Friends of the University of Montana Herbarium

Spring 2023

Reviving Interest in the MONTU Diatom Collection

by Heidi Abresch

Figure 1. Many diatom species are usually documented on a single slide. The largest central diatom is *Epithemia adnata*.

Diatoms are single-celled algae that are found anywhere you can find water – in marine, freshwater, and even terrestrial ecosystems. They are small but mighty organisms – ranging in size from about 5 micrometers to half a millimeter, but together they produce an estimated 20% of oxygen in the atmosphere. While you can't see them with your naked eye, you likely come across them often. For example, every year in late summer, the Clark Fork River grows green mats of the green algae *Cladophora glomerata*. Soon after, the green streamers turn a golden brown or rusty red. This dramatic change in color is driven by rapidly growing diatoms that completely coat the green algae. Diatoms are perhaps most well known for their intricate, glass cell walls called frustules. Their detailed geometric shapes captured the attention of early naturalists and artists. Beginning in the early 1800s, people created microscopic arrangements of diatoms on microscope slides, using a single boar hair to position single cells to create elaborate patterns. These jewels of the microcosmos are also exceptionally diverse with estimated species numbers totaling anywhere from 30,000 to well over 100,000.

Diatoms are used in everyday life and across many scientific fields. Diatomaceous earth is made primarily of empty diatom frustules and is used widely, including for pest control, water filtration, and polishing aids. Diatoms are also a primary focus for scientists assessing water quality and used as environmental indicators to understand ecosystem changes and remediation. Frustules also preserve well in sediments; so diatom samples are phenomenal environmental time capsules and exceptionally useful for reconstructing past ecosystems. By extracting sediment cores and identifying diatoms in each layer, scientists can characterize historical environmental conditions and how they changed over time with remarkable accuracy. To accomplish any of this research, diatom collections are critical. (*continued on p.5*)

NOTES from the BOARD

by Scott Mincemoyer

Herbaria continue to be critical repositories and research facilities related to the studies of plant systematics, taxonomy, floristics and for plant conservation efforts. In Montana, MONTU is an invaluable source of information pertaining to the natural world around us. The specimen data from MONTU has been critical to the work conducted by the Montana Natural Heritage Program over the last several decades. One effort in particular that is making use of the digitized specimen data relates to the development of predictive habitat for individual plant species. These models use known locations of an individual plant species with statewide biophysical layers to predict where suitable habitat exists across the landscape for that species. Biophysical layers include site, climatic and environmental characteristics such as geology, soils, precipitation, temperature, elevation and slope to name just a few. These model outputs are often useful for targeting surveys to find new locations of rare species and for various conservation planning efforts when used individually or when many outputs are overlain to identify key habitat areas. Collections from the herbarium are one of the critical data sources for these efforts. However, the species' data used in these models needs to be fairly precisely georeferenced and be relatively recent or it is not useful in such efforts. As many older specimens do not have precise locations and/or may have been collected when the habitat was different (i.e. a human-modified habitat or converted by fire from a forest to a shrubland) they are not able to be utilized in such efforts. This means newer collections (i.e. in the last several decades) which often have been precisely georeferenced are more valuable. This is one reason that a static collection lacking new accessions is not as valuable as a growing one! If you'd like to see an example of one of these models that incorporates herbarium data, visit https://mtnhp.org/models/ or they can be found on the MT Field Guide in an individual species' account (recent model example: *Cercocarpus ledifolius*. Spring is upon us. Happy Botanizing!

2020 FOH Annual Meeting

The annual Borad of Directors business meeting of the Friends of the UM Herbarium has yet to be determined. If you wish to attend, please contact GiovannaBishop@mso.umt.edu. Open to the membership.

Friends
of the University of Montana
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Visitors to MONTU in 2022

General Public & Private Consultants
Dani Yashinovitz (OCRW), Maria Mantas, Steve Shelly, John Pierce, Scott Mincemoyer, Emmy Hause, Julian Colescott (Catena Consulting)
UM Researchers & Students
Austin Orville, Heidi Albresch, Biology 220 students, Ethnobotany intern students
Federal, State, Tribal and NGO Biologists
Grahm Johnson (Missoula Parks & Recreation), Eva Masin (U.S. Forest Service)

Publications using MONTU specimens

Lesica, P. 2022. Manual of Montana Vascular Plants, 2nd edition. BRIT Press, Fort Worth, TX.

Kimball, S. and P. Lesica. 2022. Wildflowers of Glacier National Park, 2nd edition. Trillium Press, Kalispell, MT.

Lesica, P. et. al. 2022. Noteworthy Collections. Madrono 69: 205-206.

Ackerfield, J. et. al. 2020. Thistle be a mess: Untangling the taxonomy of *Cirsium* (Cardueae: Compositae) in North America. Journal of Systematics and Evolution 58: 881-912.

Donors

Cary Lund
John Pierce

What Good Are Herbaria

by Peter Lesica

Herbaria have been around for centuries. They are often considered museums, but they lack things that the average person considers interesting. There are no stuffed animals, no awe-inspiring artwork and no interesting hands-on learning machines. Most people think of a herbarium (if they think of them at all) as a work place for eccentric plant taxonomists. But these days there is a lot going on.

Herbaria have historically served several functions. The majority of visitors to MONTU are interested in using the collections to verify specimens they collected during their field work. Perhaps the most important use of the collections in the past has been for taxonomic studies where taxonomists have requested loans in order to examine examples of Montana plants first-hand. A recent history of MONTU loans can be found by examining the "Loans for Research" section in past newsletters (Newsletters (umt.edu). Recent loans have included specimens of *Sphagnum*, *Stellaria* and *Tofieldia*. Herbarium specimens also provide data on plant geographic distributions such as those presented in local and regional floras (9,16). These functions have been greatly facilitated by the recent drive to database and photograph herbarium specimens, allowing researchers to acquire data on location, habitat and gross morphology from across North America and the world by simply going online. MONTU received a National Science Foundation grant in 2005 to database our specimens.

More recently herbarium collections have provided data for studies in several other fields of diverse biological research. The Montana Natural Heritage Program employs herbarium data to conduct niche modelling where climate, soil and geographic variables are used to determine potentially unknown locations for rare and endangered plants. Doug Soltis used herbarium data to elucidate hotspots of plant endemism in Florida (36). A different endangered plant study conducted across eastern North America compared the size of a valuable medicinal plant, American ginseng (*Panax quinquefolius*) over the course of almost two centuries. Ginseng plants collected from northern populations did not decline in size, while plants from midwestern, Appalachian and southern states showed sharp declines in stature. Human harvest could explain the rapid change in ginseng stature (21).

Herbarium collections have also proved useful in studies on the evolution of morphological traits. Australian researchers used over 1900 herbarium specimens to demonstrate that morphological traits of introduced plants have shown significant change during the last 150 years (4). The results suggest that rapid evolution in introduced plant species could be common. Similarly, herbarium specimens from the last 140 years were used to understand the evolution of common ragweed (*Ambrosia artemisiifolia*) as it became more invasive under the influence of human disturbance in eastern North America (18). Researchers in Belgium used molecular genetics methods to examine herbarium specimens of European tumble mustard (*Sisymbrium austriacum*) and found strong divergence in flowering time genes over the past 100 years, indicating that rapid genetic adaptation preceded the spread of this species and possibly assisted in overcoming environmental constraints (38). Grass taxonomists used molecular markers from herbarium specimens to elucidate the patterns of speciation in the bluestem grasses (20). Researchers from Canada and Europe used herbarium specimens from the past two centuries to determine that modern farming methods have enhanced the evolution and speed of invasion in the agricultural weed waterhemp (*Amaranthus tuberculatus*) (14).

The most common use of herbarium specimens in this age of molecular genetics has been exploration of human-caused global changes. There have been numerous studies of changes in the timing of annual plant developmental stages (phenology). A recent study showed that herbarium records did provide accurate estimates of mean flowering date over almost two centuries (5). Numerous studies of flowering phenology based on herbarium specimens have been employed to examine the effects of climate change (25,27,33). In 2021 the California Botanical Society published an entire issue of their journal, Madroño (Vol. 68, No.4) on plant phenology. More than one-third of the articles used herbarium data to determine how climate change was altering flowering date both within and among species and how these changes might affect plant persistence (19,28,29,37,42). Based on herbarium specimens, the flowering date of rare species in the Central Rocky Mountains has become 42 days earlier since the late 1800s, with plants in sagebrush basins showing the strongest accelerations. High winter temperatures were associated with the acceleration of phenology in low elevation sagebrush habitats, whereas high spring temperatures explained accelerated phenology in the high elevation alpine habitat (26). Similarly across New England, the mean leaf-out dates across all species and sites were ca. one half day earlier per decade (7).

Herbarium specimens can also be used to document temporal changes in plant morphology. Researchers in French Guiana analyzed herbarium specimens of the rainforest species *Humiria balsamifera* that date as far back as 1788 and

showed that as atmospheric carbon dioxide levels increased with industrialization, plants responded by increasing photosynthetic activity and using more water (3). Herbarium specimens of 42 species across three continents documented a response in floral pigmentation to anthropogenic climatic change, suggesting that global change may alter pollination through its impact on floral color, with repercussions for plant reproductive fitness (13). Researchers in Kansas used 13 decades of foliar isotopes from herbarium specimens to find that nitrogen availability has declined in spite of anthropogenic increases in deposition. These results suggest that declines are driven by increased ecosystem N storage as a result of increased atmospheric CO_2 (22).

Long-term data from herbarium specimens can provide information to resource managers, helping to prioritize needs, make effective management decisions, and develop targeted prevention (2). Researchers in Indiana compared pre-1940 herbarium records with their current flora. They found a 2.4 species/year rate of decline for native species with a 1.4 exotic species/year increase over the past 70 years in Indianapolis (6). Invasion researchers used herbarium specimens to determine whether exotic species exhibited morphological changes following their invasion into the United Kingdom. They found that trait changes occurred early in their invasion and these changes were still occurring one to two centuries after their introduction. They suggest that this information provides important clues for their appropriate management (8).

Pressed plants, especially mosses, can often act as storage sites for atmospheric pollutants. Spanish researchers found that mineral concentrations in the north and east regions of Spain have substantially changed throughout the twentieth century (32). Concentrations of nitrogen as well as phosphorus and sulphur have increased in the last decades (31), and atmospheric CO2 concentration has increased by 25% over preindustrial levels (30). Over the past century herbarium moss specimens showed a strong trend of increasing foliar nitrogen content in South Africa (40). On the bright side, over the past century, lead has declined in both northern England (35) and Rhode Island (34).

Herbarium specimens provide information on the presence of and susceptibility to insect pests and disease. For example, researchers from across the United States examined herbarium specimens to determine that the lengthening growing seasons are resulting in more extensive insect damage (24). European researchers studying the horse-chestnut leaf-mining moth used amplified nuclear and mitochondrial DNA fragments from larvae pressed within leaves of herbarium samples collected across Europe from the past 150 years. They determined that this highly invasive moth had a Balkan origin and set back its history in Europe by more than a century (15). Climate scientists in Raleigh, North Carolina used historical specimens to find that an herbivorous scale insect has increased in the hottest parts of the city and during the hottest years in nearby forests (41). Researchers from the University of Virginia and Amherst College examined thousands of herbarium specimens to determine the range of anther-smut in the eastern United States. The disease occurred exclusively on perennial plants, and incidence in *Silene virginica* and *S. caroliniana* increased significantly over the past century and was higher in marginal populations (1,12). Herbarium specimens of infected plants provide an historical record of both the geographic distribution and genetic diversity of citrus bacterial canker. An exact match of pathogen genotypes from Japan and Florida, demonstrated that Japan was the source of the original outbreak of the canker in Florida in 1911 (17).

The above examples of recent research using herbaria is far from exhaustive. Many more examples can be found in recent review articles (10,11,39), and many uses of herbarium specimens are just beginning to happen (23). So next time you walk into the University of Montana Herbarium, think of it as a time capsule for plant biology.

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Reviving Interest in the MONTU Diatom Collection,

(*continued from p.1*)

Fig. 2 *Rhopalodia gibba,* which is very abundant in the Clark Fork River in late summer.

The Montana Diatom Collection began in 1968 and now contains over 15,000 permanent diatom slides from all over the Northwest United States, with samples dating back to at least 1936 and the most recent specimens arriving in the last year. This collection includes over 100 type species, which are specimens used to formally describe a new species. A large part of the MONTU diatom collection was curated by diatomist Loren Bahls, whose collections for Montana are currently being compiled and published. The first volume of **Diatoms of Montana and Western North America** was published in 2021. This collection, although massive, takes up relatively little space in the Herbarium – only two bookshelves. The storage boxes are only the size of a couple of composition notebooks, but each holds 100 slides. One slide is prepared from a single location that includes multiple diatom species—sometimes over 50 species per slide! Each slide in a diatom collection therefore holds a wealth of information about the entire diatom community because it conserves both species diversity and relative abundance.

In 2020, I began my PhD in Scott Miller's Lab at UMT studying a specific family of diatoms – Rhopalodiales – which have cyanobacteria living inside the diatom cells called spheroid bodies. In exchange for a comfortable place to live inside the diatom, the spheroid bodies fix nitrogen from the atmosphere and provide it to the host. This relationship functions similar to that of rhizobia and legumes. While the symbiosis was first documented in 1869, relatively little is known about how the partners work together. However, recent studies have shown that Rhopalodiales have massive impacts on food webs and are a key source of nitrogen in aquatic environments.

In my research, I use the Montana Diatom Collection in multiple ways, including species identification and compiling distributions of these species. This can then be correlated with environmental conditions samples were taken from to better understand where and how these diatoms thrive. A key goal of my research is to expand available resources for studying Rhopalodiales by building a culture collection of live strains from around the world. Through a new NSF grant, we are receiving specimens collected from every continent except Antarctica. Each sample will be added to the diatom collection at MONTU.

During my academic journey, I found a great passion for photomicrography and sharing the beauty of the microcosmos. While diatom collections are being increasingly recognized as crucial to understanding aquatic ecosystems and predicting future environmental impacts, they often receive little attention due to their small space requirements and microscopic nature. So, along with my research, I am excited to be working with MONTU to digitize and increase the accessibility of the diatom collection.

Farewell to Shannon

For the past seven years Shannon Kimball has guided and enhanced the University of Montana Herbarium for the benefit of its many users. Day to day activities for her and her students and volunteers included mounting and accessioning specimens as well as entering new label data and photographing the mounted specimens to increase the online digital database that is used by people all over the world but especially here in Montana. For those who needed hands-on experience with the collections, there were loans to process. During her tenure Shannon and her people also databased the type collection and the moss collection. She guided one of her best students to perform the regular "pest check" looking for carrion beetles that can ruin collections.

These day-to-day tasks would be enough for any part-time curator, but Shannon had a lot more on her plate. In 2010, the U.S. Forest Service MRC Herbarium became part of MONTU. All of these ca. 10,000 specimens had to be databased and accessioned into the collections- no small task and it mainly fell to Shannon. She also found experts to check and update the determinations of the moss and lichen collections that had been previously ignored; part of this endeavor was funded by a grant from the Institute of Museum and Library Sciences that she coauthored. Around the time of Shannon's arrival, MONTU received the "Craighead Herbarium" from Johnny Craighead who lives here in Missoula. The specimens were collected as vouchers for John and Frank's Rocky Mountain Wildflowers book and their grizzly bear research in Montana and Wyoming. Finally, Shannon deaccessioned MONTU's fungi collection and sent it to the Denver Botanic Garden where it could be properly cared for.

Shannon elevated MONTU's role in education. Every year she has lead several tours for UM's Rocky Mountain Flora Class and for the Plant Systematics class from UM-Western at Dillon. She began assembling an official teaching collection that can be used in classrooms by people who have not been trained to handle museum specimens. Shannon facilitated evening herbarium classes for the Montana Native Plant Society. As if that weren't enough, Shannon designed and installed a large herbarium educational display across from the Biological Sciences office that demonstrates the value of the herbarium to the scientific community.

Management usually implies taking care of day-to-day issues, but it also requires thinking about the future. Shannon did this too. Between 2019 and 2021 Shannon developed a strategic plan for the herbarium meant to help guide and prioritize future activities. At the same time she coauthored a portion of the Montana Plant Conservation Strategy that outlines the role of herbaria in conservation. Shannon also conducted a fundraiser that provided the means to purchase eleven new herbarium cabinets to house the ever-increasing collections. Supporters of MONTU started an herbarium endowment two years prior to Shannon becoming the curator. That endowment has more than quadrupled during the time of her tenure at MONTU.

Shannon always had time to give visitors, such as the Beaverhead Forest Botany Crew, a tour of the herbarium. She did a great job preparing FOH board meeting agendas and taking notes. Those who worked with Shannon appreciate her hard work and humility. Thank you, Shannon; MONTU has come a long way under your guidance. Your presence in and dedication to the herbarium over these many years will be missed.

New Aquisitions

Joe Elliott: 134 mosses from MT, ID
Kurt Hansen: several vascular plants from E. MT
Karen Gray: 79 bryophytes, 1 lichen from ID, WA, MT
Matt Lavin: 10 grasses and forbs from MT
Peter Lesica: 80 MT vascular plants collections
J. Stephen Shelly: 11 MT vascular plants
Maria Mantas: 17 MT vascular plants
Scott Mincemoyer: 21 MT vascular plants
John Pierce: One MT collection of *Vallisneria*

Introducing Giovanna Bishop

My passion for herbaria and natural history collections started at Wheaton College (MA) where I was an undergraduate. The first collection I databased was a historic mollusk collection that had been sitting in boxes for decades. However, I quickly learned my passion was botany, specifically taxonomy, floristics, and identifying plants. Ultimately, the challenge, patience, and meticulousness of lichens and bryophytes caught my attention. After I graduated with a B.S. in Environmental Science I started working at The Farlow cryptogamic herbarium at Harvard University Herbaria (HUH).
During my time at HUH, my love for herbaria blossomed. I was formally trained on herbarium practices such as mounting vascular specimens, filing, curating lichens and bryophytes, as well as databasing, imaging and much more. After a few years working I knew graduate school would allow me to pursue a job as a curator and I applied to work with Dr. Jessica Allen, a lichenologist at Eastern Washington University (EWU). My M.S. project was on the impacts of rock climbing on lichen and bryophyte cliff communities at local rock climbing areas near Spokane, WA. I collected many state and county records including the crustose lichen *Henrica americana*, which had only been previously known to Montana and is widespread throughout Europe. I hope to continue collecting, identifying, and studying both lichens and bryophytes and to follow my passion for preserving the environment and natural history collections as the curator of MONTU. My past outreach activities include forays, bioblitz's, leading hikes on lichens and bryophytes, and educating youth about the importance of the environment and different ecosystems. One of my goals as curator is to recreate the community the herbarium had before the pandemic, and to advocate for the continued growth of the collections as a high-standard research source for the state of Montana and beyond.

MONTU Activities

As of January, when I first started as the new curator of MONTU, there has been an increase of students, volunteers, and people working in the collections. Thankfully Dorothea Kast was hired just before my arrival and helped to mount several vascular specimens, clean up the image backlog in the database, and accession many new specimens. Nic Gravley, a 2021 UM graduate in the biology department, was hired in March to help continue working through the vascular backlog. He has been essential in verifying identifications and helping to implement a new filing strategy for Montana vascular plants. Currently, there are three students working in the collections. Jazmine Raymond, Kipp Stebbins, and Emily Davis are all seniors with a passion for botany. Emily has been helping to accession the MRC lichens and bryophytes, Kipp has been adding annotation slips to the lichen collection after Tim Wheeler updated the taxonomy, and Jazmine has been helping to file and curate bryophytes while also working on some sticker and t-shirt designs for MONTU. Jazmine and Kipp have also been helping to check pest traps bi-weekly where common pests have already been found in just one month. Additionally, a few volunteers have been coming to help with unidentified material and other projects. Sol Ziegert, who currently works in the O'Connor Center on campus, has been coming in to help get through some harder unidentified material and redetermine some specimens with outdated or incomplete identifications. Luke Brown, a hydrologist from the Forest Service, recently took an interest in botany and will be helping with a few miscellaneous projects. Heidi Abresch, a current PhD student in the biology department, has been pulling the type slides out from the diatom collection in order to get all of them photographed as an important source to add to the MONTU website. She will also be making a diatom type box so they are more easily accessible in the future. MONTU is so thankful to have students, volunteers, and experienced workers to help the collections continue to grow and I look forward to having more people in the collections in the near future.

Yes! I want to help protect the irreplaceable collections and enhance the facilities of the University of Montana Herbarium

Name:_____
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Join or renew online: www.hs.umt.edu/herbarium/support.php

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