Conserving the Green Mountain College Herbarium

report on a 2020 Les Mehrhoff Botanical Research Award project
for the New England Botanical Club

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Introduction

The future of the Green Mountain College Herbarium became uncertain when the Rutland County, Vermont college closed in summer 2019. Student collections in the herbarium documented local flora (usually the more common species) and vouchered student research projects, and modest faculty collections documented some of the less common plant communities and taxa in the region, the flora at study sites, and species in a few distant places. However, it might have been reasonable to characterize the herbarium as a kind of botanical backwater: it was small, and faculty never had much time to curate. On the other hand, five things suggested that a collection such as this very likely contained specimens important at the state and regional level. (1) With 5000 specimens, even if just 1 in 100 were valuable, that would be 50 specimens. (2) The collection represented far more frequent and intensive field work at several sites in the region than was represented in any other herbarium. (3) Though relatively inexperienced, student collectors were advanced in undergraduate botanical training, and several had a good eye in the field. (4) Specimens were skillfully prepared and location data and other vital documentation complete. (5) Annotation was the only thing that many specimens lacked to become excellent specimens: many were identified by students and still needed my annotation. With enough time, this gap could be filled. Annotation became the major professional botanical work required to conserve the herbarium. The question wasn't whether there were any valuable specimens in the GMC Herbarium, but how many.

The "Conserving the Green Mountain College Herbarium" project goal is to save a wealth of floristic, ecological, and genetic information in the college plant collection for biologists, students, and conservationists to use. I'm a plant community ecologist, interested in factors that account for plant distribution. Species morphology and spatial patterns on the landscape signal the factors at play, so bringing to light the floristic and morphological information in an out-of-the-way plant collection is like a historian publishing newly discovered old photographs with well-documented dates and regional locations that had been nicely preserved in an attic. In this report, I document accomplishments and additional steps planned to complete the project.

Acknowledgements

I thank my mentors in plant ecology, including Susan Bratton, Mary Lindsay, Carl Monk, Robert Peet, Peter White, Dennis Knight, and Martha Christensen. They were good botanists who saw that plants manifest ecological processes.

At Green Mountain College, botanist John Czar started the herbarium in 1959, and left his high-quality collections when he retired in 1980. Starting in 1996, students in my Botany, Local Flora, and Dendrology classes collected and prepared most of the specimens added to the herbarium; special thanks go to Megan Nugent, Shannon Bonney, Evan Miller, Olesea Cojohari, and Ruth Larkin who made major contributions in support of their undergraduate research. I also thank many Botany Work Study students and AmeriCorps members who maintained order, mounted and repaired specimens, and managed data. As the college prepared to close in Spring 2019, Zoe Rybnikar, Cody Ferlow, and Emily Ray mounted and repaired hundreds of good specimens to reduce the unprocessed backlog, and helped inventory the entire collection. At the same time, Elisabeth Rondinone and Kailey Ware helped organize donations to start teaching collections at local high schools: they identified schools of interest, drafted correspondence, and compiled specimens suitable for donation.

To annotate specimens, I have been fortunate to work with many skilled botanists in Vermont. Aaron Marcus, Bob Popp, Art Gilman, Matt Peters, Anya Beale, Ann Bove, Diane Burbank, Adam Crary, Alexis DeGabriele, Allaire Diamond, Kathy Doyle, Mike Duffy, Marybeth Hanley, Charlie Hohn, Levy Keszey, Kate Kruesi, Everett Marshall, Erika Mitchell, Laura Schlivek, and Susan Warren have all annotated specimens in the herbarium. Aaron (assistant botanist with the Vermont Agency of Natural Resources) and I organized the Green Mountain College Herbarium BioBlitz, a gathering of botanists to annotate herbarium specimens. I thank North Branch Nature Center in Montpelier for hosting the event, and providing work tables with dissecting scopes and lighting; and I thank staff biologist Sean Beckett for making site arrangements and photographing annotated specimens.

At the Pringle Herbarium at the University of Vermont, the major receiving institution for the Green Mountain College Herbarium, curator Dave Barrington has been enthusiastic, supportive, and a pleasure to work with. I also thank Mary Droege for facilitated my donation of 235 woody plant specimens to Castleton University to support local flora and dendrology courses there, and Michael Gamache at Mill River Union High School, Scott Worland at Long Trail School, Ben Worthing and Fair Haven High School, and Sally Shaw at Southshire Community School who received teaching collections for their science programs.

During my time on the Green Mountain College faculty, the college provided workspace, materials, lab equipment, and herbarium cabinets. Before it closed, to help me conserve the herbarium, the college donated the plant collection, herbarium materials, two herbarium cabinets, and a small chest freezer for sterilizing plants, so that I could create a herbarium work area and move the collection home until specimens are ready for new homes.

The New England Botanical Club supported my work on the herbarium project with a 2020 Les Mehrhoff Botanical Research Award. Mehrhoff awards support growth of floristic knowledge, so conserving the Green Mountain College Herbarium was an ideal fit. I thank the New England Botanical Club for its important efforts to support plant collections and floristic research.

Methods

To conserve the herbarium, a project was designed with 7 components, corresponding to sections of this report. These roughly address history, weeding, documentation, annotation, statistics, distribution, and outcomes. Bibliographic citations appear in the Literature Cited.

History of the collection – A brief history of the herbarium provides useful context. It gives users a sense of the timeframe, geographic extent, habitats, kinds of plants, and kinds of collectors behind the collection. The history aims to give users a quick sense of what plant species to expect. The history uses collection date data to illustrate growth of the collection over time, and identifies major time periods characterized by different collectors with different goals.

Weeding and repairs – Specimens were removed from the collection if they were (1) common species with poor quality prep, or (2) lacking vital documentation, especially the collection date or location; missing specimens were noted in the database. Any specimen not weeded was repaired as needed. Repairs were made to glue loose parts of a specimen or label, make seed pockets, and replace illegible labels.

Documentation and database clean-up – Records for each specimen in the herbarium are maintained in the GMC Herbarium Database, an Excel spreadsheet. Each specimen (on one line) is assigned values for 24 variables (in columns), corresponding to data on the herbarium label or to additional codes useful for sorting records. To clean and complete herbarium documentation, any data not found in both the herbarium label and the database was added as needed. Field by field, the database was sorted by entries for that variable, and language made consistent where that didn't change the meaning. Records for missing specimens were indicated as such in a status field: these records were kept in a complete archival database, but deleted from the database of existing specimens.

Annotations – Annotation occurred as needed throughout the project, and will continue at least through 2021. During inventory for weeding and repair, quick identifications were made for easily recognized taxa; specimens needing correction were set aside and edited as part of the weeding process. It was most efficient to annotate on a large scale, i.e., evaluating all specimens in a family or a genus in one block of time. Many resources were used to identify plants. I used printed and online keys (Gilman 2015, Haines 2011, Gleason & Cronquist 1991, Voss & Reznicek 2012, Native Plant Trust 2020), photos and illustrations (Native Plant Trust 2020, USDA 2020, Holmgren 1998, CNH 2020 for images of herbarium specimens, Uva et al. 1997 for pioneer species, Jenkins 2018 and Campbell et al. 1975 for woody species, and Cobb et al. for seedless vascular plants), species checklists (Gilman 2017, Gilman and Marshall 2018, Haines 2019), and community descriptions (Thompson, et al. 2019). Nomenclature follows Gilman (2015), or, in a few cases, Haines (2011). Taxonomy was regularly checked in several sources (Gilman 2015, Haines 2011, USDA 2020, ITIS 2020, and FNA 2020).

With more than 4000 specimens in the collection after weeding, I collaborated with more than 20 other botanists to annotate specimens (see Acknowledgements). The Green Mountain College Herbarium BioBlitz made major progress in one day. Assistant state botanist Aaron Marcus and I organized the event. Aaron flagged potential rare species and county records in the database, I flagged records of taxa that might easily be mis-identified, and I pulled and organized these 1454 specimens for the blitz in family folders. We set up the blitz event at North Branch Nature Center in Montpelier, and 19 botanists annotated over 500 specimens. In the next 3 months, I checked identifications made at the blitz to catch errors, began annotating other specimens in those

families in the collection, and began annotating other families, occasionally sharing images of specimens with other botanists to hear their opinion and interpretation. Annotation labels were glued to herbarium sheets, and contained the date, annotator (or annotator's initials), and any changes to the identification. I tallied rare species and new county records.

Statistics – To describe the collection, a few summary statistics were observed. These include numbers of genera, species, and specimens in collected families, and numbers of specimens by study area to indicate the collection's geographic focus.

Distribution of specimens – The herbarium was distributed (or will be) to 4 kinds of receiving collections. First, good-quality specimens of common species were distributed to four local schools. Interested teachers received a starter set of under 100 specimens, herbarium materials, and instructions. Second, 235 good-quality specimens of native and naturalized woody species in the region were received by the Biology program at Castleton University. Third, voucher specimens for my research at several field site, specimens for several undergraduate research projects, and study collections for Salix, Crataegus, Carex and other taxa remain in my personal herbarium. Fourth, most of the collection was donated to the Pringle Herbarium. As of December 2020, most of the Pringle donation is stored in boxes at the Pringle. The herbarium has a sizable backlog of unprocessed specimens, so curator Dave Barrington is grateful for my desire to annotate the entire collection before processing.

Outcomes of the herbarium project – Results of the herbarium project to date were reviewed in three parts, focused on (1) the value of the collection, (2) lessons learned, and (3) work yet to do.

History of the collection

The Green Mountain College Herbarium has almost no surviving record of botanical work prior to 1959. Botanist John Czar arrived in Poultney that year to join the faculty, and likely brought the 65 plant specimens collected earlier (perhaps by students) in places John had lived and worked in the northeast. He and his students prepared around 900 plant specimens over 20+ years until his retirement after 1980 (Figure 1). Most of these are John's, valuable for being prepared by a skilled botanist, and for emphasis on less common species. They include nice specimens from wetlands around Lake St. Catherine and Lake Bomoseen in Rutland County.

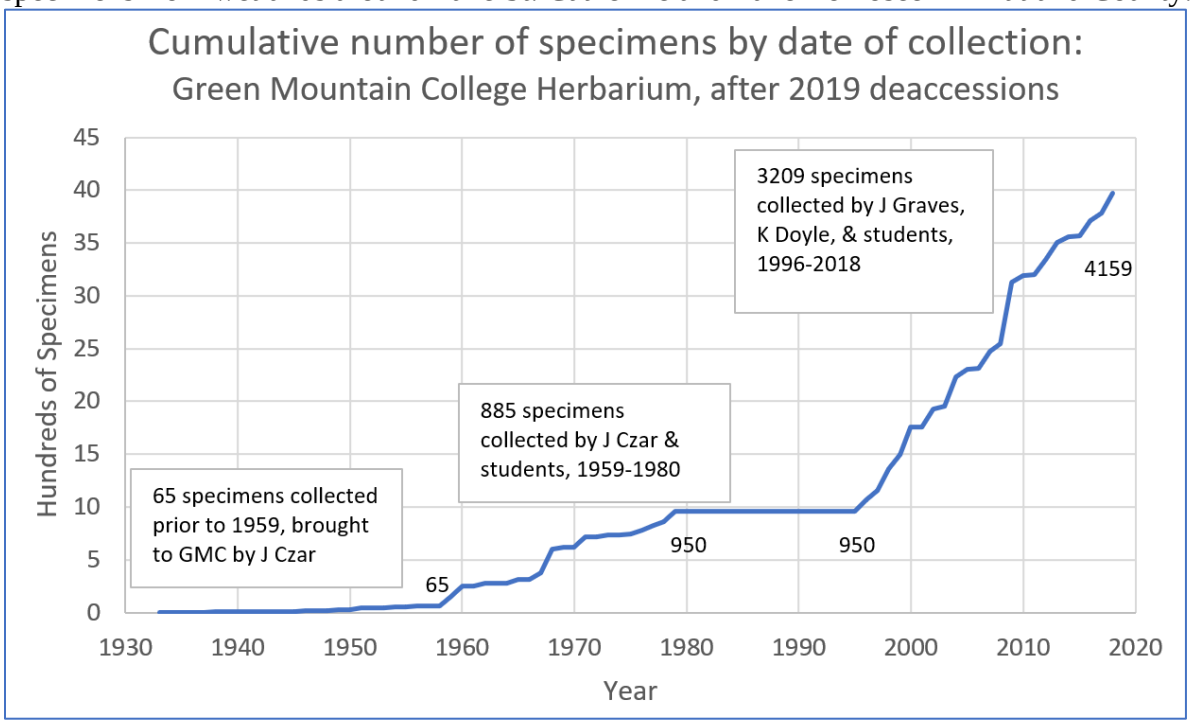

Figure 1. Growth of the Green Mountain College Herbarium. For each year, the number of specimens is the number collected on or before that year. Specimens deaccessioned or donated to local schools in 2019 are not included. Note: the graph was constructed using 3974 (out of 4159) specimens that remained after donations were made to local schools and had complete dates. Numbers near the curve indicate specimens collected through 1958, 1980, 1995, and 2018.

After John retired, the college had no botanist (and no new plant collections) until 1996 when I (a plant community ecologist) joined the faculty, was handed a key to John's herbarium cabinet, opened it for the first time in 10 years, and found his specimens in great condition. From 1996 to 2019, the herbarium grew to more than 4300 specimens, with additions of two kinds. First, students collected specimens to help inventory the 120-acre main campus natural areas on the Poultney River floodplain for a Campus Flora Project, upland forest communities at the college's 85-acre Deane Nature Preserve, and the flora of several specialized habitats visited during botany and local flora field trips, such as the white cedar swamp in Tinmouth. Second, Kathleen Doyle (research associate at the college) and I prepared specimens for ecological studies and inventories – ice storm impacts on lime-rich forests at Shaw Mountain, forest inventory on Champion lands in the Northeast Kingdom, forest inventory in the Northern Taconics, early succession on clayplain soils and on lower Poultney riparian zones, clayplain forest restoration, and others. I've added a few specimens from distant locations, including southern California plant communities visited during several biology field trip courses, and collections mailed in by students for the online masters field botany course. But most collections have been made in western Rutland County, Vermont, and northeastern Washington County, New York.

The prepared specimen collection was housed in 4 Viking metal herbarium cabinets (Figure 2), while unmounted specimens awaited processing in many bins and boxes. A small but well-equipped dedicated herbarium work space was set up in the Field Lab (Figure 3). I allocated small amounts of time to curating the collection, with the valuable help of a "Botany Work Study" student (5 hours/week). Since curation was limited, and the collection small, clear and simple procedures were essential. Most specimens were prepared by botany students. Thorough documentation was required, including date and detailed location and habitat; identical information was written on a standard GMC Herbarium label and in a spreadsheet following a template. Student records could then be simply appended to an Excel file where all herbarium records were permanently stored. The Excel file was uploaded to Google Sheets, and periodically archived in Excel, so that 2 or 3 of us could work on the data at the same time.

In summer 2019, the herbarium moved to its temporary home in Middletown Springs, Vermont. A portion of a livjng room has been rearranged to accommodate two herbarium cabinets, a mid-size chest freezer, herbarium supplies, lab cart, our large work table, floras, and an "efficiency" work station (Figure 4).

Figure 2. Liz Bourguet with the collection

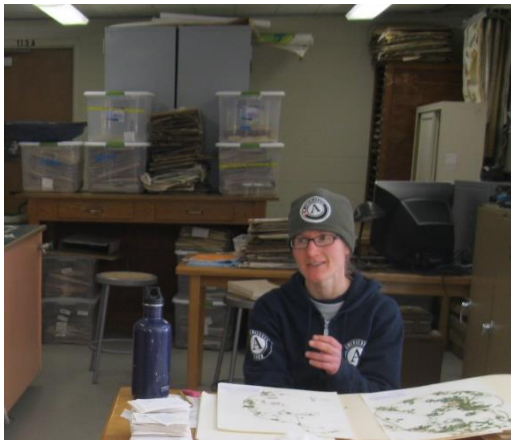

Figure 3. Ruth Larkin at the Green Mountain College Herbarium in the Field Lab in Ackley Hall. A dissecting scope and work station are out of view to the right.

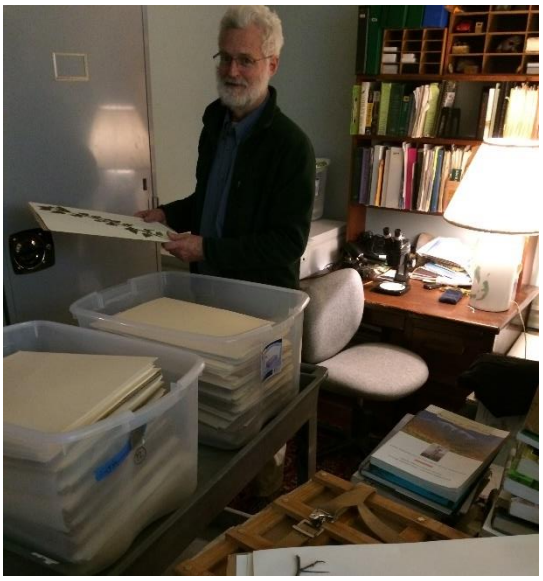

Figure 4. Jim Graves in the Green Mountain College Herbarium after its move to his home

Weeding and repairs

In early spring, 2019, the Green Mountain College Herbarium had 5149 accessions. 501 specimens were weeded (302) or missing (181). Thus, the herbarium stood at 4648 existing specimens in May 2019. As noted above, records of deaccessioned and missing specimens were kept in the database, but won't appear in any published or shared list of herbarium specimens.

Documentation and database cleanup

Database cleanup was given highest priority for the herbarium conservation project through mid-January, 2020, and prepared the way for annotation. However, improvements continued and inconsistencies continued to be discovered and fixed in 2020. The attached database (GMC-HerbariumList-2021-01-04-BeforeAnnotation) reflects changes to make language as consistent as possible without changing the meaning. Table 1 lists variables assigned values for each specimen, a description of each variable, and the edits that were made during database cleanup.

Table 1. Herbarium database variables, descriptions, and edits

Variable	Description	Edits
N	GMC accession number	Allow no dups; match database & specimen #s
Stat	Status code (e.g., M=missing, CU=donated to Castleton U.)	Use consistent codes. Blanks ok for unassigned specimens
Proj	Project or class or some other source of a set of plants	Use the same code for one class or project
W	Woodiness (H=herb W=woody)	Fill gaps
Gm	Collected on the GMC main campus (1) or not (0)	Fill gaps
Dn	Collected in GMC's Deane Preserve (1) or not (0)	Fill gaps
TNC	Collected in a TNC preserve (1) or not (0)	Fill gaps
Tax	Major taxon (1Cya=Cyanophyta,…7Ang=Angiosperms)	Fill gaps
Fam	Family name (Latin)	Correct mis-spelling; use current name
Gen	Genus name (Latin)	Correct mis-spelling; standardize the Genus name
Sp	Specific epithet (Latin)	Correct mis-spelling; standardize the specific epithet
Au*	Authority*	Use consistent abbreviations
CN	Common name	Capitalize all words; inconsistent names ok
Da	Date collected	Year-Month-Day format (xxxx-xx-xx)
SC	Season Code (1=Apr-May 2=Je-Aug 3=Sep-Oct 4=Nov-Mar)	Fill gaps
Loc	Location	Inconsistency ok (= label)
Cnt	Country	Use consistent two-letter code
St	State or Province	Use standard two-letter code
Co	County	Use county name without the word "County"
Twn	Town	Use town name, unabbreviated
Hab	Habitat	Inconsistency ok (= label)
Col	Collector	Use consistent name
Idr	Identifier	Use consistent name
Com	Comments, including earlier ID's	Inconsistency ok

* For simplicity, infraspecific taxa were entered as part of the Authority string. For example, for *Viburnum opulus* L. var. *americanum* Aiton,, Gen=Viburnum, Sp=opulus, Au=L. var. americanum Aiton. Before data transfer to a receiving herbarium's database, data in the Authority field will be split out into new fields. Further, new variables will be created to document annotations.

As of December 2020, the database is nearly clean (a major achievement!), but annotations are not yet entered (a big gap!). Thus, the database is not ready for publication. Several hundred annotations are documented only on paper annotation labels. However, in its current form, the database is useful if it is understood that it represents the herbarium before annotation, and some identifications will change.

Annotations

Early results show that the Green Mountain College Herbarium contains a number of important specimens. Table 2 shows uncommon species that annotation has identified in the collection.

Table 2. Vermont rare and uncommon species found to date in the GMC Herbarium

Family	Species - annotated	Original ID if different	Rank
Acoraceae	Acorus americanus (Raf.) Raf.	Acorus calamus L.	S3?
Adoxaceae	Viburnum rafinesquianum Schultes	!	S3
Amaranthaceae	Amaranthus tuberculatus (Moq. Ex DC.) J.D.Sauer	Amaranthus albus L.	S2
Araceae	Peltandra virginica (L.) Schott & Endl.	!	S2
Araliaceae	Panax quinquefolius L.	!	S3
Asteraceae	Heterotheca camporum (Greene) Shinners	! Possibly	S0*
Asteraceae	Solidago simplex Kunth ssp. randii (Porter) G.S.Ringius var. monticola (Porter) G.S.Ringius	!	S2
Asteraceae	Symphyotrichum ontarionis (Wieg.) Nesom	!	S1
Asteraceae	Symphyotrichum pilosum (Willd.) Nesom var. pilosum	! Adding the variety	S?
Betulaceae	Corylus americana Walter	!	S2
Campanulaceae	Lobelia siphilitica L.	!	S1
Campanulaceae	Triodanis perfoliata (L.) Nieuwl.	!	S2
Caprifoliaceae	Lonicera hirsuta Eaton	!	S2
Cyperaceae	Carex alopecoidea Tuck.	! Adding the species	S1
Cyperaceae	Carex pseudocyperus L.	!	S3
Gentianaceae	Gentianopsis crinita (Froel.) Ma.	!	S3
Juglandaceae	Carya glabra (P. Mill.) Sweet	!	S2
Juncaceae	Juncus anthelatus (Wiegand) R.E.Brooks	?	S1
Juncaceae	Juncus torreyi Coville	!	S2
Moraceae	Morus rubra L.	!	S1
Orchidaceae	Pogonia ophioglossoides (L.) Ker-Gawl.	Pogonia rosea (L.) Ker-Gawl. ex Lindl.	S3
Papaveraceae	Adlumia fungosa Ait.)	!	S3-S4
Polygonaceae	Persicaria hydropiperoides (Michx.) Small	!	S3
Primulaceae	Lysimachia arvensis (L.) U.Manns & A.Anderb	!	I**
Ranunculaceae	Ranunculus sceleratus L.	Ranunculus acris L.	I**
Rosaceae	Crataegus biltmoreana Beadle	Crataegus coccinea L.	S1
Rosaceae	Crataegus dodgei Ashe	!	S1
Rosaceae	Drymocallis arguta (Pursh) Rydb.	!	S3
Rubiaceae	Houstonia longifolia Gaertn.	!	S2
Selaginellaceae	Selaginella rupestris (L.) Spring	!	S3
Solanaceae	Solanum nigrum L.	!	I**

* Not ranked - possible new state species ** Not ranked - introduced, uncommon

In this set of 31 specimens, 26 (84%) were originally identified correctly. Annotation corrected 5 identifications, added the species name to 1, and added the varietal name to 1. Thus, annotation improved identifications in 7 (23%) of the specimens.

It was originally thought that annotations would be completed by late spring 2020. Instead, perhaps only a third of the collection has been annotated. Although slow, there are several constructive observations to make:

1. Considering that specimens dating back 70 years have usually been seen by only one botanist, and then often only briefly, a 2-year effort is starting to seem relatively quick.
2. Careful annotation is worth the effort, both to confirm correctly identified specimens and to uncover identities not recognized by the collector.
3. Most specimens of rare species in the database annotated so far were originally identified correctly, suggesting that more rare species in the database will be confirmed.
4. Collaboration is good. Botanists with expertise in particular groups can readily process specimens in those groups. Pulses such as the herbarium BioBlitz generate energy, professional interest in the collection, great collegial exchange and learning, and rapid progress (Figure 5). Virtual methods such as sharing photos of specimens allow a remote botanist to offer their observations and opinions and help annotate. With collaboration, the wider community of botanists recognizes the significance of the collection.
5. It seems best to annotate every specimen in the herbarium. Brief annotation on specimens of readily recognized species can correct spelling and add missing details like authorities, and will give a quick indication to any receiving institution that a botanist agrees with the label.

Through December 2020, several hundred specimens have been annotated. I will be dedicating more time to annotation in 2021 than was possible in 2020 (field work and a fall teaching commitment kept me busy in summer and fall), and hope to once again meet in-person with other botanists to nail down identifications in difficult taxa.

Figure 5. Botanists at the Green Mountain College Herbarium BioBlitz at North Branch Nature Center, in Montpelier, Vermont, winter 2020.

Statistics

There are 161 vascular plant families represented in the Green Mountain College Herbarium, ranging in species richness from Asteraceae (168 species), Rosaceae (92), Poaceae (75), Cyperaceae (60), and Fabaceae (51), down to 50 families that each have 1 species (Table 3). The most genus-rich families are Asteraceae (63), Poaceae (43), Fabaceae (30), Rosaceae (27), Lamiaceae (23), Brassicaceae (21), and Apiaceae (20).

Table 3. Vascular Plant Families in the GMC Herbarium, by number of species

Each entry = **Family S (G) N**, where S=# of species, G=# of genera, N=# of specimens			
8+ species	**4-7 species**	**2-3 species**	**1 species**
Asteraceae 168 (63) 645	Orobanchaceae 7 (7) 10	Cucurbitaceae 3 (3) 16	Hamamelidaceae 1 (1) 16
Rosaceae 92 (27) 292	Araceae 7 (5) 22	Cannabaceae 3 (3) 14	Aristolochiaceae 1 (1) 10
Poaceae 75 (43) 194	Scrophulariaceae 7 (5) 20	Convolvulaceae 3 (3) 12	Platanaceae 1 (1) 10
Cyperaceae 60 (11) 114	Cupressaceae 7 (4) 44	Lauraceae 3 (3) 11	Polygalaceae 1 (1) 8
Fabaceae 51 (30) 142	Oleaceae 7 (4) 20	Myrtaceae 3 (3) 6	Penthoraceae 1 (1) 6
Ericaceae 41 (17) 126	Araliaceae 7 (4) 11	Osmundaceae 3 (2) 19	Phytolaccaceae 1 (1) 6
Brassicaceae 39 (21) 107	Euphorbiaceae 7 (3) 15	Thelypteridaceae 3 (2) 12	Eriocaulaceae 1 (1) 5
Lamiaceae 37 (23) 133	Anacardiaceae 7 (2) 38	Magnoliaceae 3 (2) 10	Ginkgoaceae 1 (1) 5
Pinaceae 31 (6) 119	Hypericaceae 7 (2) 23	Cystopteridaceae 3 (2) 7	Staphyleaceae 1 (1) 5
Ranunculaceae 27 (11) 89	Celastraceae 7 (2) 17	Elaeagnaceae 3 (2) 6	Tiliaceae 1 (1) 4
Polygonaceae 26 (7) 76	Myrsinaceae 7 (1) 22	Alismataceae 3 (2) 5	Altingiaceae 1 (1) 3
Apiaceae 23 (20) 82	Papaveraceae 6 (5) 22	Ulmaceae 3 (2) 5	Butomaceae 1 (1) 3
Caryophyllaceae 23 (11) 71	Saxifragaceae 6 (4) 13	Bignoniaceae 3 (1) 11	Hydrangeaceae 1 (1) 3
Plantaginaceae 22 (8) 71	Ruscaceae 6 (3) 23	Onocleaceae 2 (2) 30	Moraceae 1 (1) 3
Salicaceae 22 (2) 159	Polypodiaceae 6 (2) 30	Athyriaceae 2 (2) 10	Agavaceae 1 (1) 2
Caprifoliaceae 19 (7) 51	Verbenaceae 6 (2) 17	Dennstaedtiaceae 2 (2) 8	Blechnaceae 1 (1) 2
Betulaceae 19 (5) 112	Equisetaceae 6 (1) 26	Boraginaceae 2 (2) 7	Clethraceae 1 (1) 2
Fagaceae 15 (4) 83	Grossulariaceae 6 (1) 9	Phrymaceae 2 (2) 7	Ebenaceae 1 (1) 2
Liliaceae 13 (11) 34	Urticaceae 5 (5) 15	Rutaceae 2 (2) 7	Hemerocallidaceae 1 (1) 2
Apocynaceae 13 (5) 32	Pteridaceae 5 (4) 15	Cistaceae 2 (2) 5	Hydrocharitaceae 1 (1) 2
Rubiaceae 13 (4) 69	Gentianaceae 5 (3) 11	Crassulaceae 2 (2) 5	Hypoxidaceae 1 (1) 2
Cornaceae 13 (2) 78	Typhaceae 5 (2) 11	Chenopodiaceae 2 (2) 3	Plumbaginaceae 1 (1) 2
Boraginaceae 12 (9) 28	Lythraceae 4 (4) 16	Cymodoceaceae 2 (2) 3	Pontederiaceae 1 (1) 2
Onagraceae 12 (6) 36	Berberidaceae 4 (3) 14	Nyctaginaceae 2 (2) 3	Woodsiaceae 1 (1) 2
Dryopteridaceae 12 (3) 66	Myricaceae 4 (3) 9	Aizoaceae 2 (2) 2	Acoraceae 1 (1) 1
Adoxaceae 11 (2) 87	Primulaceae 4 (3) 7	Combretaceae 2 (2) 2	Arecaceae 1 (1) 1
Violaceae 11 (1) 24	Iridaceae 4 (3) 6	Fumariaceae 2 (2) 2	Asparagaceae 1 (1) 1
Malvaceae 10 (7) 32	Nymphaeaceae 4 (3) 5	Balsaminaceae 2 (1) 24	Bromeliaceae 1 (1) 1
Lycopodiaceae 10 (5) 46	Polemoniaceae 4 (2) 8	Geraniaceae 2 (1) 18	Buxaceae 1 (1) 1
Sapindaceae 10 (2) 25	Aquifoliaceae 4 (1) 19	Smilacaceae 2 (1) 5	Cibotiaceae 1 (1) 1
Orchidaceae 9 (6) 23	Oxalidaceae 4 (1) 16	Ophioglossaceae 2 (1) 4	Comandraceae 1 (1) 1
Campanulaceae 9 (3) 33	Aspleniaceae 4 (1) 11	Amaryllidaceae 2 (1) 3	Commelinaceae 1 (1) 1
Potamogetonaceae 9 (2) 21	Taxaceae 4 (1) 9	Droseraceae 2 (1) 3	Garryaceae 1 (1) 1
Juncaceae 9 (1) 20		Haloragaceae 2 (1) 3	Gleicheniaceae 1 (1) 1
Amaranthaceae 8 (5) 15		Lentibulariaceae 2 (1) 3	Heliconiaceae 1 (1) 1
Solanaceae 8 (3) 25		Sarraceniaceae 2 (1) 3	Hyacinthaceae 1 (1) 1
Rhamnaceae 8 (3) 16		Colchicaceae 2 (1) 2	Lennoaceae 1 (1) 1
Vitaceae 8 (2) 25		Melanthiaceae 2 (1) 2	Loasaceae 1 (1) 1
Juglandaceae 8 (2) 24		Portulacaceae 2 (1) 2	Loganiaceae 1 (1) 1
			Parnassiaceae 1 (1) 1
			Passifloraceae 1 (1) 1
			Rhizophoraceae 1 (1) 1
			Santalaceae 1 (1) 1
			Selaginellaceae 1 (1) 1
			Sparganiaceae 1 (1) 1
			Taxodiaceae 1 (1) 1
			Thymelaeaceae 1 (1) 1
			Turneraceae 1 (1) 1
			Xyridaeae 1 (1) 1
			Zingiberaceae 1 (1) 1

Vermont specimens account for about 75% of the collection. Sets of plants from other states and provinces reflect a variety of collecting trips and professional work (Table 4).

Table 4. Number of specimens in the GMC Herbarium by state or country of origin.
"Field Botany" students in the online masters course contributed small collections made at field sites near their varied locations. "Botany" and "Ecology" students collected specimens for some field labs and for a Campus Flora Project.

#	Locations	Specific origins: Collectors
3125	Vermont	VT, especially western Rutland Co.: Botany, field studies, collecting trips
222	New York	NY, Washington Co. and other sites: Botany, field sites, Field Botany
113	New Hampshire	NH Field sites mainly in Ashuelot River watershed: Jim Graves
110	Connecticut	CT: John Czar field sites before coming to GMC, and continuing
46	Other New England states	ME(16) NJ(12) RI(10) MA(8): Field Botany, Botany & Ecology field sites, John Czar, Jim Graves
160	Pennsylvania	PA: John Czar field sites before coming to GMC, and continuing
19	Midwest	MI(8) KY(6) WV(2) IL(1) MO(1) WI(1): Field Botany, Jim Graves
60	Southeast	SC(23) FL(20) NC(6) VA(5) TN(3) AL(3): Field Botany, Anya Beale (SC), Jim Graves
107	Rockies & Great Plains	TX(25) OK(6) SD(10) ND(1) AZ(23) UT(6) CO(12) WY(18) MT(6): Field Botany, John Czar (AZ), Jim Graves
86	Pacific Coast states	CA(38) OR(20) WA(23) AK(5): Field Botany, Biology Field Trip to southern CA, Jim Graves
8	Hawaii	HI: Field Botany
15	Canada	QC(13) NB(2): John Czar
3	Europe	Sweden (3): Jim Graves
11	Latin America	Bahamas(5) Costa Rica(1) Panama(5): Field Botany

The herbarium documents vascular plant species for several local areas (Table 5). Collections for these locations were made my many individuals, in different season, and over many years.

Table 5. Number of specimens (#) in the GMC Herbarium from areas dominating the collection

#	Area
2906	Rutland County, Vermont
2329	Town of Poultney, Rutland County, Vermont: location of Green Mountain College
990	Green Mountain College 120-acre main campus
349	Deane Nature Preserve: the college's 85-acre natural area 5 miles from main campus
241	Town of West Haven, Rutland County, Vermont: location of extensive TNC preserves

Statistics above touch on just a few major patterns to indicate the herbarium's taxonomic and geographic scope. Much more floristic information can be drawn from the database. Geographic data could be enhanced by creating more searchable geographic data fields, including geographic coordinates, and fields for names of field sites – something to consider after annotations are complete.

Distribution of specimens

As described in the Methods section, distributions to local schools and to Castleton University have been completed. Fair Haven Union High School received 44 specimens, Long Trail School 80 specimens, Sally Shaw at Southshire Community School 33 specimens, and Mill River Union High School 97 specimens. The woody plant collection for Castleton contained 235 specimens and at least one of every common woody species in central Vermont.

After weeding and distributions to schools and Castleton University, 4159 specimens remained. About 2845 are already designated for UVM (Pringle Herbarium), and additional specimens will be added during annotation. The Pringle will add to its collection only those specimens that document under-represented locations in Vermont and uncommon and rare species. However, good locations are found for specimens not needed in the Pringle – college teaching collections for example (Dave Barrington, personal communication). So, donation to the Pringle will increase the value of every good specimen, whether it stays there or enters another collection.

Outcomes of the herbarium project

The value of the collection – Five kinds of value in the GMC Herbarium have emerged:

1. Uncommon and rare plant species – There are S1 species (e.g., Carex alopecoidea, Crataegus biltmoreana, and Morus rubra), S2 species (e.g., Lonicera hirsuta and Juncus torreyi), S3 species, and regionally uncommon species (new town and county records).
2. New locations – Specimens document western Rutland County, particularly the towns of Poultney and West Haven and several thoroughly botanized field sites, including the college campus land, Deane Nature Preserve.
3. Teaching collections – Specimens of common species, introduced species, duplicates of the most common species, representatives of families and genera, and phenological series make good botany and ecology lab materials.
4. Quality – Collection dates, locations, database documentation, careful specimen collecting and preparation methods, and careful annotation make specimens dependable sources of information and good models for teaching techniques.

Lessons learned – Based on the herbarium project, here are things to do to conserve a collection:

1. Document carefully – Make database entries consistent, define variables clearly, improve location data using field notes if available.
2. Be thorough – It will be inefficient to edit the same field or annotate twice.
3. Annotate all specimens in a taxon at once – Comparisons and contrasts help see distinctions made in the keys.
4. Collaborate – Invite botanists to annotate taxa they have expertise with, and, if possible, organize gatherings large or small for botanists to work in a workshop environment. Working alone, after careful observation and effort with a taxon, if identifications are uncertain, form well-focused and well-informed questions, take photos, and correspond with botanists that may have expertise in the taxon. Point out specific ambiguities, and see if collaborators have dealt with these. Annotate keys as needed.
5. Note interesting patterns – Keep a notebook or otherwise list observations and questions for later analysis using the data. These might range from the ecology of morphology to phylogeny or floristic treatments of study areas.

Work yet to do – Conserving the Green Mountain College Herbarium requires significant annotation effort yet. In 2021 (and longer if necessary) I will annotate the remainder of the collection. Since the work will take months, I'll coordinate final donations to the Pringle with Dave Barrington. It may be best to donate the collection in two or more parts. To make the herbarium beneficial to more people, I'd like to make the data available online and to write up results for publication. A paper on the herbarium conservation process might be valuable given that collections at many small schools may face similar risks, whether the schools close or not. It would be especially interesting to find new ways that herbarium data and specimens can address ecological questions. Already there are good examples of this kind of thing in studies of historic changes in the timing of phenology in response to climate shifts and changes in species composition in response to species introductions. As I annotate the collection, I'm stimulated by the questions each plant generates.

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