SECTION 7

The Roles of Herbaria in Plant Conservation

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THE ROLES OF HERBARIA IN PLANT CONSERVATION

STRATEGIC GOAL: To ensure that Montana's herbaria continue to provide information and services essential to the conservation of the State's native plant species and communities, in the near- and long-term.

THE HERBARIUM

An herbarium preserves dried, pressed plant specimens that document our Nation's flora. Our Nation's many herbaria are rich in botanical biodiversity and aid the work of researchers, educators, land managers, conservation practitioners, consultants, and students. The preserved physical specimens and their associated labels with detailed information provide a foundation for classifying and communicating the names of plants, fungi, and algae found in natural settings; and those that are cultivated for agriculture, horticulture, and forestry. Additionally, herbarium specimens help us determine a species distribution; evaluate environmental variables and threats that affect plant populations; and assess the risk of extirpation or extinction for a given species. With more than 200 years of collecting, herbarium staff have embraced new technologies, making digital specimen data available to a broader audience of users for many applications. Despite the myriad of services and information provided by herbaria, the prestige and funding allocated to them, and those who manage and curate collections has declined in recent decades. Here, in the *Montana Native Plant Conservation Strategy: Species and Habitats of Greatest Conservation Need*, we present a strategy for how to support herbaria, curators, and irreplaceable plant specimens. Our goal is to ensure that Montana's herbaria continue to provide information and services that are essential to the conservation of Montana's native plant species and communities, now and into the future.

Photo Credit: Montana State University Herbarium

Photo 7-1. Bitterroot (Lewisia rediviva). *An example of an imaged herbarium specimen from the Montana State University herbarium.*

The Establishment of Montana's Herbaria

Commissioned by President Thomas Jefferson, the Lewis and Clark Expedition made notable contributions to botany from 1803 to 1806 (Phillips 2003). In preparation for the exploration, Meriwether Lewis was sent to Philadelphia to learn how to describe and preserve plant specimens. Meriwether Lewis and William Clark were directed to notice "the face of the country, its' growth and vegetable productions; especially those not of the United States, the dates at which particular plants put forth or lose their flowers, or leaf (Cutright 1969)". And so, they collected. We know that

Botany I rank with the most valuable sciences, whether we consider its subjects as furnishing the principal subsistence of life to man and beast, delicious varieties for our tables, shade and perfume of our groves, materials for our buildings, or medicaments for our bodies.

~ President Thomas Jefferson [Phillips 2003]

some specimens were lost, but today 239 plant specimens, deposited at three herbaria (Phillips 2003), can be physically studied. A significant number of these plant specimens were collected in what is now present-day Montana. None of their botanical collections were "new" discoveries because Native American tribes had long established traditions for naming, describing, collecting, and using plants. The Lewis and Clark collection is Montana's oldest set of pressed and dried plant specimens, and it is accompanied by cultural, environmental, and historical information. With proper curatorial management, these labeled specimens preserve time and allow for future generations to use them to support new studies and investigations.

Following Montana's statehood in 1889, a university system was established that included biology departments and museums housing flora and fauna. These museums eventually became the present-day herbaria at the University of Montana, Montana State University, and Montana State University-Billings. Early in the formation of the National Park Service, herbaria were established at Glacier and Yellowstone National Parks. The parks herbaria allowed staff to catalog the local flora and share their knowledge with other employees and visitors. These early teaching collections quickly formed the foundation for permanent plant archives. Today, with more than 200 years of botanical exploration, collecting, and archiving, Montana's herbaria contain an impressive array and number of vascular plant, moss, liverwort, fungal, lichen, algae, and diatom specimens. These collections continue to grow in breadth and depth, and provide a foundation that documents state, regional, and national floras, field guides, and apps (Box 5-1).

Box 7-1. Books, field guides, and apps developed using specimens from Montana's herbaria.

Influential Floras

- 1950: Flora of Montana, Conifers, Monocots, & Dicotyledons — Booth
- 1973: Flora of the Pacific Northwest — Hitchcock & Cronquist
- 1974: Moss Flora of the Pacific Northwest — Lawton
- 1977, 1986: Flora and Atlas of the Great Plains—Great Plains Plant Association
- 1984: Vascular Plants of Montana — Dorn
- 1993, on-going: Flora of North America (a 30-volume flora)
- 2002: A Key to the Hepaticae of Montana — Hong
- 2012, 2022: Manual of Montana Vascular Plants — Lesica
- 2014: Montana Lichens: An Annotated List — McCune et al.
- 2017: Microlichens of the Pacific Northwest, Volumes 1 & 2 — McCune
- 2018: Flora of the Pacific Northwest, 2nd Edition — Giblin et al.
- 2021, 2023: Diatoms of Montana, Volumes 1 & 2 — Bahls

A Selection of Popular Plant Field Guides

- 1998: Plants of the Rocky Mountains - Kershaw et al.
- 2001, 2012: Central & Northern Rocky Mountain Wildflowers - Phillips
- 2005: Wildflowers of Glacier National Park - Kimball & Lesica
- 2005 Wildflowers of Montana - Schiemann

Plant Apps

- High Country Apps[1]
- Glacier Wildflowers
- Montana Grasses
- Yellowstone Region

[1] High Country Apps: https://www.highcountryapps.com

Montana's Herbaria

This *Strategy* addresses Montana's eight, active herbaria registered with the Index Herbariorum[2] (Figure 7-1). Associated with the Montana University System (MUS) are three long-standing herbaria: University of Montana [MONTU] in Missoula, Montana State University [MONT] in Bozeman, and Montana State University-Billings [MSUB] in Billings. In 2010, the MONTU herbarium acquired the Missoula Research Center [MRC] herbarium collections from the U.S. Department of Agriculture (USDA) Forest Service's Rocky Mountain Research Station (Lesica and Stickney 2010). Associated with our state's most prominent national parks are two long-standing herbaria: Glacier National Park [GLAC] in West Glacier, and Yellowstone National Park [YELLO] in Gardiner. In addition, two national forests have registered active herbaria: Bitterroot National Forest [BNFH] in Hamilton and the Beaverhead-Deerlodge National Forest [BDNF] in Dillon. Housed at the University of Providence in Great Falls, but under private ownership and operation by the Hong family, is the Tu-Hi Hong and Pum-Hi Hong Herbarium [GFC].

Photo Credit: Yoon-Hee Hong

Photo 7-2. Yoon-Hee Hong shows how vascular plant specimens are stored in an herbarium cabinet.

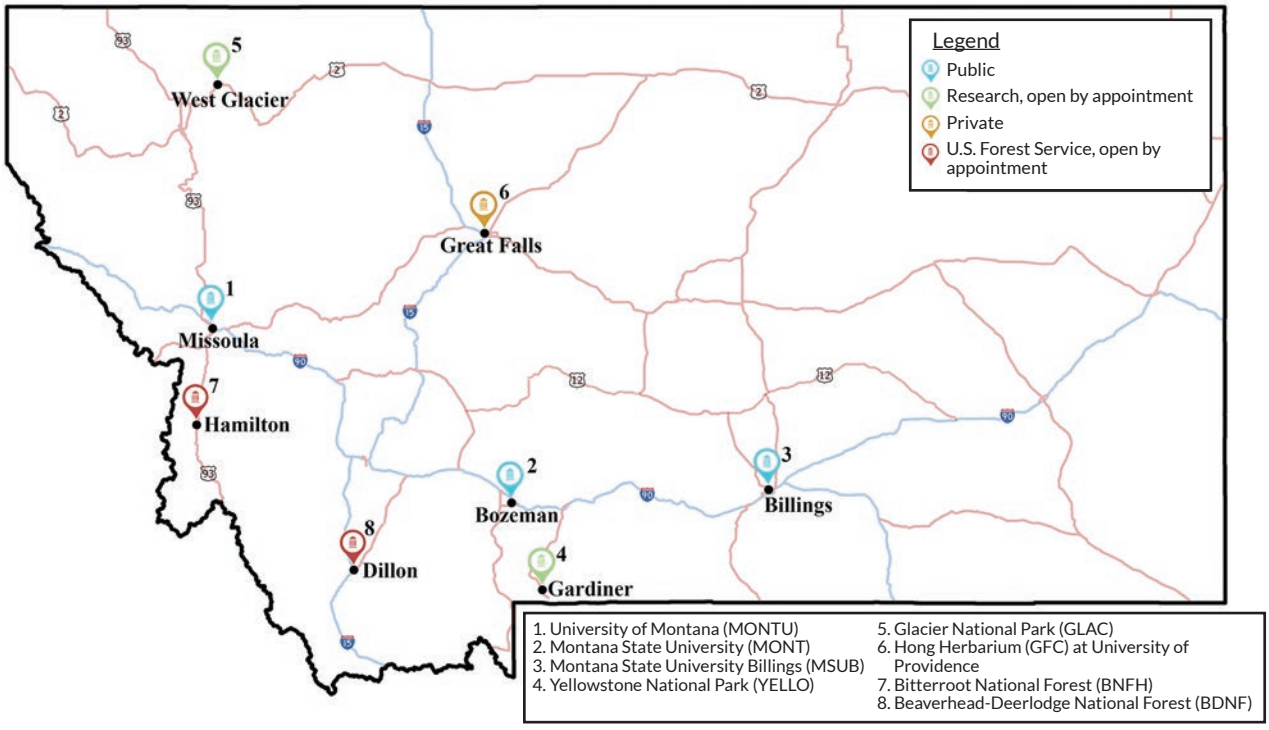

Figure 7-1. Locations of Montana's eight active, registered herbaria addressed in this Strategy.

[2] New York Botanical Garden [NYBG] Steere Herbarium. Index Herbariorum: https://sweetgum.nybg.org/science/ih/

Disclaimer: These eight active, registered herbaria are administered by different institutions and operated separately. Each herbarium determines its mission, operational structure, and goals (Appendix D). Some herbaria have official strategies or plans in place that guide operations and functions. In addition, each herbarium controls the acquisition, curation, and databasing of their specimens. It is at the discretion of the curator or collections manager to determine what specimens are acceptable for archival[3] and teaching[4] collections. The *Montana Native Plant Conservation Strategy: Species and Habitats of Greatest Conservation Need* in no way supersedes the operations or strategic directions for any single herbarium in Montana. Rather the intent of this *Strategy* is to bring awareness to the important work accomplished by these herbaria, and to provide voluntary, non-regulatory actions that could keep operations and staff funded, continue the acquisition of collections, retain the physical specimens in Montana, and improve the digital data available to the public.

HOW HERBARIA ADVANCE PLANT CONSERVATION

Established over 120 years ago, Montana's herbaria (with an increasing number of archived specimens) advance efforts to study and manage native and exotic plants, fungi, and algae in five major ways:

1) *Herbaria Help Identify "What" to Conserve*

The invention of the herbarium made it possible for scientists to systematically name and describe plants, fungi, and algae in faraway places (Thiers 2020). Plant conservation begins with an understanding of "what" needs to be saved, preserved, eradicated, or controlled (Thiers 2020). The "what" is the name that identifies and describes the species (or variety, subspecies, genetic unit, hybrid, etc.). Scientists in the fields of plant taxonomy, systematics, and evolutionary biology rely on the indispensable, archived collections of botanical specimens to answer the question of "what". The core function of an herbarium is to obtain and manage specimen data that relays information that land managers need to determine:

- What to manage? (the species, or variety, subspecies, genetic unit, etc.)
- Where does the species live? (habitat)
- How widespread is the species? (distribution or range within defined areas)

2) *Herbaria Help Determine the Status and Conservation Merit of the Species*

The extent of Montana's herbarium specimen collections—dating back to 1804—strengthens their utility in addressing management and conservation actions. Physical specimens and their labels of information help determine origin (native, exotic, or hybrid) and uniqueness (rare versus common) at the local, regional, and national level. Specimen data are increasingly used to track distribution; and changes in population size, habitat condition, and other attributes for a given species, variety, hybrid, or another taxon (Rocchetti et al. 2021). Collectively, this information assesses the risk of a species being extirpated from an area, or the degree of invasiveness for the species (or another taxon). For example, botanists

[3] Mounted dried, pressed plant specimens that have a label with information used to document a species at a particular location.

[4] Dried, pressed plant specimens that are not mounted on herbarium paper and are used in coursework to teach plant identification.

working for the newly created Montana Natural Heritage Program (MTNHP) in 1985 developed the initial Montana Species of Concern (SOC) plant list after making intensive visits to several herbaria. Revisions to the Montana SOC plant list continue to be made based on specimen data. However, maintaining an accurate SOC list requires active specimen acquisition programs and data management, to validate the need to elevate, downgrade, or remove a plant's rarity status.

Further, the long history of plant collecting helps researchers and land managers distinguish between patterns of rarity caused by biological factors (life history traits or unique habitats) from those due to human activities. This distinction is critical for some status assessments (i.e., ranking of rarity), including the Endangered Species Act (ESA) of 1973, and for placement on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2023).

3) Herbaria are Genetic Libraries

Herbaria are genetic libraries. The DNA for each specimen can generate insights into evolutionary relationships and taxonomy (Thiers 2020; Fertig 2016). Technological advances are resolving the challenges of extracting DNA without damaging plant specimens, and genetic sequencing techniques are becoming more standard and affordable. Researchers can gain access to a single species or a diverse set of taxa, across a spectrum of time and place, by visiting or requesting loans from one or more herbaria. As examples, in 2020 MONTU loaned *Sphagnum cuspidatum* moss specimens to the State University of New York at Oneonta, and *Stellaria americana* plant specimens to the Sungkyunkwan University in Korea for genetic sequencing (Dumont 2021). In 2023, MONT specimens of native strawberry (*Fragaria*) species were loaned to researchers for genetic sequencing (Lavin 2023). Dr. Matt Lavin routinely used MONT herbarium specimens for genetic analysis of legume species over the course of his career at Montana State University in Bozeman (Lavin et al. 2018).

Herbarium specimens are also used to study changes in climate and other environmental conditions (Thiers 2020; Fertig 2016). Researchers are now capable of extracting carbon and nitrogen isotopes, atmospheric carbon dioxide, and various pollutants from herbarium specimens. This allows for cross-time comparisons of atmospheric and soil conditions. For example, stable, isotope analysis was successfully applied to 397 MONT specimens of Big Sagebrush (*Artemisia tridentata*), Idaho Fescue (*Festuca idahoensis*), Prairie Junegrass (*Koeleria macrantha*), and Bluebunch Wheatgrass (*Agropyron spicatum*) to evaluate ecosystem-level changes in plant productivity from 1881 to 2016, which was biased towards the production of carbon-rich and nitrogen-poor plants (Brookshire et al. 2020).

4) Herbaria are Institutions of Botanical Learning

Montana's herbaria facilitate learning through research and teaching; and by providing an opportunity for people to directly see real plants, fungi, and algae, thus empowering them. Permanent, archived specimens are used for scientific research by plant taxonomists, geneticists, ecologists, anthropologists, and specialists from other disciplines. They allow people to scrutinize specimens, agree or disagree on identifications, and annotate specimens, furthering the process of understanding. Consultants, land managers, students, and others visit herbaria to directly view and study identifiable traits, especially for a plant that is rare, or one that is a new invader to the state. Montana's public herbaria (MONTU, MONT, and

Photo Credit: Andrea Pipp

Photo 7-3. Retired USFS Research Botanist, MRC Curator, and founder of the University of Montana Herbarium endowment, Peter Stickney, shows a student an array of his herbarium specimens. Peter advocated for creative ways in which to use specimens, such as attaching photos to relay color or displaying stages of plant growth.

MSUB) also house teaching collections used in academic coursework and for specific student-guided research projects. At MONTU and MONT, "Herbarium Night" brings in students and Montana Native Plant Society (MNPS) members to engage in learning about a particular group of plants or fungi. By enabling direct experiences with specimens, herbaria help people remove "plant blindness", the tendency to see plant species blending together without recognizing their distinctive characteristics [Balding and Williams 2016].

5) *Herbaria Provide Free Access to Digital Data*

Herbaria are taking the lead in innovative processes that provide access to millions of digitized specimens and their metadata (Rocchetti 2020). Herbarium staff are using high-resolution cameras to photograph specimens; high quality digitizing tools to scan annotations and label information; and mapping software to geo-reference collection locations. This information is integrated into databases, and it is widely accessible to everyone via online portals. Herbaria curators and collection managers collaborate to host and share specimen data, improving the utility, value, and relevance of plant specimens. The result is that plant specimen data is being used in new ways by a greater array of disciplines including genomics, resource conservation, anthropology, ecology, botany, phenology, and taxonomy (Rocchetti 2020). For example, high quality images are being used by botanical illustrators (Angell 2017). At MONTU, MONT, and MSUB, adding specimen information to digital databases is on-going with future expansion needed (Table 5-1).

Table 7-1. Online portals and data aggregators used by Montana's herbaria as of December 2023.

Online Portal	MONTU	MONT	MSUB
Consortium of Bryophyte Herbaria [CBH]	■	■	
Consortium of Lichen Herbaria [CLH]	■	■	
Consortium of Northern Great Plains Herbaria [CNGPH]			■
Consortium of Pacific Northwest Herbaria [CPNWH]	■	■	
Global Biodiversity Information Facility [GBIF]	■	■	■

THE FUNDAMENTAL DIFFERENCE BETWEEN PHYSICAL SPECIMENS AND DIGITAL PLANT DATABASES

Photo Credit: Andrea Pipp

*Photo 7-4. A student's herbarium specimen of Serviceberry (*Amelanchier alnifolia*) displays dried cultural foods, berries, and vegetative materials. Note: Professional curators use folded paper and not plastic envelopes.*

In the digital Computer Age, collecting, sharing, and aggregating botanical information around the world by botanists, conservation practitioners, land managers, academics, citizen scientists, and others is an enormous effort. Three general categories of digital datasets are emerging and actively being used by people in Montana:

- Collaborative networks compiling digitized herbarium specimen-based field data— Examples: CBH, CLH, CPNWH, CNGPH, and SEINet[5]
- Citizen science programs compiling photo-based field data— Examples: iNaturalist, Adventure Scientists, Rare Care, and Montana Citizen Botany Program[6]
- Conservation organizations and academic institutions aggregating digital biodiversity data from numerous sources—Examples: GBIF, iDigBio, GPI, and JACQ[7]

Although publicly available, these growing datasets of digital botanical data are derived for different purposes, and differ both in the quantity and quality of information provided; and the ability to substantiate it. Nonetheless, with increased access to digital herbarium data, the fast-paced accumulation of citizen science derived data, and the aggregation of biodiversity data from numerous sources, there is a notion that it may no longer be necessary to keep or maintain specimens in a physical repository. Collections should never be discarded after they are digitized. **Physical specimens cannot be replaced by digital information.** Here, we demonstrate four reasons why it is important to obtain new physical specimens, and why existing collections should be maintained.

1) *Preserved, Physical Specimens are More Data-Rich than their Digital Counterparts*

Herbaria house a tremendous amount of biological, chemical, ecological, demographic, cultural, and historical information. The specimen itself displays morphological and reproductive features, relays phenology, and contains chemical and genetic data. Specimen labels provide additional information on geography, ecology, history, species' identification annotations, and many other details. In contrast, digital datasets from citizen science programs typically provide one to few photos, primarily relay presence data, and report little to no information on population size, habitat, and other attributes of the sighting. Even electronic scans of herbarium specimens reduce the organism from a three-dimensional to a one-dimensional image, thereby losing information.

[5] Refer to the "Acronyms and Abbreviations" section at the end of the *Strategy*.
[6] Refer to the "Resources" section at the end of the *Strategy*.
[7] Refer to the "Acronyms and Abbreviations" section at the end of the *Strategy*.

2) *Preserved, Physical Specimens Promote Education and Research*

Preserved, physical specimens are necessary to support on-going education and research. Through loans and visitations, physical specimens provide a long-lasting source for teaching plant identification skills, examining traits, and conducting research for a multitude of applications, only partially addressed in this *Strategy*. This is because herbarium specimens are cataloged and kept in a stable, long-term place of storage where people can find it. While digital specimen data is available to a broader audience, it is the properly preserved specimen that gives credibility to the data and any resulting research. In addition, many significant morphological traits, such as hair type and glands, can only be directly examined or measured on the specimen with the aid of a hand-lens or microscope and ruler; small-sized morphological traits are not visible on a scanned image. Likewise, the utility of DNA and isotope extraction can't be done on a digital image.

3) *Preserved, Physical Specimens are the Ultimate Data to Prove Observations*

Physical specimens are irreplaceable due to their ability to validate or prove field observations and to show the range of variation exhibited by a taxon (example: species, variety, hybrid, and others). The physical specimen allows people to examine and re-examine the morphology of one individual, and to question or agree on its identity. By annotating specimens, plant taxonomists can trace the trail of examinations and identifications, which are used to update Montana's flora, field guides, and apps (see Box 5-1). Digital datasets derived from citizen science data, literature, and photographs cannot fully prove an observation.

4) *Preserved, Physical Specimens Provide a Basis for Defining and Naming Organisms*

Preserved, physical specimens create the foundation for defining and naming the taxon (family, species, variety, hybrid, genetic unit, and others); together, name and specimen, become the language used to communicate across disciplines, agencies, states, and countries. Specimens make it possible for scientists to examine, compare, classify, and name plants with a standard approach. These data-rich libraries of preserved collections are also a source for discovering new species. It is estimated that nearly one-quarter of newly described species resulted from existing unidentified or misidentified herbarium specimens (Bebber et al. 2010), and that as many as 70,000 undescribed plant species might still be lurking inside the world's herbaria (Bebber et al. 2010). New species are based on a single specimen, which is designated as the name-bearing "type" and archived in an herbarium; they are considered formally accepted when described in a scientifically recognized publication. Hence, type specimens are of great significance to biologists and plant taxonomy studies.

Photo Credit: Yoon-Hee Hong

Photo 7-5. Mosses, liverworts, and lichens are dried and preserved in folded paper packets with attached labels of information. Tu-Hi Hong and Pum-Hi Hong Herbarium at Great Falls.

CHALLENGES FACING MONTANA'S HERBARIA

During the past 30 plus years, the prestige and funding afforded to herbaria has waned, despite their proven utility and relevance to plant conservation and many other disciplines. The challenges faced by Montana's herbaria are similar to those faced by other herbaria across our Nation. They are complex, reflecting changes in our society, and have led to fewer collections, reductions in staff, changes in space allocations, and ultimately in less funding for herbaria (Thiers 2020). Here, we summarize seven challenges facing Montana's herbaria.

1) Shifting academic priorities

Competition for space and budget reductions have led to the closure of many university herbaria (Deng 2015). Since 1997, one herbarium in seven has closed in North America (Deng 2015; Fertig 2016). Fortunately, for most closures, the collections were transferred to other herbaria (Fertig 2016). In Montana, the MRC herbarium with more than 10,000 plant specimens was transferred from the U.S. Forest Service to MONTU in 2010 (Lesica and Stickney 2010).

2) Trends in botanical research are relying less on field observations

Biological research has shifted to studies of cellular and sub-cellular processes (Thiers 2020), such as genomics, and to landscape-level analyses like species modelling and remote sensing. These fields of study de-emphasize exploratory field studies, which were the prominent means for documenting the diversity of botanical life from the late 1800s to early 1900s (Thiers 2020), and for discovering rarity, from the 1980s to early 2000s (Pipp 2023).

3) Sifting trends in faculty positions can create potential disconnects between academic disciplines and herbaria use

The number of faculty hires specializing in specific taxa has declined as academic degrees shift to microscopic and landscape-level programs (Thiers 2020). Gradually use of the herbarium by faculty and students wanes if not supported by other academic needs. Over the past 20 years, both MONT and MONTU curators have noticed that fewer university faculty and students visit and use their academic herbarium (Bishop 2023; Lavin 2023). Likewise, the number of students authoring research papers that involve herbarium specimens has lessened (Bishop 2023). However, this apparent decline might be more accurately portrayed as a shift away from direct visitation towards accessing collections online (while also not crediting the herbarium).

4) Fewer formal botany degrees are offered in the USA

In 1988, approximately 36 of the 50 top-funded USA universities offered advanced degrees in botany (Deng 2015). By 2015, at least half of these universities no longer offered those degrees (Deng 2015). With shifting academic priorities in the Montana University System (MUS), traditional botany degrees have been retired or re-tooled into various flavors of biology, environmental studies, and forestry programs. While the *Montana Native Plant Conservation Strategy: Species and Habitats of Greatest Conservation Need* makes no inference or judgement on the degrees offered by the MUS, this *Strategy* does acknowledge the fact that fewer courses in plant identification, plant ecology, and collections management are offered to students. The consequence is that fewer graduates enter the job market with

plant identification, monitoring skills, and an understanding of plant biology and ecology. Meanwhile, botanical skills continue to be highly sought after, while individuals from other professions are increasingly expected to take on botanical work.

5) *Lack of credit given to the herbaria that digitize plant data*

Online users often credit the portal or collaborative network that displays the digital data, and not the actual herbarium who funds, manages, and digitizes the specimens. A lack of advocacy by herbarium curators and collections managers has also contributed to this absence of credit (Rocchetti et al. 2021; Fertig 2016; Pipp 2023; Giblin 2021).

6) *Changes in the operation of land management organizations has reduced direct visitation and information exchanges with herbaria*

During most of the 20th Century, federal and state resource professionals frequently contributed to and/or examined plant specimens in the course of their normal work duties. This exchange of information created strong working relationships and shared work projects between curators, managers, and users. Over the past 30 years, there has been a noticeable decline in the number of visits and specimen acquisitions by federal and state resource professionals to Montana's public university herbaria (Comer 2021; Lavin 2023; Pipp 2023).

7) *A perception that herbaria are outdated*

There is a perception that herbaria are dead places, providing antiquated ways of understanding plant systematics and distributions (Deng 2015; Thiers 2020). This perception is often unfounded and one that this Strategy aims to correct.

ACTIONS

ACTIONS TO ENSURE THE LONGEVITY OF MONTANA'S HERBARIA

Although Montana's herbaria are used, the time is now to address these challenges and implement actions to ensure their longevity. This *Strategy* identifies five objectives and many subsequent actions designed to address current challenges confronting Montana's herbaria. These voluntary actions can be pursued or implemented by a single entity, or as a collaborative effort on the part of individuals, agencies, and organizations. They are presented in no prioritized order.

Objective 1.

Ensure the continued operation of Montana's herbaria through financial, institutional, and community support for staffing, equipment, space, and operational needs.

1) Communicate to decision-makers and university stakeholders the rationale for supporting each university herbarium with a collections manager, curator, and student internships.

2) Convene meetings with stakeholders (decision-makers, herbarium staff and users) to identify short- and long term funding sources and develop a financial strategy.

ACTIONS

3) Communicate to decision-makers and university stakeholders, the need for and value of returning botany classes to the curriculum for existing natural resource and biological degree programs. In these discussions, include the federal requirements for qualifying in the professional botany job series.

4) Develop community support groups and volunteers to advocate for funding and operational needs:

   a. Initiate the formation of a support group, with engagement from the respective curator. The University of Montana Friends of the Herbarium (FOH)[8] serves as a potential model. Consider expanding the FOH group to cover the three university herbaria in Montana (MONTU, MONT and MSUB), or develop focus groups specific to each herbarium. Promote student and public membership in the FOH group.

   b. Encourage financial donations to herbaria to support operations and special projects. Some herbaria have endowments, and contributions may be tax-deductible.

   c. Encourage volunteer assistance at a local herbarium. Most herbaria welcome volunteers and may rely on them for conducting day-to-day work (Thiers 2020). Academic herbaria may also offer work-study jobs and internship opportunities for students.

5) Identify potential stakeholders relative to Montana's university [U], federal [F], and/or private [P] herbaria. Potential herbarium stakeholders may include, but are not limited to:

   a. Dean of the university department that houses the herbarium. [U]

   b. Herbarium curator and collections manager. [U, F, P]

   c. Academic faculty, especially those that use the herbarium for teaching or research. [U, F, P]

   d. Students, especially those that use the herbarium for research and coursework. [U, F]

   e. Federal administrators within the National Park System. [F]

   f. Support groups associated with a specific herbarium. [U, F, P]

   g. Land management agencies (federal, state, county) and extension services, who may have established workflow processes or formal agreements that specify the repository to use for collections and validating specimen identification. [U, F, P]

   h. MTNHP botanist and program lead whose work relies heavily on herbaria. [U, F, P]

   i. Collaborators at online herbarium portals. [U, F, P]

   j. Other users of the herbarium. [U, F, P]

6) Develop an operating strategy for MONT and MSUB herbaria that involves leadership from the curator, collections manager, and appropriate University Dean.

[8] See "References" for FOH newsletters, and the "Resources" section at the end of the *Strategy*.

ACTIONS

Objective 2.

Implement efforts to strengthen or create working relationships between the herbarium, federal and state land management agencies, non-governmental organizations (NGOs), consultants, and private landowners.

1) Identify users specific to the herbarium, with the goal to strengthen (or create) working relationships.
2) Advertise products, in-person and on-line resources, and other services provided by the herbarium to land management agencies, NGOs, consultants, landowners, and other users.
3) Identify data gaps in herbarium specimens that pertain to taxa, time, and/or geography.
4) Develop and strengthen partnership agreements between users and herbarium staff. Partnership agreements should identify commitments made by all parties involved.

Photo Credit: University of Montana Herbarium

Photo 7-6. Herbarium Night at the University of Montana herbarium. Members of the Montana Native Plant Society build their plant identification skills using microscopes and pressed plants.

5) Organize a Montana-based herbaria working group that advocates for the preservation, function, and relevance of herbaria. A working group could also address statewide challenges, create efficiencies, and foster relationships with land management agencies and non-governmental organizations. Key members may include, but are not limited to:
   a. Curators
   b. Collection managers
   c. MTNHP botanist
   d. MNPS representatives
   e. Government and non-government herbaria users
6) Host workshops and demonstrations at the herbarium to teach land managers, consultants, and other users the best practices for collecting, pressing, drying, and recording associated data for plants, fungi, and algae. This could be done in conjunction with the MNPS, Master Naturalist program, county weed extension service, and others.

ACTIONS

7) Create how-to-videos under the name of the herbarium and market to consulting firms, land management agencies, and NGOs.

8) Identify websites and other places to showcase the partnership that developed between the herbaria and MNPS to create Montana Grasses and Glacier Wildflowers apps. Ensure that these products are prominently displayed with proper credits, and easy to find on or download from the MNPS website. These actions could bring stronger awareness and recognition to herbaria and the MNPS.

9) Use data aggregators like GBIF and iDigBio[9] to track scientific publications that cite herbaria specimen data. These data aggregators can help track use that a curator or collections manager may not be aware of. Information on how specimen data is useful to a wide audience helps demonstrate the use and value of herbaria.

Objective 3.

Build relationships between the herbarium, MNPS, and non-profit organizations.

1) Identify non-profit organizations, community support groups, and individuals that are (avid) users of the specific herbarium.

2) Collaborate with the MNPS and other non-profit groups to host educational events or fund-raising efforts. MNPS members, non-profit groups, and individuals could host workshops that focus on a specific species, family, or vegetation community.

3) Create a website or team with a partnering organization to host plant inventory checklists and/or manage personal checklists by MNPS members. This could encourage MNPS members and other botany amateurs to use herbaria to resolve their plant identification problems and create a support group for the herbarium. The Washington Native Plant Society (WNPS) serves as a potential model. WNPS teamed together with CPNWH staff to host a password-protected webpage where members can create and edit personal plant lists and geo-reference field trip locations.

4) Collaborate with the Montana Citizen Botany Program to sponsor forays designed to fill specific-herbaria data gaps and provide opportunities for winter-time plant identification and specimen preparation

5) Encourage the MNPS-MTNHP Citizen Botany Program (if available) or other botany interest groups to conduct a bio-blitz or foray (collection trip) to address an herbarium's data gaps. When coordinated with the curator or collections manager, these activities also provide plant identification and specimen curation projects for amateur and professional botanists in winter or at other times.

6) Evaluate users' experiences at the herbarium, identify potential problems, and make recommendations for change. Factors that can improve or hinder individual use include ease of access, campus parking, space accommodations for examining specimens, ability to contact staff, etc.

[9] Refer to the "Resources" section at the end of the *Strategy*.

ACTIONS

Objective 4.
Promote herbaria and plant education through outreach actions.

1) When using information sourced by an online portal or herbarium, credit the herbarium that directly manages and digitizes the specimen(s) and data.

2) Create educational displays that showcase herbaria collections, plant preservation techniques, botanical collectors, history of botanical exploration, and other related topics. Displays can promote learning opportunities and pique interest in herbaria.

   a. Continue to display MONTU's collections on the University of Montana campus, such as occurring in the Health Sciences and Mansfield Library buildings; seek out new opportunities for campus displays.

   b. Bring herbarium-themed educational programs and presentations to primary and secondary schools, art classrooms, and community groups, including Girls in Science, Girl Scouts of the USA, Boy Scouts of America, Future Farmers of America, and many others. Teaching children to identify plants, create plant lists, and preserve specimens builds connections with plants while building curiosity.

   c. Collaborate with art galleries, museums, and/or American Society of Botanical Artists (ASBA-Rocky Mountain Chapter) to display herbarium specimens or the art of curation. Examples include, but are not limited to:

      - Create a travelling exhibition focused on plants collected by Montana's early botanists and curated at a Montana herbarium.
      - Host an annual art contest; develop a contest in the same vein as the Federal Duck Stamp.
      - Teach botanical illustration classes using herbarium specimens or images.

3) Encourage members of the community to write articles that highlight a particular herbarium in local, regional, or state-wide newsletters. Newsletter articles that highlight specific plants or projects relative to the organization's mission promotes learning and creates awareness of a local herbarium. This could include historical information, current research, or special collections.

Photo Credit: Jane Olson

Photo 7-7. The Yellowstone National Park botanist carefully spreads out the collected plant before placing it in the plant press.

ACTIONS

Pertinent conservation organizations[10] that produce a newsletter include, but are not limited to:

a. The MNPS [*Kelseya*]
b. College and university campus newspapers
c. National Park Service publications
d. Montana Historical Society [*Montana the Magazine of Western History*]
e. Montana Audubon Society [Monthly E-News]
f. Montana Watershed Coordination Council [*Watershed News*]
g. Montana Association of Conservation Districts [*The Montana Conservationist*]
h. The Nature Conservancy [*Nature Conservancy Magazine*]
i. Penstemon Society
j. Eriogonum Society

Objective 5.

Ensure collections remain relevant and accessible through specimen data digitization and acquisition.

1) Pursue funding opportunities in concert with natural resource professionals, herbarium support groups, non-profits, and others. Consider fund-raising campaigns, memberships, and donations. Funding is needed to:
   a. Repair, purchase, and loan equipment and software used to accession, photograph, and digitize specimens at all eight herbaria.
   b. Pay staff salaries and/or student internships.
   c. Cover shipping and mailing costs for specimen loans.
   d. Purchase herbarium supplies.
   e. Keep the lights on, and facilities maintained.
2) Pursue grant opportunities to fund special projects, equipment, or events. Consider collaborating with state or regional herbaria to strengthen the need for projects or the expected outcomes of proposed work. Potential funding sources include the Institute of Museum and Library Services and the National Science Foundation.

[10] (a) Kelseya Archive: https://mtnativeplants.org/archive/
(d) Montana the Magazine of Western History: https://mhs.mt.gov/pubs/Magazine1
(e) Montana Audubon Society Monthly E-News: https://mtaudubon.org/news
(f) Watershed News: https://www.mtwatersheds.org/resources/watershed-news/
(g) The Montana Conservationist: https://macdnet.org/category/the-montana-conservationist/
(h) The Nature Conservancy Magazine: https://www.nature.org/en-us/magazine/
(i) Penstemon Society: https://penstemons.org/index.php
(j) Eriogonum Society: https://eriogonum.info
Also see "Resources" at the end of the *Strategy*.

ACTIONS

3) Convene a working or sub-group comprised of curators and collection managers to assess statewide needs common to the eight Montana herbaria (see also Objective 2, #5). This could include developing tasks, workflow processes, and formal agreements among all parties, and address how the needs within their facility might dovetail with the needs of other herbaria (Pipp 2023).

4) Communicate with land managers, extension services, and NGOs on the value of and need for acquiring specimens. Specimen acquisition includes, but is not limited to:

   a. Taxa new to state, county, or other defined geographical area,

   b. Taxa representing current times.

   c. Taxa or specimens that fulfill the herbarium's mission.

   d. Taxa with special designations: Species of GCN; SOC; PSOC; Sensitive: Species of Conservation Concern; and others.

   e. Existing specimens from other herbaria.

5) Encourage University herbaria to share via data aggregators (IDigBio, GBIF, etc.) to expand the herbarium's users, and educate them to credit the herbarium that funds, stores, manages, and digitizes the collections.

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