plant and fungal collections in BG-Base. In 2012, both collections' specimen data was transferred from BG-Base to the Symbiota software platform, and over the next five years, transcription, imaging and georeferencing specimens was a focus. Plant, fungal and arthropod specimen data are publically available through multiple online portals. For discoverability, users are directed to SEINet (swbiodiversity.org) for plant specimens, Mycoportal (mycoportal.org) for fungal specimens, and SCAN (symbiota4.acis.ufl.edu) for arthropod specimens. About 70% of the plant collection is fully digitized – imaged, transcribed and georeferenced, and about 60% of the fungal collection is transcribed and georeferenced. The arthropod collection is 100% transcribed and georeferenced in Symbiota. All specimen data is available online. In 2015, an inventory of the plant collection was completed.

Summaries of each collections' founding and management is below.

Denver Botanic Gardens Collection of Arthropods. DBGA was founded in 2014 by Richard Levy, Research & Conservation Database Associate, to discover and document arthropod diversity within the Gardens properties, support Gardens research, and supply educational materials for Gardens programs.

Kathryn Kalmbach Herbarium. KHD was founded in 1943 by George Kelly and Kathryn Kalmbach as part of the Colorado Forestry and Horticulture Association and moved to Denver Botanic Gardens in 1959. Kathryn Kalmbach, the first curator, served until her death in 1962. At that time, Dr. Helen Marsh Zeiner became Chairman of the Herbarium Committee. She was appointed Honorary Curator in 1973 and served in that position until 1995 when she became Herbarium Curator Emeritus. Dr. Janet L. Wingate became Herbarium Manager in 1995 (first paid herbarium position) and promoted to Curator in 2005. Dr. Wingate oversaw the first paid floristic projects and published several identification books. In 2011, Dr. Melissa Islam became the Associate Director of Research & Head Curator of the Gardens' Herbaria. She oversees both the Kathryn Kalmbach Herbarium and the Sam Mitchel Herbarium of Fungi. Through the efforts of dedicated staff and volunteers, the herbarium continues to expand its collections through an active collecting program and by exchanging with other herbaria.

Sam Mitchel Herbarium of Fungi. The Sam Mitchel Herbarium of Fungi was founded by Dr. Duane H. "Sam" Mitchel, a Denver internist and poisonous mushroom expert. Dr. Mitchel started collecting fungi along with Mrs. Mary Wells and identifying those specimens at the Denver Museum of Nature and

Science. They moved their specimens, equipment, slides, and books to the Gardens in 1967. In 1973, Dr. Mitchel was named Honorary Curator of Mycology. Until 1990, the herbarium was managed by volunteers who together made thousands of collections, documented and photographed them, and carried out collections-based research projects culminating in the publishing of scientific peer-reviewed articles and books. In 1990, Vera Evenson, Assistant to the Curator (volunteer position) was hired as the Associate Curator (first paid position for the mycology collection) and promoted to Curator in 2006. In 2017, an Assistant Curator of Mycology was hired marking the first, full-time research focused position for the natural history collections. Through the efforts of dedicated staff and volunteers, the herbarium continues to expand its collections through an active collecting program.

V. Content and Scope of the Natural History Collections

The natural history collections serve a critical role in the Gardens’ mission to *connect people with plants, especially plants from the Rocky Mountain region*. The content and scope of each collection and the subsequent stewardship, expansion, and development of the collections is directly connected to realizing the Gardens’ mission.

Kathryn Kalmbach Herbarium. KHD contains over 62,000 scientific specimens of dried, pressed vascular plants and 400 ethnobotanical specimens. Representation of plant families reflects the known Colorado flora (Ackerfield 2015) with the top four families in number of specimens reflecting the top four families in number of species in the Colorado flora. For example, Asteraceae is 16% of the collection and is nearly 17% of the flora (Table 1, Ackerfield 2015).

Table 1. Taxonomic and geographic distribution of each collection based on the number of databased records in Symbiota as of October 2017.

	KHD	DBG	DBGA
total # of databased specimens	65,515	18,388	568
# of families represented	248	142	89
top families by % of collection	Asteraceae (16%) Poaceae (11%) Fabaceae (11%) Cyperaceae (6%)	Agaricaceae (13%) Strophariaceae (12%) Tricholomataceae (6%) Russulaceae (6%)	Apidae (7%) Halictidae (7%) Acrididae (6%) Cerambycidae (5%)
# of countries represented	48	23	1
# of states represented	50 plus Washington, DC	42 plus Washington, DC	2

KHD specimens were collected from 48 countries and in the USA all 50 states plus Washington, DC (Fig. 1). Over 98% of the collection is from the USA of which 80% represent native and naturalized plants of Colorado. The earliest collections date from the 1800s, not long after Colorado's statehood with an overall trend of an increasing number of specimens collected over time (Fig. 2). Over the last five years, on average 1,900 specimens were accessioned annually.

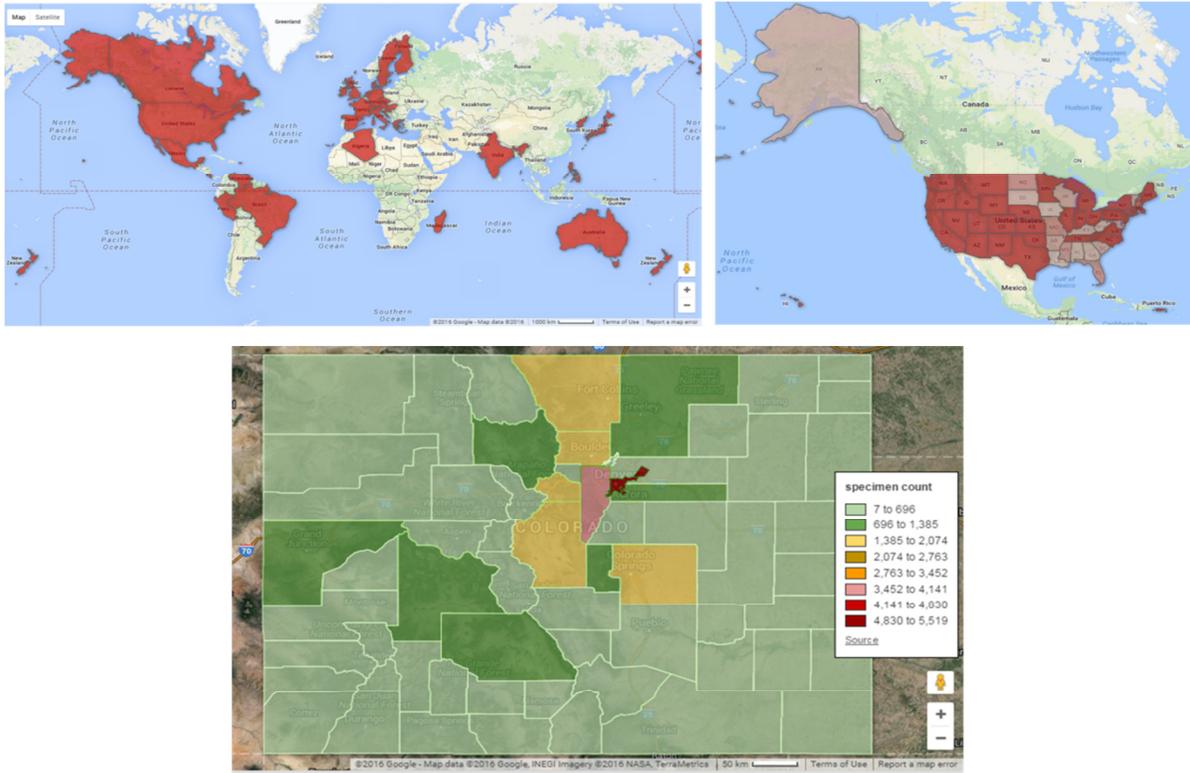


Figure 1. World and USA plant specimen distribution based on October 2017 data retrieved from SEINet, and Colorado distribution based on March 2016 data retrieved from SEINet.

Collections of note include, one holotype, 12 paratypes, 14 of the 16 federally listed Colorado plant species, two of the three candidate species, and vouchers for tissue deposited in the Gardens biorepository as part of the international Global Genome Biodiversity Network. The collection also includes plants cultivated at the Gardens including several national collections, Plant Collections Network (PCN) Multisite *Quercus* Collection and PCN Alpines of the World, and a water lily standard. In addition to standard plant specimens, KHD holds a small ethnobotany collection that highlights the relationship between plants and people, particularly the way plants are used for medicinal and cultural purposes. This collection focuses on the use of plant species sold throughout the region in markets especially Hispanic medicinal herb stores called botánicas.

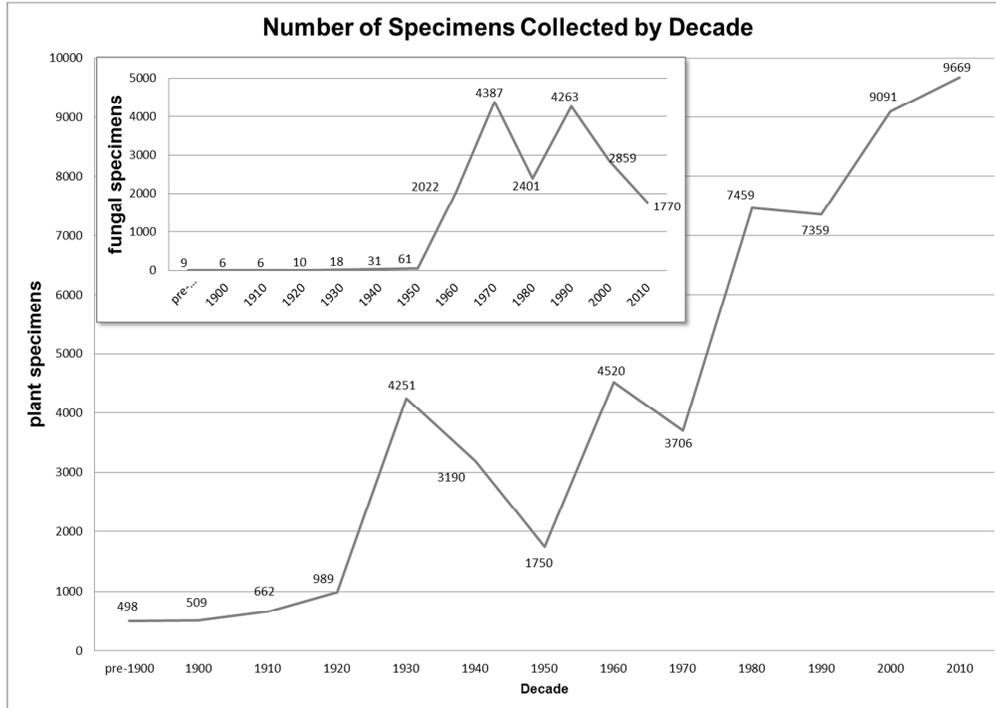


Figure 2. Number of fungal and plant specimens collected by decade. Data from SEINet and Mycoportal from March 2016 with number of 2016 specimens added based on data retrieved October 2017 from both databases.

Sam Mitchel Herbarium of Fungi. DBG is recognized both locally and nationally as the most complete, diverse, and well-documented mycological herbarium in the Southern Rocky Mountain region. The herbarium contains approximately 18,000 fungal specimens (Table 1) with the primary focus on macrofungi (fungi with sporocarps over 1 cm) with small collections of microfungi, such as rusts and smuts, and myxomycetes. Nearly every specimen includes in-situ image(s) and a specimen card with detailed notes regarding fresh characters, spore prints, and microscopy.

Collections are from 23 countries and within the USA from 42 states and the District of Columbia. Nighty-six percent of the specimens were collected in the USA with 94% of those representing native or introduced fungi in Colorado (Fig. 3). The largest number of specimens are in Agaricaceae, Strophariaceae, Tricholomataceae and Russulaceae (Table 1). Collecting started in the 1960s with peaks in number of specimens collected in 1970s and 1990s (Fig. 2). A full-time research position was hired in 2017, which will contribute to an increased number of specimens collected per year. Over the last five years, about 430 specimens were accessioned annually. DBG holds 57 type specimens including holotypes, isotypes and paratypes.

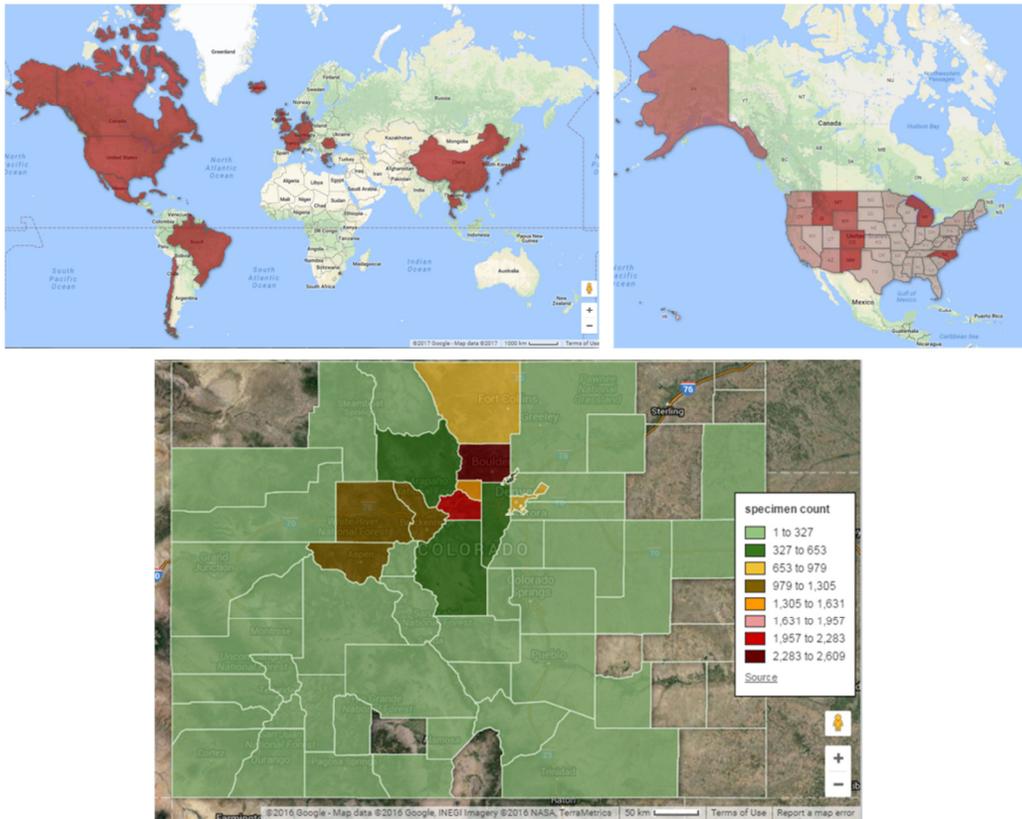


Figure 3. World and USA fungal specimen distribution based on October 2017 data retrieved from Mycoportal, and Colorado distribution based on March 2016 data retrieved from Mycoportal.

VI. Audience, Access, and Interpretation

The Gardens supports collection-based research to inspire, educate and inform, further connecting people with the natural world and providing foundational data for ecological and evolutionary research.

As articulated in the Interpretive Engagement Framework, Denver Botanic Gardens strives to deepen audience connections to the natural world through collections, programs, and expertise and to foster appreciation of and responsibility for life on Earth, preserving and restoring biodiversity. Through its work, Denver Botanic Gardens works to create audience communities who are actively:

- Appreciating
- Participating
- Understanding
- Transforming
- Stewarding

The natural history collections are integral to engagement and carrying out the Interpretive Engagement Framework. A wide range of audiences use the natural history collections including:

- Denver Botanic Gardens staff, members and visitors
- Denver Botanic Gardens Education and Exhibits departments for education and exhibit programs
- Scientists
- Naturalists
- Citizen scientists
- K-12 students, undergraduate and graduate students
- Botanical illustrators
- County, state and federal agencies
- Environmental and botanical consulting firms
- Societies
- Nurseries, plant growers, horticulturists, landscape architects
- Rocky Mountain Poison Center

VII. Collections Assessment and Analysis

Strengths

Housed within a public garden, which is located in a dense, urban area, the natural history collections are a public face for botany, mycology, collections-based research, and biodiversity science in the state. Public outreach and education is stressed as an essential part of the department's mission and includes educating the public about botanical and mycological research in the state and the importance and value of natural history collections. The audiences we reach are often not typical museum attendees. In 2016, we interacted with 24,751 people not including media and over 1,000 people visited the collections (Fig. 4) even though they were closed for renovation during part of the year. A bulleted list of collections strengths is below.

- The collections are scientifically valuable - specimens are well preserved and well documented.
- Specimens are virtually accessible on multiple platforms with about 80% of the collections databased and accompanied by specimen images for nearly all of the plant specimens and 10% of fungal specimens.
- The collections are active and include species of historical interest.

- Good regional representation of the Colorado flora especially of the Colorado Front Range, metropolitan area and adjacent plains.
- The fungal collection is one of the most diverse and complete collections of macro-fungi located in the Southern Rocky Mountain region.
- Representative collections of federally listed species.
- One of the few regional herbaria with a good collection of cultivated plants.

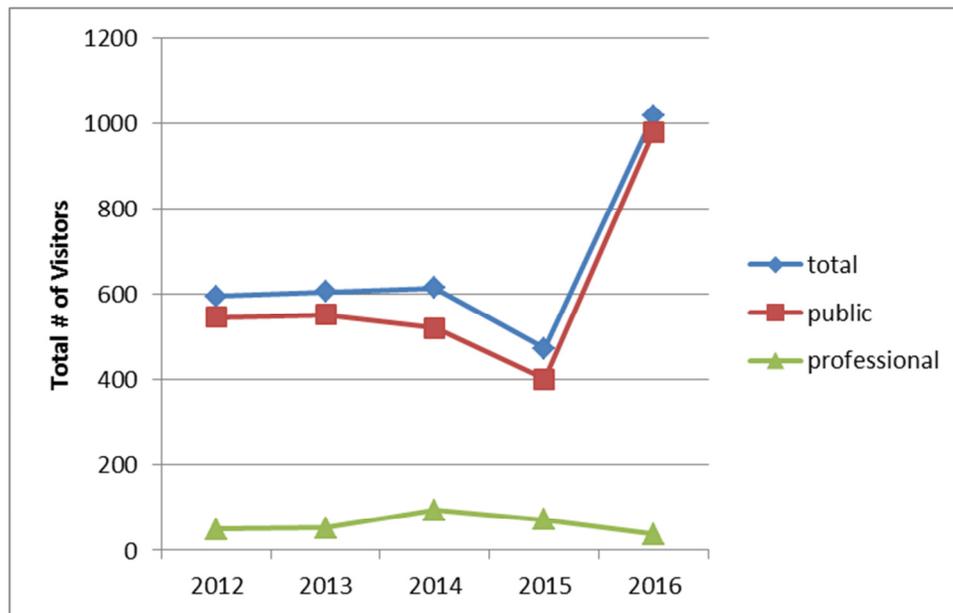


Figure 4. Total number of visitors to the Gardens natural history collections per year. Professional visitors use the collections for research, and public visitors are touring the collection to learn more about collections-based research.

Weaknesses

Space. The herbaria are housed in 1,500 square feet of space that includes work areas for staff, volunteers and visiting researchers, a digitization station, books, reference materials, and a mycology lab with fume hood. In 2016, high-density shelving was installed alleviating overcrowded specimens and providing about 20 years of growth for the plant and fungal collections. The arthropod collection has about 8 years of growth and with increased focus on documenting pollinators we will need to add to the arthropod housing in the next five years. However, fresh collections are still processed in the same space accessioned specimens are housed, which is not ideal for maintaining a pest free environment, and we continue to have difficulty accommodating visiting researchers, seasonal staff and volunteers.

Virtual Access. Georeferenced specimens provide crucial data to studies on distribution. The arthropod collection is 100% georeferenced; however, the plant and fungal collections are about 80% georeferenced leaving approximately 17,000 specimens that need to be georeferenced. The plant and fungal digital collections need improvement especially for the plant collection, which was databased by many volunteers creating a number of issues and a wealth of legacy specimens, which are handwritten and difficult to transcribe.

Research and analysis

Based on preliminary spatial gap analyses of all digitized collections for plants and fungi, Gardens collections mirror spatial distribution of most other collections with the fewest collections representing plant and fungal diversity on Colorado’s eastern plains followed by the western slope with the highest number of collections centered in the mountains (Fig. 5). Collections management is working on five-year goals to guide gaps in the collections within the context of the department’s five-year strategic plan to ensure resources are directed towards these goals. Strategic planning for the collections is linked to the opening of the Center for Science, Art, and Education building (CSAE), a new Gardens facility tentatively planned to open late 2019 or early 2020. Collections management will wait for the final facility design and infrastructure support plan before finalizing the five-year goals to guide collections.

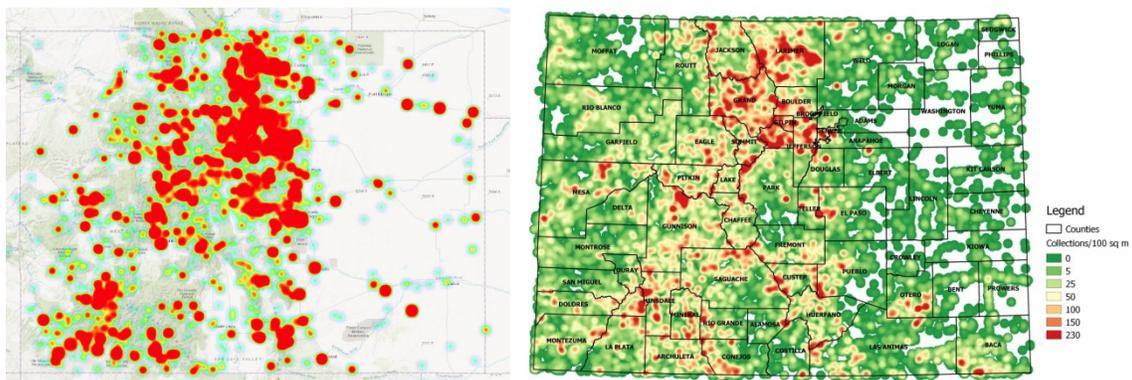


Figure 5. Heat maps of specimen data. On the left all georeferenced fungal specimens in the Mycoportal, Oct. 2017, collected from Colorado. On the right all georeferenced plant specimens in SEINet and University of Colorado-Boulder herbarium’s database as of 2015 collected from Colorado.

- Determine a long-term strategy for growth of collections through gap studies that incorporate all digitized plant and fungal specimens in the Southern Rocky Mountain Region.
- Support studies that target gaps in documentation of plant and fungal species in the Southern Rocky Mountain Region or of particular habitats.

- Support robust documentation of species that incorporates in-situ images, tissue samples for deposit in the Gardens biorepository, and improved data quality standards.

VIII Opportunities and Priorities

Preservation

- Working with architects and other stakeholders, designing collection and work spaces in the CSAE with facilities and environmental conditions to support best-practices stewardship and preservation of the natural history collections. This is a priority to ensure the long-term wellbeing of the natural history collections and other non-living collections. In the current design, collection housing will be separated from processing of fresh materials and provide room for expansion for all collections.
- Working with Archives to better care for ancillary items related to collections such as field books, photo slides and prints, correspondence and related records and accession books, which will improve with the move to the CSAE.
- Working with the Library to better care for and facilitate collaboration and efficiency in managing books in the natural history collections especially when the collections move to the CSAE.

Access

- Expand visitor knowledge about the collections and collections-based research by leveraging the improved location of the collection space in the CSAE.

IX. Addenda: Supporting Documents and Forms

N/A