

# Final Abstract

Final Report Approved on November 27, 2024

## M.L. 2020 Project Abstract

For the Period Ending June 30, 2025

**Project Title:** Improving Pollinator Conservation By Revealing Habitat Needs

**Project Manager:** Colleen Satyshur

**Affiliation:** U of MN - College of Biological Sciences

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**Funding Source:**

**Fiscal Year:**

**Legal Citation:** M.L. 2021, First Special Session, Chp. 6, Art. 5, Sec. 2, Subd. 03g

**Appropriation Amount:** \$500,000

**Amount Spent:** \$466,236

**Amount Remaining:** \$33,764

### Sound bite of Project Outcomes and Results

Our wild bees need nests to grow and overwinter, yet plants used in nest construction remain poorly understood. Alongside volunteers from all ecological sections of Minnesota, we gathered plant matter from bee nests for novel analysis by spectrometry (resins) or genetic sequencing (leaves) to identify the plants these pollinators use.

### Overall Project Outcome and Results

Wild bees rely on nests to protect their developing young and survive Minnesota winters. Many bee species use plant materials such as resin and leaves to construct the internal structures of their nests. The plants from which bees harvest this material are an integral part of bee habitat but remain largely unknown as the material in nests is in small pieces and not identifiable by sight. To better understand bee nest habitat, we worked with 125 volunteers from 50 counties all around Minnesota to put out 200+ nest-traps. These traps allowed us to sample nest plant material from 150+ bee nests for which we conducted GC-MS analysis of resins or DNA sequencing of leaves to determine the plant species the material came from. We identified >2000 bees from 4000+ specimens. A total of 25 bee species nested in the traps, with the most common being: *Osmia lignaria*, *Heriades carinata*, *Osmia albiventris*, *Osmia tersula*, *Megachile campanulae* and

Megachile relativa. Based on our analysis, a variety of conifer resins were used most frequently in resin bee nests, including pines, spruces, tamarack and cedar species. However, some bees also used resins from Populus trees, such as cottonwood and quaking aspen. DNA sequencing of leaf material so far highlights that bees often used plants in the Rosa genus. Other plants identified include: raspberries/blackberries, strawberries, bitternut hickory, white goosefoot, black bindweed, ironweed, staghorn sumac and in one location, buckthorn. As results of further analysis and continued identifications become available, we will post them on our improved website, [minnesotabeeatlas.umn.edu](http://minnesotabeeatlas.umn.edu). Through this project, we gained valuable new information about plants that make up an important part of the habitat needs of Minnesota bee species, with the aim that this information can be used by agencies and landowners to improve management for bee habitat.

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

We maintained a facebook page, regularly posting about native bees and bee habitat. We also substantially improved our website, now at [minnesotabeeatlas.umn.edu](http://minnesotabeeatlas.umn.edu), including results pages and an updated species guide with photos and information from MN Bee Atlas 2016-2023. Specimen information is available through the Minnesota Biodiversity Atlas, and vouchers are at the UMN Insect Collection. We reported results to local agencies that hosted traps, conducted 11 training sessions, ten talks, tabled four events, and were featured on KAXE in northern Minnesota. We anticipate peer reviewed publications once analyses are completed. Results will contribute to a PhD dissertation.



## Environment and Natural Resources Trust Fund

M.L. 2020 Approved Final Report

### General Information

**Date:** December 11, 2024

**ID Number:** 2020-032

**Staff Lead:** Noah Fribley

**Project Title:** Improving Pollinator Conservation By Revealing Habitat Needs

**Project Budget:** \$500,000

### Project Manager Information

**Name:** Colleen Satyshur

**Organization:** U of MN - College of Biological Sciences

**Office Telephone:** (612) 625-3761

**Email:** csatyshu@umn.edu

**Web Address:** <https://cbs.umn.edu/>

### Project Reporting

**Final Report Approved:** November 27, 2024

**Reporting Status:** Project Completed

**Date of Last Action:** November 27, 2024

**Project Completion:** July 31, 2024

### Legal Information

**Legal Citation:** M.L. 2021, First Special Session, Chp. 6, Art. 5, Sec. 2, Subd. 03g

**Appropriation Language:** \$500,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to use citizen scientists and novel analyses to determine the nesting and overwintering needs of wild bees to allow more specific protection and enhancement of pollinator habitat across the state.

**Appropriation End Date:** June 30, 2024

## Narrative

**Project Summary:** Wild pollinators must survive outdoors during our harsh Minnesota winters. We aim to help them persist by discovering habitats they require for shelter through statewide citizen scientists and novel analyses.

**Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.**

Pollinators have two main needs -- food and shelter. The overall goal of this project is to understand the largely unknown needs that wild bee pollinators have for shelter. Efforts to protect pollinators have properly focused on which flower species provide their food. But to effectively help pollinators persist we also must preserve the species of plants they need for nesting and overwintering. Small, solitary, and secluded wild bee nests are hard to find and difficult to study, resulting in the current lack of foundational data. Our native bees survive the winter inside their nests, which are often built with plant materials the bees have chewed up and compacted. This plant material is integral to nests, but what plant species are used is unrecognizable by sight. We have the opportunity to conduct a large scale project building off recent working relationships with citizen scientists corps, Three Rivers Parks District, MN Master Naturalists, SNA and other networks, in order to reveal the plants bees use in their nests and allow more specific protection and enhancement of bee pollinator habitat across the state.

**What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.**

Our innovative approach takes advantage of a fortuitous convergence of projects. Using the platform of the successful ENRTF project "Minnesota Native Bee Atlas" M.L. 2015, Chp. 76, Sec. 2, Subd. 03g and leveraging DNA sequencing methods developed in the University of Minnesota Future's grant "The Art and Science of Nesting Bees," we will deploy nest-traps statewide through a citizen science volunteer base built during the Minnesota Bee Atlas. Nest-traps are a widely used method for studying the numerous wild bee species that nest in dead wood and stems. Bees will bring outside plant matter into the traps to build nests, which we will collect and rear to adulthood for bee species identification. Plant matter in traps will be identified by applying Next Generation genetic sequencing and molecular techniques. Because bees only nest in spring and summer and do not reach adulthood until the following spring or summer, we are asking for a three-year grant. That would allow one complete bee nesting and sequencing cycle. However, we anticipate being able to process a supplemental nest trap cycle with fewer bees in the final fiscal year, allowing for two years of data in the three-year timeline.

**What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?**

The identities of plants used for nesting and overwintering shelters, paired with bee species, will be made available to land managers and citizens through the UMN Extension, UMN Bee Lab and, through scientific articles. Our statewide bee species data will be maintained by the Minnesota Biodiversity Atlas hosted and accessible through the Bell Museum and added to data compiled through the ENRTF Minnesota Bee Atlas project. In addition, citizen volunteers across the state will be trained in our methods and receive our latest information on how they can help bees in their area.

## Project Location

**What is the best scale for describing where your work will take place?**

Statewide

**What is the best scale to describe the area impacted by your work?**

Statewide

**When will the work impact occur?**

During the Project

## Activities and Milestones

### Activity 1: Development and deployment of nest traps, volunteer recruitment.

**Activity Budget:** \$230,000

#### Activity Description:

We will recruit volunteers from all around Minnesota, through the successful Minnesota Bee Atlas corps, as well as Master Naturalist, and other programs. Volunteers will be trained in our field methods and will each be given a nest trap to hang at their site. In the first spring we will send out standard economical nest traps as used in the Minnesota Bee Atlas from which we can obtain some nest materials. A small subset of traps, up to 16, will be designed or acquired to facilitate greater in-nest plant matter collection. This easy-open subset will be placed in select locations projected to return especially high quality results, while the project as a whole will continue to seek bee populations in semi-natural sites. We will update current Minnesota Bee Atlas websites to continue to receive volunteer seasonal observations, track nests and disseminate results. In the second spring we will send out a smaller supplemental round of nest traps within the scope of what can be reared and identified before the grant end date.

#### Activity Milestones:

Description	Approximate Completion Date
Standard economical and easy-open nest traps built or acquired, website prepared, volunteer manual written	February 28, 2022
Volunteers recruited and trained, nest traps deployed	April 30, 2022
Standard and easy-open traps returned for rearing and nest plant matter collection	November 30, 2022
Bonus nest traps built and deployed	April 30, 2023
Bonus nest traps returned and nest plant matter collected	November 30, 2023

### Activity 2: Nest rearing and material analysis

**Activity Budget:** \$270,000

#### Activity Description:

Nests will be reared to identify bee species. Leaf plant matter will be collected from as many bee nests as possible in the standard traps, as well as from nests in the easy-open traps. We anticipate up to 100 nests in the main trapping year and 15-20 bonus nests the following year. DNA will be extracted from leaf samples, and submitted for amplification and sequencing preparation of 2-3 gene regions through the services of the UMN Microbiome Institute. Sequencing will be done using Next Generation technologies, such as Illumina, through the UMN Genomics Center. We will match the resulting sequence data to existing plant databases or reference samples to obtain plant identification. A subset of samples will receive advanced sequencing of longer strings of DNA for more full genome type analysis which should allow for more detailed identification results. Resin will be collected from up to 10 additional bee nests traps and resin fingerprinting and identification will be accomplished using gas or liquid chromatography-mass spectrometry. Resin analysis requires a reference collection, so this includes driving to up to 10 sites to nondestructively collect tree resin reference samples.

#### Activity Milestones:

Description	Approximate Completion Date
Nest plant matter samples collected from main trapping season. 80 leaf, 8 resin	February 28, 2023
Bees nests reared to adulthood in lab, from main trapping season	May 31, 2023
Nest matter samples from main trapping season receive analyses	October 31, 2023
Nest plant matter samples collected from supplemental trapping season. leaf: 15-20/year	December 31, 2023

Bees emerging from nests from main trapping season will be identified to species	December 31, 2023
Bees nests from supplemental trapping season reared to adulthood in lab.	May 31, 2024
Nest matter samples from supplemental trapping season receive analyses	May 31, 2024
Bees emerging from nests from supplemental trapping season will be identified to species	June 30, 2024
Final results prepared; database contributions complete	June 30, 2024

## Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Britt Forsberg	University of Minnesota-Extension	Britt Forsberg, current project coordinator and outreach specialist of MN Bee Atlas working in UMN Extension. She will contribute her expertise in this area either as project personnel or in an advisory role.	Yes
Dr. Rob Blair	University of Minnesota	will provide advice on citizen science and bee science as needed	No
Dr. Marla Spivak	University of Minnesota	will provide advice on citizen science and bee science as needed and the MN Bee Lab will provide lab space for molecular work.	No
Dr. Clarence Lehman	University of Minnesota	will provide advice and assistance on data management and archiving and provide laboratory bench and nest rearing space in the Ecology building.	Yes
Dr. Declan Schroeder	University of Minnesota	will provide molecular methods and bioinformatics expertise and analysis assistance.	Yes
Dr. Jerry Cohen	University of Minnesota	will provide resin analysis methods and expertise, lab space for resin work and access to equipment.	No
Thea Evans	University of Minnesota	Thea can be hired as project coordinator based on her work on the MN Bee Atlas and outreach background	Yes

## Dissemination

**Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.**

Dissemination of information developed during the project will occur through the following outlets: 1) The identities of plants used for bee nesting and overwintering shelters, paired with bee species, will be made available to land managers and citizens through the UMN Extension and UMN Bee Lab, for example, under the “Learn More” tab (on <https://www.beelab.umn.edu/>). 2) Bee species distributions will be made available through the digital portal for the Minnesota Bee Atlas under the “Species Guide” (eg on <https://apps.extension.umn.edu/environment/citizen-science/bee-atlas/bee-blocks/>), as well as the MN Biodiversity Atlas (<https://bellatlas.umn.edu>), adding to existing data compiled through the ENRTF MN Bee Atlas project and curated by and accessible through the Bell Museum. 3) We will distribute information to volunteers through print and web materials and face-to-face workshops. 4) DNA sequence data will be contributed to appropriate online databases and bee specimens will be contributed to the UMN Insect Collection. The Minnesota Environment and Natural Resources Trust Fund (ENRTF) will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications per the ENRTF Acknowledgement Guidelines.

## Long-Term Implementation and Funding

**Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?**

The long-term strategy for the project is to discover what plants and habitats bees use for shelter and provide this data in open-access form so that land managers and citizens can apply it in the conservation of Minnesota’s wild bees. Plant identification data will be maintained through the UMN Bee Lab and sequence data archived in an appropriate open access database. Bee specimens will be deposited for long term curation in UMN Insect collection, and bee species data will be added to the Biodiversity Atlas housed at the Bell Museum.

## Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount	\$ Amount Spent	\$ Amount Remaining
<b>Personnel</b>										
Principal Investigator		overall project coordination, bee rearing and ID, nest plant matter collection and basic laboratory work on molecular components, analysis of results, development of dissemination materials			26.74%	2.25		\$158,023	-	-
Citizen Science Coordinator		Coordination of citizen science outreach and logistics components. Including necessary bee rearing and archiving work, as well as development of dissemination material			24.13%	2.4		\$148,398	-	-
Lab assistant		assist with bee nest rearing and archiving, including: pinning, data entry. Assist with basic bee nest materials analysis, such as initial DNA extraction in preparation for sequencing on vegetation samples, plant resin database creation, travel to collect and ID vegetation/resin			24.13%	2.25		\$45,583	-	-
Databasing and Archiving Assistance		Assist with genetic databasing			26.74%	0.03		\$3,855	-	-
Molecular DNA sequencing and bioinformatics assistance		Provide high level sequencing and bioinformatics analysis assistance.			26.74%	0.06		\$35,345	-	-
undergraduate worker		Assist with molecular lab work and/or with bee rearing and pinning. May include travel to field sites for nest or sample collection			0%	0.06		\$9,500	-	-
Post doc resin/DNA sequencing		advanced laboratory processing and bioinformatics analysis. This analysis is needed in order for main project			20.25%	0.12		\$15,296	-	-



		staff to perform more project functions instead of using existing expertise such as from the UM Genomics Center								
							<b>Sub Total</b>	<b>\$416,000</b>	<b>\$391,285</b>	<b>\$24,715</b>
<b>Contracts and Services</b>										
Witty Web Design	Professional or Technical Service Contract	Citizen science web site maintenance and updates as needed. Witty Web Design was picked competitively for building the Minnesota Bee Atlas web site. Our work will build on the existing website instead of starting over.				0		\$8,200	\$7,760	\$440
Bioinformatics analyst	Professional or Technical Service Contract	Bioinformatics analysis for resin or DNA sequences. Pay rate approximately equivalent to post doc level work at UMN but allows access greater expertise in some analysis which exists outside the UMN.				0		-	-	-
Plant metabolomics	Professional or Technical Service Contract	Analysis by Mass Spectrometer for identification of resin samples to determine plant species used by nesting bees.		X		0		\$10,000	\$6,120	\$3,880
							<b>Sub Total</b>	<b>\$18,200</b>	<b>\$13,880</b>	<b>\$4,320</b>
<b>Equipment, Tools, and Supplies</b>										
	Tools and Supplies	Trap nesting blocks with signs and postage. ~100 blocks of standard economic design. ~16 blocks of modified design that allows them to be opened more easily.	Nests will attract native bees, modified design will allow for easier sampling. Postage is most efficient way to deliver nests to dispersed sites around the whole state	X				\$7,200	\$6,480	\$720
	Tools and Supplies	Rearing supplies including collection tubes, glue, containment bags, insect cabinet for permanent storage, pins, bags, tubes, glue, label paper	to rear nests, collect, identify and archive adult bees, collect nest vegetation samples					\$16,600	\$15,803	\$797

	Tools and Supplies	Molecular lab supplies including vials, tubes, bead-beater beads, pipettes and tips, reagents, and primers.	Supplies for vegetation and resin sample acquisition and preparation and initial DNA extraction. Some sequencing can be done by project personnel at \$150/sample so this also covers reagents needed for that work on approximately 75 samples					\$17,800	\$17,498	\$302
	Tools and Supplies	Outreach and educational supplies	necessary materials for volunteers to participate					\$900	\$883	\$17
	Equipment	laptop computer	This would be an instrument for data management and bioinformatics analysis. Also streamlines feasibility of supply purchasing, communication with volunteers including training, developing project reports and disseminating information.	X				\$2,300	\$2,300	-
							<b>Sub Total</b>	<b>\$44,800</b>	<b>\$42,964</b>	<b>\$1,836</b>
<b>Capital Expenditures</b>										
							<b>Sub Total</b>	-	-	-
<b>Acquisitions and Stewardship</b>										
							<b>Sub Total</b>	-	-	-
<b>Travel In Minnesota</b>										
	Miles/ Meals/ Lodging	Travel expenses including hotel, mileage or vehicle rental	Travel to deliver or retrieve nest traps, conduct volunteer training (1/year), attend conferences with study results, collect resin from 10 sites for resin tree ID, mileage or small vehicle					\$3,000	\$2,695	\$305

			rental from UMN Fleet Services s months/year							
							<b>Sub Total</b>	<b>\$3,000</b>	<b>\$2,695</b>	<b>\$305</b>
<b>Travel Outside Minnesota</b>										
							<b>Sub Total</b>	-	-	-
<b>Printing and Publication</b>										
	Printing	volunteer manuals and other materials	printed supplies so volunteers can participate					\$1,000	\$464	\$536
							<b>Sub Total</b>	<b>\$1,000</b>	<b>\$464</b>	<b>\$536</b>
<b>Other Expenses</b>										
		University of Minnesota Genomic Center	cost of expert labor to sequence 2-3 specific necessary gene regions of vegetation samples using specialized equipment such as for Illumina sequencing					\$17,000	\$14,948	\$2,052
							<b>Sub Total</b>	<b>\$17,000</b>	<b>\$14,948</b>	<b>\$2,052</b>
							<b>Grand Total</b>	<b>\$500,000</b>	<b>\$466,236</b>	<b>\$33,764</b>

## Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
<b>Contracts and Services</b> - Plant metabolomics	Professional or Technical Service Contract	Analysis by Mass Spectrometer for identification of resin samples to determine plant species used by nesting bees.	Dr. Vassya Bankova of the Institute of Organic Chemistry in Sofia, Bulgaria is a world expert in identification of resin used by honeybees and has refined experience with resin identification by mass spectrometry. Her participation will provide a degree of expertise that isn't available in Minnesota and bring in identification of resins used by Minnesota bees in their nesting habitats.
<b>Equipment, Tools, and Supplies</b>		Trap nesting blocks with signs and postage. ~100 blocks of standard economic design. ~16 blocks of modified design that allows them to be opened more easily.	In order to reach a statewide corps of citizen science volunteers in all parts of the state, and allow them to feasibly return nest-traps to the University of Minnesota, it is occasionally necessary to mail nest-traps, rather than arrange for in-person drop-off or pick-ups. In this case we want to pay for postage and not ask volunteers to take on this expense. Mailing can also provide budget savings over mileage costs that would be accrued if project personnel drove to each volunteers site.
<b>Equipment, Tools, and Supplies</b>		laptop computer	This would be an instrument for the project coordinator to do their job, currently none is available for the purpose. It would support the core responsibilities of the project manager position such supporting planning and data management documents, purchasing, communication with volunteers including training, and for running bioinformatics analysis and developing reports and disseminating information. The portability of a laptop is needed to allow the project coordinator to work while conducting fieldwork or travel to train volunteers. This price reflects an approximate mid-range Mac laptop as available for purchase from UMN IT services. Mac is compatible with the other computers already available for this project.

## Non ENRTF Funds

Category	Specific Source	Use	Status	\$ Amount	\$ Amount Spent	\$ Amount Remaining
<b>State</b>						
In-Kind	INDIRECT - 55% MTDC	Indirect costs associated with this proposal at 55% MTDC	Secured	\$271,150	\$256,429	\$14,721
In-Kind	UMN Dr. Jerry Cohen - 1% FTE for 3 years (\$6,900)	UMN Dr. Jerry Cohen - 1% FTE for 3 years (\$6,900) From assistance on resin analysis.	Pending	\$6,900	\$6,900	-
			<b>State Sub Total</b>	<b>\$278,050</b>	<b>\$263,329</b>	<b>\$14,721</b>
<b>Non-State</b>						
			<b>Non State Sub Total</b>	-	-	-
			<b>Funds Total</b>	<b>\$278,050</b>	<b>\$263,329</b>	<b>\$14,721</b>

## Attachments

### Required Attachments

#### *Visual Component*

File: [f4bc8283-c55.pdf](#)

#### *Alternate Text for Visual Component*

Graphic showing the components of bee habitat: food resources, nesting substrate, and the largely unknown nest building materials, and the process by which statewide volunteers will result in identification of nesting materials...

### Supplemental Attachments

#### *Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other*

Title	File
Background check certification form	<a href="#">750fa979-262.pdf</a>
Supplemental 2: updated website	<a href="#">0292ec15-c64.pdf</a>
Supplemental 3: bee nest resin and leaf sampling	<a href="#">7cf3c66a-6a7.pdf</a>
Supplemental 1: Volunteer locations across MN and bees reared	<a href="#">f218400d-404.pdf</a>
Supplemental 4: parasite poster	<a href="#">327751fa-d1a.pdf</a>

#### *Media Links*

Title	Link
Minnesota Bee Atlas Updated Website	<a href="https://minnesotabeeatlas.umn.edu">https://minnesotabeeatlas.umn.edu</a>

## Difference between Proposal and Work Plan

### *Describe changes from Proposal to Work Plan Stage*

First we adjusted the work plan to accommodate the year gap between the Minnesota Bee Atlas project and funding. This was accomplished by moving the supplemental nest trapping year to the last year of the project instead of the first. We also adapt staff appointments to account for transitions to or from other projects.

Second, we were able to accomplish the project goals within the recommended reduced level of funding by four adjustments. First, we reduced the percentage of time of staff appointments. Second, to accommodate reduced staff time in the new budget, we scaled back the workload by, for example, reducing the number of nests and samples and switching to more economical but less easily opened nest block design. Third, we shifted some of the molecular work to project staff and consequently added short periods of analysis and bioinformatics from experts. Fourth, we opted for a more basic DNA sequencing service from the UMN Genomics Center for part of the samples. This service is more economical, assuming no unexpected troubleshooting fees are necessary. The DNA sequence data returned from the basic service should still be sufficient to meet project goals of nest plant identification, especially when paired with advanced long-region sequencing for some samples. These four accommodations will allow us to successfully fulfill the important original goals of the project.

## Additional Acknowledgements and Conditions:

The following are acknowledgements and conditions beyond those already included in the above workplan:

**Do you understand and acknowledge the ENRTF repayment requirements if the use of capital equipment changes?**

N/A

**Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?**

Yes, I understand the UMN Policy on travel applies.

**Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?**

No

**Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?**

N/A

**Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?**

N/A

**Does your project include original, hypothesis-driven research?**

Yes

**Does the organization have a fiscal agent for this project?**

Yes, Sponsored Projects Administration

## Work Plan Amendments

Amendment ID	Request Type	Changes made on the following pages	Explanation & justification for Amendment Request (word limit 75)	Date Submitted	Approved	Date of LCCMR Action
1	Amendment Request	<ul style="list-style-type: none"> <li>• Budget - Other</li> <li>• Activities and Milestones</li> <li>• Budget - Professional / Technical Contracts</li> </ul>	Our original choice is no longer able to do the work. Instead Dr. Vassya Bankova (Institute of Organic Chemistry, Sofia, Bulgaria) can do it at competitive rates. She's a world expert in honeybee resin identification by mass spectrometry. She provides a degree of expertise that isn't available in Minnesota and helps future work in Minnesota by returning information on our bee's habitats. Dollar amount, goals and expected outcomes are unchanged.	January 6, 2023	Yes	January 9, 2023
2	Amendment Request	<ul style="list-style-type: none"> <li>• Other</li> <li>• Budget - Personnel</li> <li>• Budget - Professional / Technical Contracts</li> <li>• Budget - Capital, Equipment, Tools, and Supplies</li> <li>• Budget - Travel and Conferences</li> <li>• Budget - Other</li> </ul>	We need more manpower to complete project goals in the short time before the project end date and we did not need to travel to so many resin collecting sites as anticipated. More DNA work was done by collaborators so they need the money rather than the Microbiome Institute. We believe we can do bioinformatics among personnel rather than by an outside contract. Dr Bankova can do more samples. Goals and expected outcomes unchanged.	February 15, 2024	Yes	April 1, 2024
3	Amendment Request	<ul style="list-style-type: none"> <li>• Budget</li> <li>• Other</li> <li>• Budget - Personnel</li> <li>• Budget - Professional / Technical Contracts</li> <li>• Budget - Capital, Equipment, Tools, and Supplies</li> <li>• Budget - Other</li> </ul>	We ask to shift funds between personnel categories to match the people available to do the work. We have greater need for rearing supplies given unanticipated late emergence of bees this spring and would like to shift funds within the equipment category and some from the contracts and services so that we can complete that work.	June 24, 2024	Yes	June 24, 2024



4	Completion Date	Previous Completion Date: 06/30/2024 New Completion Date: 08/31/2024	Extra time to complete data analysis	June 24, 2024	Yes	June 24, 2024
5	Completion Date	Previous Completion Date: 08/31/2024 New Completion Date: 07/31/2024	Extra time needed for data analysis	June 24, 2024	Yes	June 24, 2024

# Status Update Reporting

## Final Status Update September 14, 2024

**Date Submitted:** September 13, 2024

**Date Approved:** October 4, 2024

### Overall Update

Throughout this grant, we worked with 125 volunteers (90 in 2022, 30 in 2023 +22 4H youth) from 50 counties across all ecological sections of Minnesota to put out 190+ nest-traps and 23 nest bundles. We identified >2000 bees from 4000+ total specimens. We found 25 bee species across Minnesota, with the most commonly observed being: *Osmia lignaria*, *Heriades carinata*, *Osmia albiventris*, *Osmia tersula*, *Megachile campanula* and *Megachile relativa*. From nest material experiments, we harvested resin and leaves from 150+ bee nests, for which GCMS (resins) or DNA sequencing (leaves) was used to identify the species of origin. While conifer resins appear more commonly in nests, bees also used *Populus* resin. Sequencing analysis so far highlights that bees often used plants in the *Rosa* genus, as well as buckthorn, raspberries/blackberries, bitternut hickory, white goosefoot, black bindweed, ironweed, staghorn sumac and strawberries. We updated the project webpage, now at [minnesotabeeatlas@umn.edu](mailto:minnesotabeeatlas@umn.edu), to make the bee species guide more accessible to volunteers and the public and display results. Overall, we conducted 11 training sessions (100 participants), gave 10 talks (audience ~500), tabled 4 events (attendance of several thousand), and were featured in a radio program on KAXE in northern Minnesota.

### Activity 1

Overall, we worked with 125 total volunteers (90 in 2022, 30 in 2023 +22 4H youth) from 50 counties across all ecological sections of Minnesota to put out 190+ nest traps and 23 nest bundles (Supplemental 1). While this activity was essentially completed by fall 2023, we continued to stay in contact with volunteers, providing email and facebook updates. As results from DNA and resin analysis have arrived, we have communicated with volunteers about the trees and plants growing near their nest traps, to confirm our lab results with what is growing nearby. Over the last six months, we have also made major updates to the project web page to make the bee and wasp species guide more accessible to volunteers and the public (Supplemental 2). The new bee atlas website is at [minnesotabeeatlas@umn.edu](http://minnesotabeeatlas@umn.edu). Prior project work was archived, and ongoing work has pages where updates and results can be posted. We retained the same volunteer login portal and databases, but made the species guide easier to locate and updated photos and information, and improved the overall look and viewability. This improved website will be a useful venue for communicating our project results with the public.

*(This activity marked as complete as of this status update)*

### Activity 2

Our second field season yielded 1451 specimens (801 bees, 210 nests) from 71 traps. Across all years, we identified >2000 bees from 4000+ total specimens in 50 Minnesota counties. Specimens are labeled and permanently stored in the UMN Insect Collection or Lab 530, Ecology building. We uploaded specimen data to our website for volunteers to view, and submitted it to the Minnesota Biodiversity Atlas. Distribution maps in the species guide on our new website: [minnesotabeeatlas.umn.edu](http://minnesotabeeatlas.umn.edu) contain data from all project years. We observed 25 bee species across Minnesota, with the most common being: *Osmia lignaria*, *Heriades carinata*, *Osmia albiventris*, *Osmia tersula*, *Megachile campanula* and *Megachile relativa* (Supplemental 1). From nest material experiments, we harvested resin and leaf material from 150+ bee nests, for which GCMS (resins) or DNA sequencing (leaves) was used to identify the species of origin. While conifer resins appear more commonly in nests, bees also used poplar species. Sequencing analysis so far highlights that bees often used plants in the *Rosa* genus, as well as buckthorn, raspberries/blackberries, bitternut hickory, white goosefoot, black bindweed, ironweed, staghorn sumac and strawberries (Supplemental 3). We expect a peer-reviewed manuscript

to summarize these final results once analyses are complete.

*(This activity marked as complete as of this status update)*

### **Dissemination**

Throughout the project, we maintained a facebook page, with regular updates, information about bees, nesting habitat and pollinator plantings. To facilitate sharing project results with both volunteers and the public, we made major improvements to our website, now at [minnesotabeeatlas.umn.edu](http://minnesotabeeatlas.umn.edu). It also features an updated species guide with photos, biological information, and distribution of 2016-2023 MN Bee Atlas records. Specimen information is publicly available through the Bell Museum Biodiversity Atlas. Voucher specimens are available for other researchers to examine at the UMN Insect Collection. We reported to local agencies on traps in state and county parks, SNAs, and Nature Conservancy lands. Overall, we conducted 11 training sessions (100 participants), gave ten talks (audience ~500), tabled at four events (attendance= several thousand), and were featured in a radio program on KAXE in northern Minnesota. We had 125 volunteers from 50 Minnesota counties. We trained six undergraduates, three technicians and a high school student on wild bee research. One undergraduate continued on working with Chrysidid bee parasites with a professor for credit and future publication (Supplemental 4). We anticipate peer reviewed publications, which we will send, once analyses are completed and results will contribute to Colleen Satyshur's PhD dissertation.

# Additional Status Update Reporting

## Additional Status Update August 14, 2024

**Date Submitted:** September 13, 2024

**Date Approved:** October 4, 2024

### **Overall Update**

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### **Activity 1**

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### **Activity 2**

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### **Dissemination**

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# Status Update Reporting

## Status Update January 1, 2024

**Date Submitted:** January 15, 2024

**Date Approved:** January 31, 2024

### Overall Update

Activities in the past 6 months focused on identification of bees from the main trapping season, completion of behavioral resin choice experiment to aid in the resin part of the project, the return of bonus traps for rearing, and the completion of the plant DNA extraction with sequencing by Declan Schroeder. Volunteers and project staff and advisors tested a larval sampling method that we hope will provide backup for adult rearing and allow nest traps to be used for monitoring while preserving local bee populations. Plant data analysis is ongoing. Bonus nest traps from the 2023 season are in cold storage and will be reared this spring.

### Activity 1

Volunteers returned nest traps to our lab in October and November 2023. Of the 62 bonus trap nests that were sent to volunteers, all traps were hung and 60 traps were returned. Vegetation samples will be collected from 10-15 nests in January 2024. Because no adults emerged from some of the 2022 nests, a few nests don't have a pairing of bee species to plant species. However, we preserved larvae from some nests and anticipate testing DNA barcoding of larvae to obtain bee species. With the possibility of failure of adults in mind and with the idea of finding less lethal methods of studying bees, we collected larvae from bonus traps. We involved volunteers in the process, conducting online training with 20 volunteers. 4-H stem bundle nest traps were returned in October and November, and a wrap-up meeting was held with 4-H staff and youth volunteers at the end of October. All nest traps are now being held in cold storage in preparation for rearing in March 2024.

### Activity 2

Pinning of bees from the main trapping season (2022) is complete. Of the ~1300 adult bees that emerged, approximately 88% have been identified to date. DNA extraction from leaf material from the main trapping season is complete. Plant material from 87 nests was collected, 86 extracted, 69 of which also produced adults from 9 bee species. Plant identification from sequencing is in progress.

We have not yet received further chemometry of the conifer resin in nests from Dr. Bankova as her colleague who was to do the analysis needed surgery during this period.

We completed the resin choice observation experiment in July and August. Data analysis is underway. Results from this observational experiment will complement resin analysis from nests to provide additional insight into solitary bee resin preference.

As mentioned above, we are looking to get bee species ID for nests without adults by DNA barcoding of larva. Additional larva from bonus traps will also be used. Larvae are being held in -20 freezer in preparation for DNA extraction and barcoding by the UMN Microbiome Institute. A reference barcode collection from adult bees with known identification will be created to support and verify larval barcoding.

### Dissemination

Project staff presented 3 online training sessions for volunteers who tested a larvae sampling method and also held 14 hours of online office hours in early October for volunteers to use if they wanted extra coaching during block opening and sampling. Project staff held a wrap-up meeting with 4-H staff and youth volunteers in October. In November, we published a journal article in PeerJ that summarizes MN Bee Atlas findings from the previous LCCMR grant from 2016-

2020, and shared the publication with all volunteers by email and on our facebook page. Addition of bee identifications from the first trapping season to the website volunteer portal and species guide is planned for January.

# Status Update Reporting

## Status Update July 1, 2023

**Date Submitted:** June 30, 2023

**Date Approved:** August 9, 2023

### Overall Update

Activities in the last 6 months have focused on getting samples of resin and leaf material from bee nests in blocks that volunteers monitored all around the state, rearing, pinning, and identifying the bees from those nests, and setting up a resin choice experiment on campus. We started DNA extraction from leaf samples, working with Dr. Declan Schroeder, and received preliminary results from the first round of resin samples that we sent to Dr. Bankova.

### Activity 1

Bonus easy-open nest traps were sent to 30 volunteers this spring, most of whom were volunteers the previous season. We also reached out to 4-H educators and sent nest traps made from plant stems to 22 youth who are participating in the 4-H Pollinator Ambassador program. The website was updated to allow for stem bundle data entry by 4-H youth volunteers.

### Activity 2

We reared 1258 bees from the first trapping season to adulthood this spring and have begun pinning them for identification. We took samples of vegetation from 87 nests, and samples of resin from 27 nests. Out of the 114 nests we sampled, we successfully reared adult bees from 95 nests.

We received preliminary results from the 33 resin samples we sent to Dr. Bankova in October 2022. Her analysis shows that 5 nests used resin from *Populus* species, the other nests were built with conifer resins. An initial graph showing the grouping of nests that use *Populus* is attached in supporting documents. Dr. Bankova will follow up with more detailed analysis of the conifer nests this summer.

We have the opportunity to test another approach to resin use by setting up cages of nesting bees, offering them resin choices, and observing which are used.

We tested methods of plant DNA extraction. Dr. Declan Schroeder analyzed long strand DNA from an initial set of extractions and found that the method is working. An initial match of DNA sequences is attached in supporting documents. Remaining DNA extractions will be completed later this summer.

### Dissemination

Project staff presented 5 online trainings for volunteers in April and May. We also gave presentations at the MN Horticultural Society Shade Tree Short Course on March 14 and 15, and a radio interview on the KAXE morning show on June 6. We continue to communicate with volunteers regularly through email and facebook posts.

# Status Update Reporting

## Status Update January 1, 2023

**Date Submitted:** January 6, 2023

**Date Approved:** January 9, 2023

### Overall Update

In the past months we completed our main nesting field season and have brought back the trap nests for winter rearing. Volunteers and communication were an important part of this effort. Traps were examined upon arrival and nests cataloged. Samples of both resin and vegetation will be selected for analysis from among the >200 anticipated bee nests. Nests traps are being reared in winter conditions according to protocols. We have also sent off resin nest material samples for analysis. These samples were collected in the summer and fall from the 21 traps in the resin choice experiment, along with reference tree resin samples. Plans have been made for nest vegetation sampling early in the new year.

### Activity 1

Nest traps were returned to the St. Paul campus from locations throughout the state beginning in October. Volunteer participation and communication has been an important activity for this part of the project. Of 104 traps sent out in spring, 101 were hung. As of the first week in December, 97 traps have been returned. We are communicating with volunteers for the return of the other 4. Traps were returned in person, by mail or at collection sites located at UMN cooperative extension offices statewide. Trap nests in the Aspen Parklands were retrieved by project staff. After arriving on campus, traps nests were cataloged and set up in storage conditions to mimic winter until bees will be ready to emerge in the spring. Updates continue on the website as needed for data entry and volunteer use. Planning for spring 2023 bonus nests has begun

### Activity 2

Nest traps from the main trapping season were returned to the St. Paul campus from locations throughout the state beginning in October. They are being reared in winter cold storage. We used a borescope to record all nest plugs in traps. We found 141 nests with plugs of any type of plant material and 180 nests with resin plugs, of which approximately half are likely to be bee nests. Material for resin and DNA analysis will be selected from among these nests.

In September we took resin samples from the 33 nests in the 21 blocks that were placed on the St. Paul campus in June 2022 for an in-depth study of nesting preference for resin bees. Nests were returned to outdoor locations for the winter. During the summer we also collected reference samples from native resin producing trees. In October resin samples were sent to Dr. Vassya Bankova at the Institute of Organic Chemistry in Sofia, Bulgaria for analysis. Dr. Bankova is a world expert on bee nest resin analysis. We were able to send 33 samples which was more than anticipated.

Protocol development and training in plant material sample collection and DNA extraction are underway.

### Dissemination

In addition to regular email communication about project logistics, volunteers received project updates via email newsletter in late August and December. Project staff gave a web presentation for the Minnesota State Horticultural Society on June 23, tabled at the Minnesota Valley National Wildlife Refuge Pollinator Palooza on June 30, and gave an in person presentation at Fond du Lac Tribal and Community College on October 13. Data from fall plug surveys was entered into the project website in December 2022 where it is available to volunteers.



# Status Update Reporting

## Status Update July 1, 2022

**Date Submitted:** June 30, 2022

**Date Approved:** July 1, 2022

### Overall Update

Recent project activities have concentrated on recruiting volunteers, instating protocols and designing and deploying nest traps as we go into our first and larger field season. We updated our website and recruited 90 volunteers, who received either live or recorded zoom trainings and manuals. We developed a new nest trap block design to meet project needs and traps were placed in 105 locations, including every ecological section in the state. Plans and preparations were made for a smaller number of blocks to be used to study resin choice in select high quality locations this coming summer.

### Activity 1

We recruited volunteers by emailing past Bee Atlas volunteers and people indicating interest via the website. We advertised on Facebook, the webpage and the Minnesota Master Naturalist newsletter. We confirmed 90 volunteers. Live zoom volunteer training given on March 19, 25 and 30th were attended by 52 volunteers. All volunteers received printed manuals and a link to a recorded training. In fall 2021, we designed new trap nests that can be opened easily to sample leaf and resin material, then closed again for rearing. Traps are compatible with the existing Bee Atlas website database and made from inexpensive and easily sourced materials. We confirmed 105 trap locations, across every ecological section in Minnesota, 30 of which also included plant stem bundles to sample species that prefer stems. Ninety-nine nest traps were sent to volunteers while 6 were hung in Nature Conservancy land in the Tallgrass Aspen Parklands province. Additionally, 21 traps were hung on the UMN St. Paul campus in mid-June where the proximity of diverse resin trees promotes in-depth nesting comparisons. The website was updated with current information about the project in March 2022. Our protocols leverage the existing website format to receive seasonal volunteer observations.

### Activity 2

Activity two relies on having samples of resin or leaf material to analyze. These samples will begin to come in this summer and fall when this summers bees build their nests. However we have taken steps to collect resin and leaf material as incidental nests have come our way. We have collection protocol and materials on hand ready for when nests are built this year.

### Dissemination

We have given three zoom workshops to 52 volunteers. We maintain a facebook site used to share bee knowledge in posts.