

## **2018 Project Abstract**

For the Period Ending June 30, 2022

**PROJECT TITLE:** Minnesota Biodiversity Atlas - Phase 2

**PROJECT MANAGER:** George Weiblen

**AFFILIATION:** University of Minnesota, Bell Museum

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**FUNDING SOURCE:** Environment and Natural Resources Trust Fund

**LEGAL CITATION:** M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 03c as extended by M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18

**APPROPRIATION AMOUNT:** \$ \$350,000

**AMOUNT SPENT:** \$ \$350,000

**AMOUNT REMAINING:** \$ 0

### **Sound bite of Project Outcomes and Results**

The Minnesota Biodiversity Atlas provides online access to 150 years of natural history information by integrating and disseminating data from state agencies, museums, colleges, and universities. It enables the general public, natural resource managers, educators and researchers to investigate past and present biodiversity patterns and make predictions about future directions.

### **Overall Project Outcome and Results**

This project expanded an online natural resource database situated at the University of Minnesota's Bell Museum to include data from multiple state agencies and museum collections. Extensive records of Minnesota biodiversity, past and present, are the product of ongoing biological surveys by agencies and organizations beginning with the Public Land Survey in 1848. As the official state museum of natural history, the Bell Museum is responsible for preserving and making available records of Minnesota plant and animal life. These records are the bellwether of informed responses to environmental change but literally millions of data points remain scattered among state agencies, museum collections and academic institutions.

The [Minnesota Biodiversity Atlas](#) serves to integrate and disseminate biodiversity data online. This second phase II of this project increased the size of the Atlas from 640,000 to 1,585,000 records of mammals, birds, fish, amphibians, reptiles, crustaceans, invertebrates, plants and fungi. Additions included expert observations from the Minnesota Department of Natural Resources and the Minnesota Pollution Control Agency and also specimen records from the University of Minnesota Duluth, the Science Museum of Minnesota, the College of St. Benedict's/St. John's University, and Minnesota State University, Mankato.

Understanding biodiversity change in Minnesota and adapting to it are essential for cultural, economic and environmental health. The Minnesota Biodiversity Atlas provides the historical baseline against which contemporary observations are compared to manage our natural heritage today and into the future. The Atlas is used by natural resource professionals, educators, and the public for species identification, distribution mapping, habitat assessment, restoration planning, management decision making, and learning. During the

project, the Atlas grew to 500,000 digital images and 1.4 million mapped records. Software development needs for a mobile phone-friendly version of the Atlas were also identified.

### **Project Results Use and Dissemination**

Online retrieval of data from the Minnesota Biodiversity Atlas grew from 76,000 page views in 2018 to 307,000 in 2021. Visitors to the Bell Museum also learn about the Biodiversity Atlas in the Minnesota Journeys gallery and it featured in a traveling exhibit that received over 70,000 in-person visitors. Two training workshops in using the Atlas were offered to over 30 natural resource professionals from across the state. In local media, it was twice featured on the “Grow with KARE” segment on channel 11 and in the *Minnesota Daily*.



# Environment and Natural Resources Trust Fund (ENRTF) M.L. 2018 ENRTF Work Plan (Main Document)

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**Today's Date:** 6 March 2023  
**Date of Next Status Update Report:** Final Report  
**Date of Work Plan Approval:** 19 September 2018  
**Project Completion Date:** 30 June 2022  
**Does this submission include an amendment request?** No

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**PROJECT TITLE:** Minnesota Biodiversity Atlas - Phase 2  
**Project Manager:** George Weiblen  
**Organization:** University of Minnesota  
**College/Department/Division:** Bell Museum of Natural History, College of Food, Agricultural and Natural Resource Sciences  
**Mailing Address:** 140 Gortner Lab, 1479 Gortner Avenue  
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**Location:** Statewide

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**Total Project Budget:** \$350,000  
**Amount Spent:** \$350,000  
**Balance:** \$0

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**Legal Citation:** M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 03c as extended by M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18

**Appropriation Language:** \$350,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to expand the biodiversity atlas project by adding more than 800,000 records and images of Minnesota wildlife, plants, and fungi, including observations from state agencies and other museum collections, to enhance research, guide field surveys, and inform conservation planning. This appropriation is available until June 30, 2021, by which time the project must be completed and final products delivered.

M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18. ENVIRONMENT AND NATURAL RESOURCES TRUST FUND; EXTENSIONS. [to June 30, 2022]

## I. PROJECT STATEMENT:

***We propose to double the size of a natural resource management tool, the Minnesota Biodiversity Atlas, by including state agency observations and specimen records from four additional museum collections.***

The Minnesota Biodiversity Atlas (<http://bellatlas.umn.edu/>) is a publicly accessible web application that enables users to map species distributions, create species checklists, view digital images, and search records. Phase I of this ENRTF project made accessible 630,000 records and 250,000 high-resolution digital images of Bell Museum specimens. In Phase II we propose to add:

- 300,000 observation records of animals and plants from the Minnesota Biological Survey (DNR MBS)
- 365,000 records of invertebrates and wetland plants from the Minnesota Pollution Control Agency (MPCA)
- 35,000 plant and animal specimen records from the University of Minnesota at Duluth (UMD)
- 35,000 bird and mammal specimen records from the Science Museum of Minnesota (SMM)
- 30,000 plant specimens from the College of St. Benedict/St. John's University (CSB/SJU)
- 15,000 plant specimens from Mankato State University (MANK)
- a mobile device application providing access to 1.4 million records in the field

As the state natural history museum, the Bell Museum has a statutory mandate to produce, preserve, and make biodiversity data available to the public. The Atlas complements the new Bell Museum and Planetarium in Saint Paul by serving these data online. The information is used by natural resource professionals (DNR & MPCA), educators, and the general public for activities including:

- accurate identification of species in the field (vegetation assessment, rare plant and animal surveys)
- checklists for user-defined areas (training, education, field surveys)
- species distribution maps (restoration planning, management, conservation)

The Atlas is currently limited to Bell Museum data including specimens collected by DNR and MPCA. **This work plan will make additional expert observations of DNR and MPCA accessible through the Atlas. It will also integrate other natural history collections in Minnesota. Lastly, it will expand the reach of the Atlas data by developing a mobile smart device application for offline use in the field.** With phase II, natural resource professionals will have at their fingertips an integrated data source for biodiversity collections and observations. Expanding the Atlas database and adding mobile functionality will increase accessibility to the biodiversity data that serves resource managers, professionals, educators, and citizens alike.

## II. OVERALL PROJECT STATUS UPDATES:

### **First Update January 31, 2019**

We expanded the Biodiversity Atlas to support observation records in addition to museum specimen records. We used 3,723 expert-verified observations of amphibians and reptiles as a test case to demonstrate the expansion of the web interface that allows users of the Atlas to simultaneously map the locations of collections and observations. 110,664 specimen records were added and 67,798 records were either georeferenced or edited for quality during this phase of the project. Digitization Manager Katie Noren coordinated with project partners including the Minnesota Pollution Control Agency (MPCA) and the University of Minnesota Duluth to obtain datasets and process them for upload to the Atlas. This work involved processing of 49,117 plant specimen records and 2,265 taxonomic names from the Olga Lakela Herbarium in Duluth and 65,534 fish observations from statewide MPCA surveys. We also coordinated with other project partners to prepare and plan for digitization starting in year two of the project. These partners included another ENRTF-supported project, the Minnesota Bee Atlas, Minnesota Biological Survey, Science Museum of Minnesota, Mankato State University, and College of St. Benedict/College of St. Johns. Database developer Tom Prather under the supervision of Michael Milligan worked on upgrading the Symbiota software platform to address technical issues associated with the expansion of the Atlas.

### **Second Update June 30, 2019**

92,000 Bell Museum specimen records and 73,000 images were added to the Atlas during this phase of the project, increasing the total to 720,000 records and 323,000 images searchable online. In addition, more than 397,000 expert observations from the MPCA were made publicly available. Non-public data including the locality information for endangered, threatened and special concern species is protected by the Atlas and made available to only to users permitted by the Minnesota DNR. Workshops were held to train professions in using Biodiversity Atlas and to prepare project partners for initiating Activity 2.

### **Third Update January 1, 2020**

During this phase, we added 2,051 plant observation records (all georeferenced) from the U.S. Army Corps of Engineers Mississippi Headwaters Recreation Area sites in north central Minnesota. We also installed the digitizing station at the University of Minnesota, Duluth and trained project partners Amanda Grusz and Gretchen Meier in its operation. They were able to begin photographing specimens soon after and, so far, have taken over 16,000 high resolution images. We also assisted the Science Museum team with the setup of their digitizing station and hired three University of Minnesota undergraduate students to begin work digitizing bird specimens in the Science Museum collection. Furthermore, we added 1,834 specimen records to the Atlas from the herbarium of the Leech Lake Band of Ojibwe.

### **Fourth Update June 30, 2020**

We added 394,340 plant observation records (all georeferenced) from the MN DNR Minnesota Biological Survey "releve" database. We also added 24,890 records (all georeferenced) from the Minnesota Bee Atlas from the University of Minnesota's Extension Service and 255 biodiversity observations (animals and plants) from the University of Minnesota's Cedar Creek Ecosystem Science Reserve. Restrictions related to the COVID-19 limited our digitizing activities during the second half of the spring semester on all partner campuses and the Science Museum. We did initiate limited remote work on the project including data transcription from digital images and georeferencing and added 185 new records from the Olga Lakela herbarium and georeferenced 2,961 records. In June, Tim Whitfeld offered a Bell Museum "Member master class" focused on plant collections. Part of the workshop included an introduction and orientation to the Biodiversity Atlas, for the 56 participants.

### **Amendment Request as of July 1,2020**

The impact of COVID-19 on University operations dramatically curtailed the involvement of undergraduate student workers in achieving the objectives of year two. Students were barred from campus until recently so we were not able to retain student workers over the summer at UMN or UMD. Nor could we recruit students from partner institutions (CSJ/SBU and MANK) to digitize their specimens in our facility over the summer. In order to deliver the full scope of the second project objective, we propose to shift effort from part-time student workers to full time staff at UMN and UMD. There are two advantages to reallocating the work. First, full time staff are much more proficient and efficient at digitization. Second, there exists the real possibility of the campus being closed to students again due to COVID-19.

Proposed changes to the budget as outlined in the budget spreadsheet are as follows. Funds allocated for employment by UMN-Twin Cities of summer interns from MANK and CSJ/SBU, \$11,000 and \$30,000, respectively, are to be redirected to continue the effort of the digitization manager (Katie Noren) into the final year of the project and to increase the effort of digitization lead (Tim Whitfeld). The amount proposed to continue Noren's effort is \$25,000 and the amount proposed to increase Whitfeld's effort is \$16,000. These workers together with the remaining UMN student interns will aim to complete the work held over from year two during year three.

The proposal for UMN-Duluth is similar. The \$35,000 originally budgeted from undergraduate student workers was re-allocated to increase the effort of the UMD Digitization Manager (Gretchen Meier) in the amount of \$19,000 and to involve an M.Sc. student employee in the amount of \$16,000.

Amendment Approved by LCCMR 8/24/2020

**Fifth Update January 1, 2021**

All University Minnesota campuses opened for fall semester under guidelines that included a blend of in-person, remote, and hybrid classes. Restrictions related to work spaces were also in place and this limited the number of student workers we could employ on campus. The Science Museum of Minnesota (SMM) also faced restrictions related to student workers, as did Minnesota State University, Mankato (MANK). Overall, COVID19-related workplace restrictions limited our ability to carry out digital imaging of specimens. Nonetheless, we made progress by working remotely and adding available records from other institutions including 54,099 from the University of Minnesota Entomology Collection (UMSP). The SMM added 1,503 records and 356 imaged specimens while MANK and UMD added 7,593 and 2,989 records, respectively. With 9,333 and 97 new plant and fungi records from the Bell Museum, the size of the Atlas had reached 1,780,510 records. We also added plant species checklists from Eloise Butler Wildflower Garden, Itasca State Park, Lost Valley Prairie Scientific and Natural Area and the Minnesota Landscape Arboretum. Development of a hand-held friendly version of the Atlas was initiated in response to changing technology and end-user needs.

Project extended to June 30, 2022 by LCCMR 7/1/21 as a result of M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18, legislative extension criteria being met.

**Sixth Update June 30, 2021:**

During this project period a total of 12,705 records and 43,423 images were added to the Atlas and 51,195 existing records were transcribed or digitized.

**Seventh Update January 31, 2022:**

During this project period a total of 11,752 records and 26,158 images were added to the Atlas and 32,405 existing records were transcribed or digitized.

**Final Update June 30, 2022**

During the final project period a total of 32,196 records and 28,445 images were added to the Atlas and 18,523 existing records were transcribed or digitized.

This project expanded an online natural resource database situated at the University of Minnesota's Bell Museum to include data from multiple state agencies and museum collections. Extensive records of Minnesota biodiversity, past and present, are the product of ongoing biological surveys by agencies and organizations beginning with the Public Land Survey in 1848. As the official state museum of natural history, the Bell Museum is responsible for preserving and making available records of Minnesota plant and animal life. These records are the bellwether of informed responses to environmental change but literally millions of data points remain scattered among state agencies, museum collections and academic institutions.

The [Minnesota Biodiversity Atlas](#) serves to integrate and disseminate biodiversity data online. This second phase II of this project increased the size of the Atlas from 640,000 to 1,585,000 records of mammals, birds, fish, amphibians, reptiles, crustaceans, invertebrates, plants, and fungi. Additions included expert observations from the Minnesota Department of Natural Resources and the Minnesota Pollution Control Agency and specimen records from the University of Minnesota Duluth, the Science Museum of Minnesota, the College of St. Benedict's/St. John's University, and Minnesota State University, Mankato.

Understanding biodiversity change in Minnesota and adapting to it are essential for cultural, economic, and environmental health. The Minnesota Biodiversity Atlas provides the historical baseline against which contemporary observations are compared to manage our natural heritage today and into the future. The Atlas is

used by natural resource professionals, educators, and the public for species identification, distribution mapping, habitat assessment, restoration planning, management decision making, and learning. During the project, the Atlas grew to 500,000 digital images and 1.4 million mapped records. Software development needs for a mobile phone-friendly version of the Atlas were also identified.

**III. PROJECT ACTIVITIES AND OUTCOMES:**

**ACTIVITY 1: Add Expert Observations to the Minnesota Biodiversity Atlas**

**Description:** We will expand the Atlas by adding expert observational data from the DNR MBS and the MPCA Environmental Analysis & Outcomes Division. MPCA surveys have accumulated observations of 100,000 fish, 240,000 stream and wetland macroinvertebrates, and 25,000 wetland plants. MBS survey data include more than 200,000 plant observations and 100,000 observations of birds, reptiles, amphibians, mammals, fish, mollusks and invertebrates. None of these digital records are publicly accessible online and together will dramatically improve the resolution of species distribution maps for Minnesota.

Under the supervision of Minnesota Supercomputing Institute (MSI) project manager Michael Milligan, programmer Tom Prather will implement the Atlas functionality for hosting observation records using the open source code base of Symbiota (<http://symbiota.org/docs/>). The digitization manager supervised by Bell Museum curators will map data from agency partners to the Atlas data model. Observational data will be uploaded to the Atlas by Prather, checked for quality by the curatorial assistant, and released publicly through the Biodiversity Atlas server within the first year of the project. Prather will commit 10% of his effort to this component of the project.

In preparation for the rollout of the observational records, we will actively seek feedback from agency partners and resource professionals through email invitations and meetings. We will work with our development team to adjust functionality and design details to maximize the utility of the product. Locality details for threatened and endangered species will be hidden from public view, with permissions for registered users granted by curators upon request. Once a public data release has been made, we will seek additional feedback and re-optimize as necessary. We will communicate to registered users how to make use of observational records in conjunction or apart from specimen records (see Section 5: Dissemination, below).

**ENRTF BUDGET: \$47,000**

<b>Outcome</b>	<b>Completion Date</b>
1. Implementation of Atlas expert observation functionality	October 2018
2. Data mapping, uploading, & quality assurance for 665,000 observations	April 2019
3. Release of observation data to professionals for comment and public use	June 2019

**First Update January 31, 2019**

The first project outcome, implementation of Atlas expert observation functionality was completed during this period of the project. Work was initiated on the second outcome to map, upload and improve expert observations. We used 3,723 expert-verified observations of Minnesota amphibians and reptiles from HerpMapper (<https://www.herpmapper.org/>) to test the expansion of the Atlas web interface allowing users to simultaneously map the locations of observations and collected specimens. We also integrated 65,534 fish observations from statewide MPCA surveys. The integration of MPCA fish records and the Minnesota amphibian and reptile records from HerpMapper with the scientific specimen records of the Bell Museum represents progress toward the third project outcome. We received comments and suggestions from professionals that demonstrated how the expansion of the Atlas improves the quantity, quality and public accessibility of diverse kinds of natural resource information.

### **Second Update June 30, 2019**

During this phase of the project, we added 45,011 MPCA fish, 24,245 wetland plants, and 328,490 stream invertebrate observation records. These additions represent progress toward the second and third outcomes of the project. Specimen records and expert observations together provide high-resolution distribution maps for Minnesota fish, stream invertebrates and wetland plants.

### **Third Update January 1, 2020**

During this phase, we added 2,051 plant and animal observation records (all georeferenced) from the U.S. Army Corps of Engineers Mississippi Headwaters Recreation Area sites in north central Minnesota. These observation records, together with the specimen records, increase the resolution of distribution maps for Minnesota species.

### **Fourth Update June 30, 2020**

We added 394,340 plant observation records from the ENTRF supported DNR Minnesota Biological Survey vegetation plot (“releve”) database. All these records are georeferenced. These expert observations come from several decades of vegetation surveys across Minnesota and their addition dramatically increases the resolution of plant distribution maps. We also added 24,890 records (all georeferenced) from the Minnesota Bee Atlas from the University of Minnesota’s Extension Service (ENTRF supported). These records were generated through citizen engagement. Furthermore, we added 255 observations of animals and plants from the University of Minnesota’s Cedar Creek Ecosystem Science Reserve.

### **Fifth Update January 1, 2021**

The project completed the three outcomes of Activity 1 in 2020.

### **Sixth Update June 30, 2021:**

Nothing to report.

### **Seventh Update January 31, 2022:**

Nothing to report.

### **Final Update June 30, 2022**

Nothing to report.

**ACTIVITY 2:** Add records from participating natural history collections in greater Minnesota

**Description:** We will expand the Atlas to include specimens housed in the Science Museum of Minnesota, University of Minnesota Duluth, Mankato State, and St. Benedict/ St. John’s. Together, these collections comprise 160,000 specimen records of Minnesota plants and animals that are not yet online, and will expand the current Atlas to a total of 790,000 specimens. We will digitally photograph plant specimens, animal specimen labels and their accompanying documentation. Text from label images will be transcribed using the Biodiversity Atlas.

Image capture begins with retrieval and organization of the specimens from museum cabinets and drawers. Specimens are organized according to taxonomic groups (e.g. families, genera, and species) and referenced according to a unique accession number that was assigned to the specimen at the time it was deposited in a museum collection. Accession numbers are located on the label documentation that accompanies each specimen. The next step is to associate a numerical barcode with each accession. Pre-printed barcode labels are affixed to the specimen label and captured digitally using a hand-held barcode scanner. If a specimen accession consists of multiple prepared objects stored separately (e.g. feathers, bones, eggs), unique barcodes are assigned to each object under the same accession number. Specimen labels (and specimens in the case of plants) are placed in a digital imaging station, photographed, and digital image files are named using the hand-

held barcode scanner. Digital imaging stations include a lighted copy stand equipped with a neutral background, ruler, and color reference palate, and a digital SLR camera.

Sets of raw images (approx. 40 MB each) are processed in bulk using Photoshop Lightroom for quality, consistency, and generation of smaller JPEG files (approx. 5 MB). Smaller image files and corresponding associations between barcodes and accession numbers are then uploaded to the Symbiota server for transcription of specimen label data (often hand-written) into the database. The larger raw image files and associated data will be provided to University Libraries for archival digital preservation. Image capture will continue as necessary throughout the course of the grant. Under the supervision of curatorial staff and the digitization manager, undergraduate employees will capture images using two high resolution imaging systems already purchased by the University. The herbarium sheets and consequently their images include a barcode that is linked directly to the electronic image file. Subsequent to capture, internet-servable versions of these images will be made available through the Atlas portal. In addition, under the supervision of John Butler and Jon Nichols, high quality versions of these images will be stored and brought under preservation management in the digital archiving system of University of Minnesota Libraries,, which will provide: (1) a highly stable image" backup" in case of data loss, and 2) a digital "back up" of the museum specimen herbarium sheet, and (3) preservation of metadata.

Equipment and protocols will be deployed to University of Minnesota Duluth where Amanda Grusz will supervise the digitization of 35,000 museum specimens at UMD. The Bell Museum plant digitization manager will train the UMD digitization manager in the use of the equipment and protocols, who will then oversee the employment of UMD undergraduate assistants to carry out the steps described above.

The Bell Museum plant digitization manager will train Steven Saupe of College of Saint Benedict & Saint John's University and Matthew Kaproth of Mankato State University in Atlas database protocols. 30,000 CSB/SJU specimens and 11,000 MANK specimens will be loaned to the Bell Museum where CSB/SJU and MANK students recruited by the Bell Museum for summer internships will complete digitization. The Bell Museum plant digitization manager will oversee the student summer interns and return the loan of specimens upon completion of the work.

Equipment and protocols will also be deployed to the Science Museum of Minnesota where Laurie Fink will supervise the digitization of 35,000 museum specimens at SMM. The Bell Museum plant digitization manager will train the SMM digitization manager in the use of the equipment and protocols, who will then oversee the employment of SMM interns to carry out the steps described above. Undergraduate students from the University of Minnesota will be recruited by the Bell Museum and paid as SMM interns, providing an immersive learning experience in a professional museum setting.

**ENRTF BUDGET: \$256,000**

<b>Outcome</b>	<b>Completion Date</b>
1. Digitization of UMD, CSB/SJU, MANK & SMM specimens	June 2020
2. UMD, CSB/SJU, MANK & SMM images and records published to the Atlas	June 2021

**First Update January 31, 2019**

Progress toward the first outcome of this project activity involved preparing 49,117 plant specimen records from the Olga Lakela Herbarium in Duluth for upload to the Atlas. This required careful evaluation of 2,265 scientific names to bring outdated names into alignment with the current system of biological classification. We planned a workshop for project partners at CSB/SJU, MANK & SMM for Spring 2019 to prepare personnel for digitizing specimens, uploading data, and managing data sets in the Atlas.

### **Second Update June 30, 2019**

Specimen records of the Olga Lakela Herbarium at UMD were released to the public. Portals were also established for two other Minnesota collections, the Carol Mortensen Herbarium at Minnesota State University Mankato, and the herbarium of the Itasca Biological Station and Laboratories at Itasca State Park. Daylong workshops were held at the Bell Museum on March 30th and April 6th 2019 for 37 project partners and natural resource professionals. The goals of the workshops included demonstrating the efficiencies and economies of scale associated with distributed database networks. Participants were trained in how to (1) use the Biodiversity Atlas to obtain data for research, (2) archive and manage legacy data sets specific to institutions and/or locations, (3) create regional maps of biodiversity, and (4) develop area-specific checklists for public engagement, curriculum development, resource management and strategic planning. Participants included staff from the Bell Museum, Cloquet Forestry Center, Hubachek Wilderness Research Center, Itasca Biological Station Leech Lake Band of Ojibwe, Minnesota Biological Survey, Minnesota Landscape Arboretum, Minnesota State University Mankato, Prairie Island Indian Community, University of Minnesota Extension, US Army Corp of Engineers and University of Minnesota faculty. The workshops further prepared project partners for achieving outcomes under the second objective of the project.

### **Third Update January 1, 2020**

In August, 2019, Tim Whitfeld (Collections Manager, Bell Museum Herbarium) traveled to UMD to install their digitizing station and train project partners Amanda Grusz and Gretchen Meier in its operation. They were able to begin photographing specimens soon after and, so far, have taken over 16,000 high resolution images. In November, Whitfeld also assisted the Science Museum team with the setup of their digitizing station. We hired three University of Minnesota undergraduate students to begin digitizing bird specimens in the Science Museum collection. Furthermore, we added 1,834 specimen records to the Atlas from the herbarium of the Leech Lake Band of Ojibwe.

### **Fourth Update June 30, 2020**

March 9, 2020 was the beginning of spring break at the University of Minnesota. At this time, the Coronavirus was establishing, the pandemic was beginning, and the State of Minnesota implemented a "Stay at Home Order." Concurrently, the University of Minnesota extended spring break by a week, mandated remote classes, and barred students from returning to campus. Around this time, the College of Saint Benedict and Saint John's and Minnesota State University, Mankato also closed their campuses and initiated remote classes and the Science Museum of Minnesota closed. Student workers employed to digitize specimens at the Science Museum were not able to continue working and we were not able to train students to start digitizing herbarium specimens from MANK or CSB/SJU as planned. We did initiate limited remote work on the project including data transcription from digital images and georeferencing. This included adding 185 new records from the Olga Lakela herbarium and georeferencing 2,961 records.

### **Fifth Update January 1, 2021**

Despite COVID restrictions, we recruited two new undergraduate students to work at the Science Museum of Minnesota. A third student hired in 2019 resumed her digitizing position after undergraduates were permitted to work on campus again. This group created 1,501 SMM records and transcribed label data from 356 specimens. We note that progress with animal records is considerably slower than for plants. This is because each bird or mammal mount and the associated label tags must be carefully positioned and imaged from multiple angles in order to capture the dimensionality of the specimen. At UMD, three students were recruited to work on the project, adding 2,989 new records and 14,161 specimen images. Minnesota State University, Mankato added 7,593 plant records and set up a digitizing station for future specimen imaging. We added 54,099 insect specimen records from the University of Minnesota Entomology Collection (UMSP) and incorporated species checklists from other institutions including Eloise Butler Wildflower Garden, Itasca State Park, Lost Valley Prairie Scientific Natural Area, and the Minnesota Landscape Arboretum.

### **Sixth Update June 30, 2021:**

During this project period we added new records including 9,505 from Bell, 293 from UMD, 2,892 from SMM. Specimen label transcription and georeferencing improved 26,250 Bell records, 24,255 UMD records, 557 MANK records and 530 SMM records. Digital images added to the Atlas included 14,526 from the Bell, 22,620 from UMD and 6,277 from SMM.

**Seventh Update January 1, 2022:**

During this project period we added new records including 8,256 from Bell, 249 from UMD, 422 from the U.S. Army Corps, 2,588 from SMM and 237 from MANK. Specimen label transcription and georeferencing improved 26,423 Bell records, 5,971 UMD records and 11 SMM records. Digital images added to the Atlas included 6,515 from the Bell, 5,038 from UMD, 5,467 from SMM and 9,138 from CSBSJU.

**Final Update June 30, 2022**

During the final project period we added new records including 12,283 from Bell, 2,584 from UMD, 557 from MANK and 16,772 from CSBSJU. Specimen label transcription and georeferencing improved 17,802 Bell records, 704 UMD records and 17 MANK records. Digital images added to the Atlas included 11,428 from the Bell and 2,558 from UMD, and 16,771 from CSBSJU.

**ACTIVITY 3: Create a customizable, mobile field Atlas that can be used anywhere**

**Description:** Natural resource professionals often require specimen images and data to identify species in the field or to determine whether a species is known from a particular area. The Atlas will be adapted for use on smart devices to serve as a portable field guide to Minnesota biodiversity with species lists and images. Since the complete Atlas is much too large for most mobile devices (phones or tablet computers), we will develop an application allowing users to download data and sets of images customizable by location or species similar to using Google maps offline in low data coverage areas.

Tom Prather at the Minnesota Supercomputing Institute will modify Symbiota source code to develop an offline version of the application, named Symbiota Mobile. The functionality of the Biodiversity Atlas will be expanded to include an option to download a package of checklists, record sets, images, and coordinates for a user-defined area prior to leaving coverage. Data packages will be readable by Symbiota Mobile for searching, mapping, and viewing images of records. The digitization manager will work with Prather to test the application prior to beta-testing by agency partners and other natural resource professionals.

**ENRTF BUDGET: \$47,000**

Outcome	Completion Date
1. Development of Symbiota code for data download to a hand-held application	June 2019
2. Beta-testing in the field of the offline Symbiota extension	June 2020
3. Release of the mobile, offline field guide to Minnesota’s biodiversity data	June 2021

**First Update January 31, 2019**

This activity was not initiated during the first reporting period.

**Second Update June 30, 2019**

Contact was established with the current developers of the Symbiota software at Arizona State University. They advised our developer at the Minnesota Supercomputing Institute to await the next release of the software in late 2019 before initiating development of the code for a hand-held application.

**Third Update January 1, 2020**

Tom Prather, our developer, upgraded the Symbiota software schema from version 1.0 to version 1.1. This upgrade improved the functionality of the Minnesota Biodiversity Atlas in several important ways. First, the user interface was improved with a more intuitive presentation of search options. Second, the Symbiota data model

was adapted to address a major problem with the collision of identical taxonomic names referring to organisms in different kingdoms of life (plants, animals & fungi). For example, the name *Abronia* refers to both a plant genus and a group of lizards.

#### **Fourth Update June 30, 2020**

The development team at Arizona State University released source code for Symbiota2. Tom Prather was introduced to the new developer and the stage was set for testing an implementation of an instance of the Minnesota Biodiversity Atlas in Symbiota2. The main improvement of Symbiota2 is the addition of modularity to the software. Planning was initiated to develop a Symbiota2 module for an offline, handheld instance of the Minnesota Biodiversity Atlas.

#### **Fifth Update January 1, 2021**

The project software developer investigated a beta-test of the Symbiota2 software, concluding that neither version of the software will support development of an offline version of the Atlas. However, mobile coverage is now so extensive throughout Minnesota that professionals in the field have service even in most remote areas. Instead of developing an offline version of the Atlas, the programmer explored development of a more hand-held friendly interface for the existing software. This involves adjusting Atlas page views to accommodate the smaller screen size of hand-held devices.

#### **Sixth Update June 30, 2021:**

A modified version of the Bell Atlas website was established for internal beta-testing but the vulnerability of Symbiota software to evolving malicious attacks caused us to redirect our attention toward “bots” capable of creating thousands of fake user accounts almost overnight. None of the attacks compromised the integrity of the data or the stability of the Atlas but our attention was diverted away from beta-testing.

#### **Seventh Update January 31, 2022:**

The mobile site remained protected behind a virtual private network which limited our capacity for beta-testing. The main menu icons were adjusted to display on a phone. A phone-friendly filter function was added to select data sources for searching and mapping. Searches report results “list” format because “table” format doesn’t display well on a phone. Maps, by default on a phone, display a user’s current location and nearby data points with flags. Clicking a flag brings up the occurrence info.

#### **Final Update June 30, 2022**

We decided to delay the release of the mobile app to the general public pending further consultation from other developers of Symbiota who claim to be developing similar software in parallel. We anticipate a public beta-release in the near future.

### **IV. DISSEMINATION: Raising awareness of the Minnesota Biodiversity Atlas**

**Description:** The results of this project will be communicated to three primary audiences by different means. First, we will continue to promote the availability of images and records through Bell Museum programming, the website, and an interactive kiosk in the main exhibit of the new Bell Museum. We specifically target audiences including educators, naturalists (e.g. participants in the Minnesota Master Naturalist program), paraprofessionals and hobbyists (Minnesota Native Plant Society, Minnesota Herpetological Society, Minnesota Ornithologists’ Union). During phase I of the project, we recruited a volunteer group of 60 citizen scientists who participate in Mapping Change, a crowd-sourced Zooniverse project dedicated to transcription of museum specimen labels that ultimately find a home in the Atlas. In phase II, we will expand the group with training sessions. Volunteers become advocates for the Atlas, promoting its use in outdoor recreation, education, and natural resource management. Second, we will announce the first-ever publication of state agency biodiversity observation records through a University News Service press release in coordination with agency partners. Lastly, we will demonstrate the use of the Atlas to targeted user groups (DNR staff, MPCA staff, natural resource consulting agencies, state colleges and University, K-12 educators) through email announcements and workshop

activities. The launching of the new Bell Museum in Saint Paul has increased public awareness of our state's official museum of natural history. The Atlas compliments our new facility by providing 24-7 access to the collections for virtual visitors across the state.

#### **First Update January 31, 2019**

At the new Bell Museum, the Minnesota Biodiversity Atlas is featured in two exhibit locations. The first is a 72-inch touch screen interactive in the Touch & See Lab that invites visitors to explore the Atlas in real time. Interpretive guides staffing the Lab encourage visitors to use the interactive to search for biodiversity in their favorite Minnesota town, county, or state park. Supporting the kiosk required database developer Tom Prather to improve the web interface. The second location is a Discovery Station in the Tree of Life gallery where visitors are invited to learn about the research of curator Sharon Jansa and the Mapping Change citizen science project that is associated with the Atlas. Visitors get to play a game by transcribing label data from digital images of museum curiosities and are rewarded with a fun fact pulled from the Atlas.

KARE 11 also featured the Atlas in a [segment](#) about the new Bell Museum.

Kameena Anderson, a technical writer for web interface tutorials, joined the Bell Museum volunteer program and assisted us with developing more accessible user guides to the Atlas. During this project period, she completed a guide for our project partners to train them in data entry and data editing. We planned a workshop for Spring 2019 that will acquaint agency partners and the targeted user groups described above with how to use the Atlas in research, education and outreach.

#### **Second Update June 30, 2019**

A second KARE 11 [segment](#) focused on the scientific collections of the Bell Museum, encouraging viewers to explore the Biodiversity Atlas.

#### **Third Update January 1, 2020**

A presentation of the Minnesota Biodiversity Atlas was provided to LCCMR staff and commissioners during a tour of the new Bell Museum. A temporary exhibit at the museum, titled "Wicked Plants", featured the University of Minnesota Herbarium and the Biodiversity Atlas. The exhibit received over 70,000 visitors and was featured in a third KARE11 [segment](#).

#### **Fourth Update June 30, 2020**

In June, Tim Whitfeld offered a master class to 56 Bell Museum members focused on plant collections. Part of the workshop included an introduction to the Biodiversity Atlas. Internal funding from the College of Food, Agricultural and Natural Resource Sciences was awarded for a second annual Biodiversity Atlas training workshop aimed at natural resource professionals. The workshop was postponed due to COVID. Planning is underway to offer a virtual workshop during the academic year. Article in the Minnesota Daily: December 3, 2020 highlighting digitizing activities in the Bell Museum Herbarium related to Biodiversity Atlas

#### **Fifth Update January 1, 2021**

Although the workshop was postponed due to the pandemic, the Atlas played a key role during the pandemic in providing University students with access to virtual specimens and datasets when instructional labs were closed for teaching. For example, students in PMB4321: Minnesota Flora collected data from digital images of specimens with web applications, remotely measuring traits and testing hypotheses as they would have done in labs on campus had it not been closed. Students mapped the geographic distributions of species across the state to investigate habitat requirements. They also measured phenology and gathered evidence for biotic responses to climate warming. We see great potential for use of the Atlas in teaching at all levels from K-12 through to higher education.

#### **Sixth Update June 30, 2021:**

Blog posts on [carnivorous plants](#) and [aquatic plants](#) were released on the Bell Museum website highlighting specimens in the herbarium and records in the Biodiversity Atlas.

**Seventh Update January 31, 2022:**

Nothing to report.

**Final Update June 30, 2022**

During the final phase of the project, the Bell Museum featured the Biodiversity Atlas and scientific collections during an evening program attended by over 300 participants online, celebrating the 150th anniversary of Minnesota’s natural history museum. The virtual event “[A Night in the Museum Collections](#)” was a live webcast on March 23, 2022 hosted by Emily Grasslie, a nationally recognized science communicator.

**V. PROJECT BUDGET SUMMARY:**

**A. Preliminary ENRTF Budget Overview:** See attached budget spreadsheet

**Explanation of Capital Expenditures Greater Than \$5,000:** Two digitization stations for capture of data and images of 35,000 specimens at SMM and 35,000 specimens at UMD. Each station includes a digital SLR camera, a lightbox, and a barcode reader connected to a computer system with image processing software. The computer system is dedicated to image acquisition and processing for the sole purpose of completing the project. (\$5,000 each).

**Explanation of Use of Classified Staff:** NA

**Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation:**

Enter Total Estimated Personnel Hours: 14,600	Divide by 2,080 = TOTAL FTE: 7.0
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**Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:**

Enter Total Estimated Personnel Hours: 1,500	Divide by 2,080 = TOTAL FTE: 0.7
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**B. Other Funds:**

SOURCE OF AND USE OF OTHER FUNDS	Amount Proposed	Amount Spent	Status and Timeframe
<b>Other Non-State \$ To Be Applied To Project During Project Period:</b>			
<b>Other State \$ To Be Applied To Project During Project Period:</b>			
Bell Museum (University of Minnesota): curatorial effort including Barker, Jansa, Kozak, Simons, Weiblen, & Ya at 3% FTE and Grusz (UMD) at 3% for each for three years. Includes 3% base salary per annum plus 36% fringe.	\$ 88,000	\$ 88,000	
University of Minnesota Libraries: management and coordination by J. Nichols at 3% for each of three years and	\$ 31,000	\$ 31,000	

digital preservation services (10TB) at \$6,500 per year.			
<b>Past and Current ENRTF Appropriation:</b>			
Protecting Minnesota's Beneficial Macroalgae: All Stoneworts Aren't Starry	\$ 85,000	\$ 0	Pending through 2024
Integrating Minnesota's biodiversity data: a comprehensive, dynamic atlas	\$ 340,000	\$ 340,000	Completed 2018
Improved Minnesota fungus collection and database	\$ 79,000	\$ 79,000	Completed 2001
A computerized database for plants of Minnesota	\$ 130,000	\$ 130,000	Completed 1993
<b>Other Funding History:</b>			
NSF: Digitization of lichen & bryophyte collections	\$ 50,000	\$ 36,000	Pending through 2022
NSF: Digitization of carnivorous plants, succulents and orchid collections	\$ 27,000	\$ 27,000	Completed 2021
NSF: Digitization of pteridophyte (fern) collections	\$ 37,000	\$37,000	Completed 2020
NSF: Digitization of aquatic invasive species from Bell fish and plant collections	\$ 46,000	\$ 46,000	Completed 2018
NSF: Digitization of Bell microfungi collection	\$ 74,000	\$ 74,000	Completed 2018
NSF: Digitization of Bell macrofungi collection	\$ 105,000	\$ 105,000	Completed 2016
NSF: Digitization of Bell bryophyte collection	\$ 74,000	\$ 74,000	Completed 2015
Hatch, National Institute of Food and Agriculture: Georeferencing of woody plant collection	\$ 30,000	\$ 30,000	Completed 2014

## VI. PROJECT PARTNERS:

### A. Partners receiving ENRTF funding

Name	Title	Affiliation	Role
Michael Milligan	Project Manager	Minnesota Supercomputing Institute	Supervisor of application development and web services
Tom Prather	Developer	Minnesota Supercomputing Institute	Developer of applications and developer Atlas expansion
Katie Noren	Plant Digitization Manager	Bell Museum	Coordinator of multi-institutional digitization

### B. Partners NOT receiving ENRTF funding

Name	Title	Affiliation	Role
George Weiblen	Science Director	Bell Museum	Principal investigator
Keith Barker	Curator	Bell Museum	Co-principal investigator
Sharon Jansa	Curator	Bell Museum	Co-principal investigator
Ken Kozak	Curator	Bell Museum	Co-principal investigator

Ya Yang	Curator	Bell Museum	Co-principal investigator
Andrew Simons	Curator	Bell Museum	Co-principal investigator
Jon Nicols	Librarian	University of Minnesota Libraries	Co-principal investigator
Laurie Fink	Vice President of Science	Science Museum of Minnesota	Co-principal investigator
Amanda Grusz	Professor	University of Minnesota Duluth	Co-principal investigator
Stephen Saupe	Professor	College of Saint Benedict/Saint John's University	Co-principal investigator
Matthew Kaproth	Professor	Mankato State University	Co-principal investigator
Bruce Carlson	Minnesota Biological Survey Supervisor	Minnesota Department of Natural Resources	Collaborator & data provider
Hannah Texler	Plant Survey Supervisor	Minnesota Department of Natural Resources	Collaborator & data provider
Michael Bourdaghs	Environmental Research Scientist	Minnesota Pollution Control Agency	Collaborator & data provider
John Sandberg	Environmental Research Scientist	Minnesota Pollution Control Agency	Collaborator & data provider

#### VII. LONG-TERM- IMPLEMENTATION AND FUNDING:

Expansion of the Minnesota Biodiversity Atlas will be of immediate, practical use to a diverse community of managers and scientists including field workers, ecologists, conservation planners, and policy-makers, as described above. The Bell Museum and the Minnesota Supercomputing Institute are committed to long-term maintenance of this tool as part of ongoing, collaborative relationships with statewide academic institutions, museums, and agency partners. We are supported in this effort by the UMN Libraries, who will host the image data from this project according to archival standards. Outcomes from this LCCMR-funded work will leverage federal grant proposals to the US National Science Foundation for improving knowledge, management and use of Minnesota's biodiversity.

#### VIII. REPORTING REQUIREMENTS:

- The project is for 4 years, will begin on 07/01/2018, and end on 06/30/2022.
- Periodic project status update reports will be submitted 01/31 and 06/30 of each year.
- A final report and associated products will be submitted between June 30 and August 15, 2022.

#### IX. SEE ADDITIONAL WORK PLAN COMPONENTS:

- A. Budget Spreadsheet
- B. Visual Component or Map
- C. Parcel List Spreadsheet NA
- D. Acquisition, Easements, and Restoration Requirements NA
- E. Research Addendum NA

**Attachment A:  
Environment and Natural Resources Trust Fund  
M.L. 2018 Budget Spreadsheet**



**Project Title:** Minnesota Biodiversity Atlas - Phase 2  
**Legal Citation:** M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 03c  
**Project Manager:** George Weiblen  
**Organization:** University of Minnesota  
**College/Department/Division:** CFANS-Bell Museum  
**M.L. 2018 ENRTF Appropriation:**  
**Project Length and Completion Date:** 4 years/ June 30, 2022  
**Date of Report:** June 30, 2022

<b>ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET</b>	<b>Budget</b>	<b>Amount Spent</b>	<b>Balance</b>
<b>BUDGET ITEM</b>			
<b>Personnel (Wages and Benefits) - Overall</b>	\$328,000	\$328,000	\$0
<i>Atlas development supervisor (75% salary, 25% fringe) 5% FTE for</i>			
<i>Atlas developer (75% salary, 25% fringe) 10% FTE for 3 years</i>			
<i>Digitization manager (67% salary, 33% fringe) 90% FTE for years 1</i>			
<i>Digitization leader (73% salary, 27% fringe) 15% FTE for year 3</i>			
<i>(Total: 15 FTE) (Total estimated amount - \$16,000)</i>			
<i>Undergraduate student digitizers (UMN interns at SMM)</i>			
<i>Graduate student digitizer s for year 3 (UMD) (Total estimated</i>			
<i>Science Museum of Minnesota digitization manager (59% salary,</i>			
<i>University of Minnesota-Duluth digitization manager (79% salary,</i>			
<b>Professional/Technical/Service Contracts</b>	\$10,000	\$10,000	\$0
<i>Data hosting at MSI (3TB/year at \$750/year) (Total estimated</i>			
<i>Server support at MSI (\$2,600/year)(Total estimated amount</i>			
<b>Equipment/Tools/Supplies</b>			
<i>140,000 specimen barcode labels (50,000 SMM; 10,000 MANK;</i>	\$1,000	\$1,000	\$0
<b>Capital Expenditures Over \$5,000</b>			
<i>Two digitization stations for capture of data and images of 35,000</i>	\$10,000	\$10,000	\$0
<b>Other</b>			
<i>specimen shipping costs (MANK and CSB/SJU to UMN and return)</i>	\$1,000	\$1,000	\$0
<b>COLUMN TOTAL</b>	<b>\$350,000</b>	<b>\$350,000</b>	<b>\$0</b>

