

A COMPREHENSIVE HERBARIUM DATABASE OF VASCULAR PLANTS FROM NORTHEASTERN WYOMING AND WESTERN SOUTH DAKOTA

Curtis Card¹, Grace Kostel² and Mark Gabel^{2*}

¹Department of Mathematics

²Herbarium

Black Hills State University

Spearfish, SD 57799

*mark.gabel@bhsu.edu

ABSTRACT

We report on the construction of a database of essentially all vascular plant specimens from northeast Wyoming and South Dakota west of the Missouri River. The database is the result of a compilation of label information from 16 herbaria and over 96,000 plant specimens representing 1725 species and 2088 taxa. The database includes information from the 22 counties west of the Missouri River in South Dakota and two adjacent counties in northeastern Wyoming. The county represented by the most specimens and the greatest specimen density is Lawrence with >8 specimens \cdot km⁻², while the counties with the fewest specimens and lowest specimen density are Dewey and Ziebach with 0.02 specimens \cdot km⁻². The month in which most specimens were collected is July. The 1980s is the decade in which the greatest number of collections were made. The database is constructed using Specify software and is available via the Black Hills State Herbarium website (<http://herbarium.bhsu.edu>) for this continuing project.

Keywords

flora, Great Plains, grassland, Black Hills, vegetation

INTRODUCTION

The flora of western South Dakota and northeastern Wyoming is not well studied. Kaul (1986) noted "(b)asic floristic information is still lacking for large parts of our area, most notably the grasslands of Montana, Wyoming, Colorado and the Dakotas" (p. 10). Parts of the region, especially the Black Hills, have a high density of globally rare species (Ostlie et al. 1997). A major obstacle to the study of the flora of western South Dakota and northeastern Wyoming is the distribution of plant specimens. While the Rocky Mountain Herbarium (RM) at the University of Wyoming is relatively well known and has the largest number of specimens from the study area, additional specimens comprising a significant

portion of the flora of the area are distributed in a number of locations in smaller herbaria.

Western South Dakota and eastern Wyoming are included in several floras (e.g. Dorn 2001, Great Plains Flora Association 1986, Van Bruggen 1996). Unfortunately, the printed floras are static and do not include new findings (e.g. Gabel and Tackett 2008, Kostel 2009, Kostel and Hetlet 2009) or taxonomic revisions (e. g. Rothrock et al. 2009). It is the purpose of the work described here to describe the construction of a web accessible database that can be used to access data about plant specimens collected in the study area.

METHODS

The study area includes all 22 counties west of the Missouri River in South Dakota and Crook and Weston Counties in Wyoming. Label data from vascular plant specimens collected in the study area from and housed in 16 herbaria (Table 1) were entered into a database using Specify data management software, a relational database (Specify-6 2010). Students were employed at the University of South Dakota, South Dakota State University, the University of Wyoming and the University of Kansas to collect label data from specimens under supervision of the herbarium curators. Personnel from BHSU visited the remaining collections, annotated and entered data from those institutions. Where possible, georeferencing was completed using a variety of paper maps as well as electronic resources such as Biogeomancer (2010), GEOLocate (2010), GeoNames (2010)

Table 1. Herbaria contributing data to the comprehensive database with acronyms.

Badlands National Park	BADL
Black Hills State University	BHSC
Dakota Wesleyan University	DWU
Devil's Tower National Monument	DETO
Jewel Cave National Monument	JECA
Milwaukee Public Museum	MIL
Mount Rushmore National Memorial	MORU
South Dakota State University, Brookings	SDC
University of Kansas, Lawrence	KANU
University of South Dakota, Vermillion	SDU
University of Wyoming, Laramie	RM
USDA Forest Service Custer, SD	FSCU
USDA Forest Service Newcastle, WY	FSN
USDA Forest Service Spearfish, SD	FSS
USDA Forest Service Rocky Mountain Research Station	FSRC
Wind Cave National Park	WICA

and Acme Mapper (2010). Nomenclature used in the database follows USDA NRCS Plants (2010).

The BHSU Herbarium database is currently running in a virtual environment using multiple VMware ESX hosts connected to SAN storage. With VMware ESX running on multiple hosts, BHSU is able to provide reliability and redundancy to the virtual machines if any of the hosts fail. If a host were to fail, a virtual machine would continue to run but it would pull resources needed from another host until the failed host is back online. Each host can handle several virtual machines depending on the hardware resources available on the host.

We use Specify 5.2 software that accesses an SQL database. Maintenance and additions to the database are made using the Specify software. The public website is being hosted on an Apache web server and an Apache Tomcat web server. The Apache web server processes requests to the website for general information about the Herbarium using HTML and PHP. Accessing the SQL database through the internet and the Apache Tomcat server and web pages requires the use of Java software. The Apache server is unable to process SQL database requests and forwards them to the Apache Tomcat server to access (search) the database. An upgrade to Specify 6 software is planned for August 2010 and will allow mapping of specimen distributions and the continued addition of more specimens.

RESULTS

The total number of specimens included in the database is 96,107, which includes 2088 taxa and 1725 species from the study area. Approximately 81% of the specimens are georeferenced. Unfortunately, many of the older specimens do not have sufficient label data to determine meaningful longitude and latitude coordinates. The decade in which the largest number of specimens was collected is the 1980s (Figure 1). The month with the greatest number of collections is July (Table 2), while the month with the fewest collections, unsurprisingly is January.

The plant family with the most species is the Asteraceae with 274, represented by 14,860 specimens. The Poaceae of the region include 232 species, but include 17,072 specimens. Other plant families with large numbers of species or specimens include the Fabaceae (110 species and 7447 specimens), the Cyperaceae (114 species and 4260 specimens) the Rosaceae and Brassicaceae with 71 species each and 3662 and 3752 specimens, respectively.

Current numbers of specimens by county are shown in Figure 2. Notable are the greater specimen numbers and densities collected from the Black Hills (Crook, Weston, Lawrence, Pennington, Custer and Fall River Counties). Equally notable are the fewer numbers of specimens and lesser densities of specimens from Dewey, Ziebach, Shannon, Haakon, Tripp, Stanley, Lyman and Mellette Counties.

The elevation ranges of specimens from the 120,363 km² study area are shown in Figure 3. Only small areas of Crook, Weston, Lawrence, Pennington and Custer counties are above 1800 m, with more area between 900 m and 1370

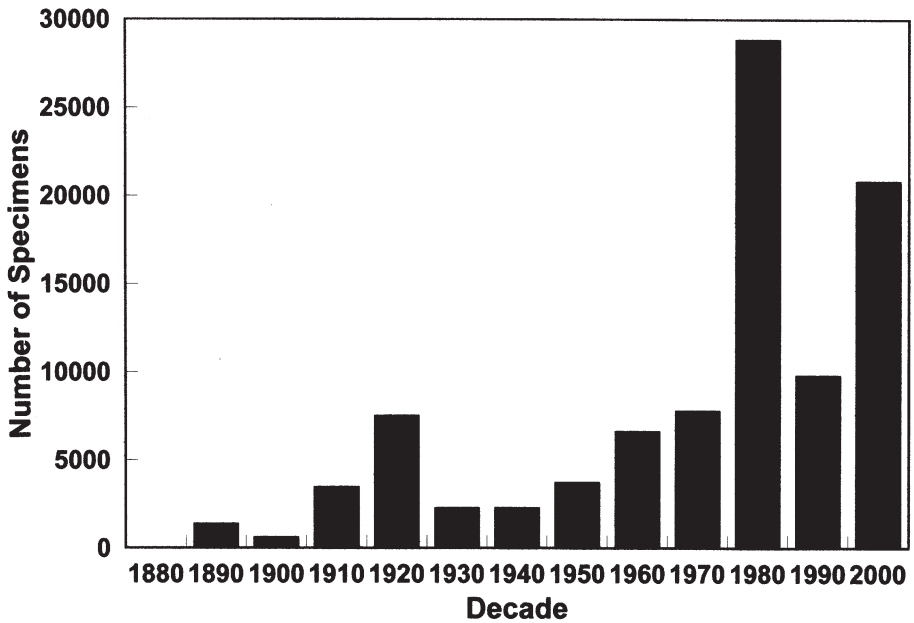


Figure 1. Number of specimens by decade collected from the study area as compiled from 16 herbaria.

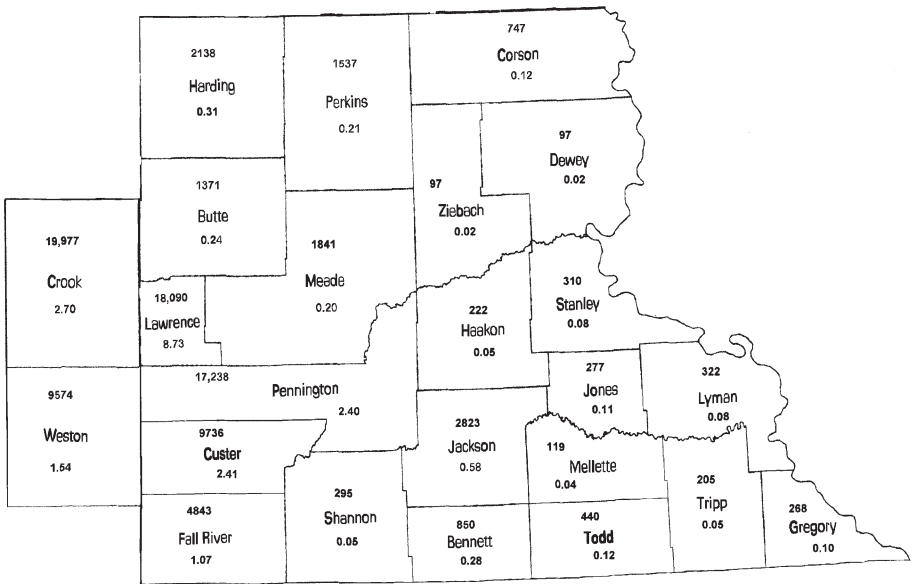


Figure 2. The study area with counties labeled. Numeral above county name is total current specimens from the county. Numeral below the county name is the density of specimens collected from that county (specimens*km-2).

Table 2. Number of specimens collected by month.

Month	Specimens
January	10
February	30
March	71
April	444
May	7,360
June	27,091
July	29,927
August	18,205
September	8,394
October	3,063
November	484
December	83

m. In contrast, only small areas along the eastern edge of the study area, adjacent to the Missouri River, are below 600 m. The majority of the land area is between 600 and 1370 m.

DISCUSSION

The database is a work in progress. The numbers reported here are current as of June 2010, but due to continued additions of specimens to the database and nomenclatural changes, the numbers will be continually changing.

There are greater numbers of plants from some areas of the region (e. g. Black Hills), but there is a lack of representation from counties in the eastern edge of the study area (Figure 3). It is critical that all areas of the project area, especially the eastern portion of the study area, be studied and additional specimens collected to arrive at a better understanding of the flora of the region. The authors hope that the web-accessible database will encourage additional floristic research within the study area. It is anticipated that more researchers will use specimens from the region in monographic or systematic works. This resource on plants of the study area in an easily accessible database should encourage more study of the region by researchers and land managers.

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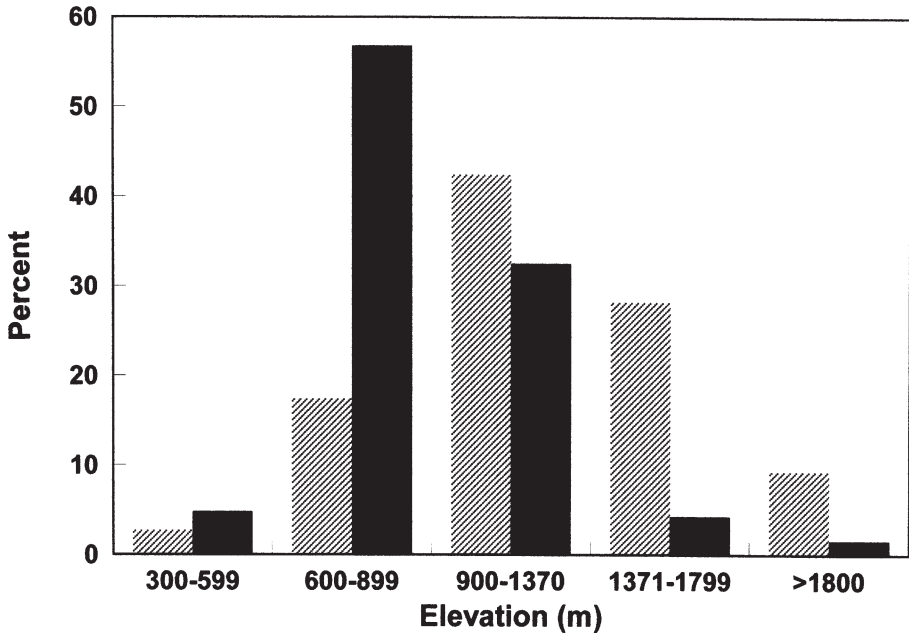


Figure 3. The percent of specimens collected at different elevation ranges within the study area. The hatched (lighter) bars represent the percent of total specimens. The black bars represent the percent of the study area within the elevation range.

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LITERATURE CITED

- Acme Mapper. 2010. Available at <http://mapper.acme.com/> (cited 7 July 2010).
- Biogeomancer. 2010. Available at <http://www.biogeomancer.org/> (cited 7 July 2010).
- Dorn, R.D. 2001. Vascular Plants of Wyoming (3rd). Mountain West Publishing, Cheyenne, WY.
- Gabel, M. and D. Tackett. 2008. A range extension for *Cypripedium montanum* Douglas ex Lindley (Orchidaceae) into the Black Hills of South Dakota. Proceedings of the South Dakota Academy of Science 87: 197-203.
- GEOLocate. 2010. Available at <http://www.museum.tulane.edu/geolocate/> (cited 7 July 2010).
- GeoNames. 2010. Available at <http://geonames.usgs.gov/> (cited 12 Jul 2010).
- Great Plains Flora Association. 1986. Flora of the Great Plains. University Press of Kansas, Lawrence, KS.

- Kaul, R.B. 1986. Physical and floristic characteristics of the Great Plains. pp. 7-10 *In* Great Plains Flora Association. Flora of the Great Plains. University Press of Kansas, Lawrence, KS.
- Kostel, G. 2009. *Thymelaea passerina* (Thymeleaceae) in South Dakota. Journal of the Botanical Research Institute of Texas 3: 901-903.
- Kostel, G., and L. Hetlet. 2009. *Castilleja angustifolia* var. *dubia* (Scrophulariaceae), a new record for South Dakota. Journal of the Botanical Research Institute of Texas 3:391-392.
- Ostlie, W.R., R.E. Schneider, J.M. Aldrich, T.M. Faust, R.B. McKin and S.J. Chaplin. 1997. The status of biodiversity in the Great Plains. The Nature Conservancy, Arlington, VA.
- Rothrock, P.E., A.A. Reznicek and A.L. Hipp. 2009. Taxonomic study of the *Carex tenera* group (Cyperaceae). Systematic Botany 34: 297-311.
- Specify 6. 2010. Available at <http://specifysoftware.org/> (cited 7 July 2010).
- USDA, NRCS Plants. 2010. The PLANTS Database. National Plant Data Center, Baton Rouge, LA 70874-4490 USA. Available at <http://plants.usda.gov> (cited 7 July 2010).
- Van Bruggen, T. 1996. The Vascular Plants of South Dakota. University of South Dakota, Vermillion, SD.