Final Abstract

Final Report Approved on October 23, 2026

M.L. 2023 Project Abstract

For the Period Ending June 30, 2026

Project Title: Linking Breeding and Migratory Bird Populations in Minnesota

Project Manager: Janelle Long

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Website: https://www.hawkridge.org/

Funding Source:

Fiscal Year:

Legal Citation: M.L. 2023, Chp. 60, Art. 2, Sec. 2, Subd. 03o

Appropriation Amount: $199,000

Amount Spent: $197,961

Amount Remaining: $1,039

Sound bite of Project Outcomes and Results

Full-annual cycle maps including habitat usage were developed using transmitter and isotope data from Minnesota birds, including Sharp-shinned Hawks, Northern Harriers, American Goshawks, and passerine species. Exposure of raptors to mercury and PFAS was assessed for geographic patterns using isotope data and were found to have differing spatial patterns.

Summary of Project and Outcomes

Bird populations across North America, including species that breed, migrate through, or spend part of their annual cycle in Minnesota, have experienced substantial declines over the past 50 years. Potential causes include habitat loss and fragmentation, changes in land use, climate change, and exposure to environmental contaminants. Understanding where birds move and the habitats they depend on throughout the year is critical for developing effective conservation and management strategies.

Through this project, we used transmitter and stable isotope data to better understand the movements, habitat use, and potential threats facing several understudied species of conservation concern in Minnesota. We developed

preliminary maps identifying breeding, migration, stopover, and non-breeding locations and habitats for Sharp-shinned Hawks, Northern Harriers, American Goshawks, and several passerine species. Movement patterns varied among individuals. Some birds used Minnesota primarily during spring and fall migration, while others remained in the state throughout much or all of their annual cycle. Analysis of home-range size and associated habitat characteristics is helping identify priority areas and habitat types for conservation and management within Minnesota.

We also analyzed isotope data from raptors tested for mercury and per- and polyfluoroalkyl substances (PFAS) to assess geographic patterns in contaminant exposure. Preliminary results suggest a relatively low risk of mercury exposure within Minnesota, while PFAS exposure appeared to be more prevalent in birds that isotope data suggested were from Minnesota. These results provide an important baseline for understanding contaminant exposure in a geographic perspective and identifying opportunities for future monitoring.

Together, the movement, habitat-use, and contaminant data provide a more comprehensive understanding of the landscapes and potential threats affecting birds in Minnesota. The resulting maps and analyses can help conservation organizations, land managers, researchers, and other decision-makers identify priority habitats, inform management and restoration efforts, and target future research and monitoring.

Project Results Use and Dissemination

Project results have been shared through formal and informal meetings with project partners and these discussions will continue as we work toward publication of results. Project data will also be publicly accessible through established scientific repositories (MoveBank and IsoBank), allowing researchers, resource managers, and others to access and build upon the data beyond the life of the project. Results and methodologies will also be disseminated through peer-reviewed publications, with at least two manuscripts anticipated within the next two years focusing on migratory connectivity, habitat use, and contaminant exposure.

Environment and Natural Resources Trust Fund

M.L. 2023 Approved Final Report

General Information

Date: October 23, 2026

ID Number: 2023-217

Staff Lead: Lisa Bigaouette

Project Title: Linking Breeding and Migratory Bird Populations in Minnesota

Project Budget: $199,000

Project Manager Information

Name: Janelle Long

Organization: Hawk Ridge Bird Observatory

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Project Reporting

Final Report Approved: October 23, 2026

Reporting Status: Project Completed

Date of Last Action: October 23, 2026

Project Completion: June 30, 2026

Legal Information

Legal Citation: M.L. 2023, Chp. 60, Art. 2, Sec. 2, Subd. 03o

Appropriation Language: $199,000 the first year is from the trust fund to the commissioner of natural resources for an agreement with Hawk Ridge Bird Observatory to map year-round habitat use of understudied bird species of special conservation concern and evaluate areas with the greatest risk of contaminant exposure.

Appropriation End Date: June 30, 2026

Narrative

Project Summary: Identify locations used by Minnesota birds during the full annual cycle and determine the risk of environmental contaminant exposure on raptors to improve conservation and management of Minnesota bird species.

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

Bird populations, including birds that live or move through Minnesota, have experienced drastic declines throughout North America in the last 50 years. Birds have long been used as indicators of how the ecosystem is doing (i.e., the canary in the coal mine). Declines signal that something might be out of balance in the ecosystem; however, the causes of these declines are largely unknown. Potential causes include, but are not limited to, habitat loss and exposure to environmental contaminants.

Researchers have monitored bird population trends at Hawk Ridge in Duluth, MN since 1972. Migratory birds depend on many different geographic locations during their entire year including breeding, stopover, and non-breeding locations. To understand population trends and create conservation plans for birds experiencing declines, we need a better understanding of all locations that Minnesota birds use during the entire calendar year.

Hazards like habitat loss and contaminant exposure can occur at any location or time of year. Even after 50 years of monitoring bird populations, we still know very little about the locations these birds use during their lives and the possible causes of these declines. Conservation and management are needed to address declines.

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.

To create conservation and management plans for Minnesota birds we propose to:

Identify and connect breeding, stopover, and non-breeding locations of Minnesota birds.
Identify locations and habitats important to Minnesota birds.
Assess the risk of environmental contaminant exposure to raptors.

We will use stable isotope analysis and attach high-resolution tracking devices to determine movements, geographic locations, and habitats used by birds in Minnesota.

We will work with bird banding stations across the state to collect feathers from birds during the breeding season. These feathers will be analyzed for stable isotopes and used to create maps showing breeding locations of birds across the state.

We will collect feathers and attach tracking devices to birds caught during migration. We will assign a breeding location to individuals using the isotope map we created and use tracking devices to determine movements and locations throughout an entire year. We will also use tracking data to determine habitats that each species commonly uses.

Lastly, we will analyze feather samples from individual birds that already have associated contaminant exposure data. Using this data, we will quantify the relative importance of breeding habitats for focal species and identify geographical areas with high risk for contaminant exposure.

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 outcome of this project will be a series of maps showing locations and habitats throughout Minnesota that are important for the conservation of several understudied species of special conservation concern (e.g., Northern Goshawk, Northern Harrier, and Canada Warbler). The proposed project will help identify breeding, stopover, and non-breeding locations and habitats for Minnesota birds while also evaluating areas of greatest risk of contaminant exposure

for raptors. We will share outcomes in the form of maps and reports with land managers, state and federal government agencies, and non-profit organizations working to conserve these species.

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?

In the Future

Activities and Milestones

Activity 1: Collect feather samples and deploy transmitters on birds during breeding.

Activity Budget: $40,221

Activity Description:
Activity 1 will support Objective #1: Determine breeding locations of birds in Minnesota using stable isotope analysis. We will coordinate with MAPS (Monitoring Avian Productivity and Survivorship) stations and breeding bird nest surveys across Minnesota to collect feather samples (n=10 for each species/site) from birds. MAPS stations study birds during the breeding season and target birds directly on their breeding locations. Stable isotope analysis is a non-invasive technique that can be used to estimate geographic location based on naturally occurring isotopic patterns in the environment. Feathers will be analyzed for stable isotopes and used to relate tissue isotope values to geographic locations. From these known isotope values we will create a base map for MN that will allow us to assign a breeding location to birds banded during migration. In addition, transmitters may be opportunistically deployed on adult breeding birds to assess broad-scale movement patterns.

We aim to target our analysis to 2-3 passerine species from MAPS stations and 3 raptor species for a total of 240 individuals analyzed for Activity 1.

Outcome: Create a map of isotope values based on feathers from birds on their breeding locations. This map will be utilized in Activities 2 and 3.

Activity Milestones:

Description	Approximate Completion Date
Develop data collection protocols for breeding bird stations and add selected species to permits.	December 31, 2023
Coordinate with MAPS stations to train staff/volunteers on data collection protocols.	April 30, 2024
Collect feather samples and deploy transmitters in the 2024 and 2025 breeding seasons.	August 31, 2025
Feathers analyzed for stable isotope analysis from both the 2024 and 2025 season.	December 31, 2025
Data analysis: Maps produced from stable isotopes and transmitter data and made available.	April 30, 2026

Activity 2: Collect feather samples and deploy transmitters on birds banded during migration to determine breeding locations and migratory connectivity.

Activity Budget: $135,379

Activity Description:
We will collect feather samples for stable isotope analysis from birds banded during fall migration of 2024 and 2025. Feathers will be analyzed as in Activity 1 and assigned to a probable breeding location based on isotope ratios and the base maps created in Activity 1. Using the geographic assignment based on dual stable isotope analysis we will quantify the proportion of migrants that are MN breeders. We will calculate odds ratios of likely breeding locations between different regions of MN and estimate distances of movement from those breeding locations.

Transmitters will be deployed on adults to confirm isotopic signatures and add resolution to isotope data. In addition to breeding locations, this data will inform us where birds are during the non-breeding season and migration. Transmitter data will be analyzed using ArcGIS to determine migratory connectivity and habitat use. We will use data to determine pathways and variability across and within birds and determine breeding, stopover, and non-breeding locations. This data will be used to identify important habitats and locations used by MN birds to inform conservation and management.

Outcome: Identify breeding, non-breeding, and stopover locations for birds banded during the fall migration season at Hawk Ridge.

Activity Milestones:

Description	Approximate Completion Date
Develop sampling protocols for fall migration data collection.	October 31, 2023
Acquire appropriate transmitters for target species.	March 31, 2024
Collect feather samples and deploy transmitters during 2024 and 2025 fall migration at Hawk Ridge.	November 30, 2025
Send samples for stable isotope analysis in both fall 2024 and 2025.	December 31, 2025
Assign breeding location to migratory birds using the isotope base map (Activity 1).	May 31, 2026
Final report detailing the important habitats and geographic locations for birds of Minnesota.	June 30, 2026

Activity 3: Assess the risk of environmental contaminant exposure to raptors in MN based on breeding origin.

Activity Budget: $23,400

Activity Description:
Birds can bioaccumulate environmental contaminants in their tissues. In addition, these contaminants can bio-magnify across trophic levels meaning that organisms feeding at higher trophic levels may experience the greatest exposure. Environmental contaminants like methylmercury can lead to reproductive and/or behavioral impacts. We will leverage existing feather samples from birds (n = 100) that have been previously analyzed for total mercury and PFAS (per- and poly-fluoroalkyl substances). We will analyze feathers from these birds to estimate their breeding origins using stable isotope analysis. This will allow us to identify geographic areas of most likely exposure in and outside of MN. We will quantify the relative risk of MN birds to contaminant exposure and also assess whether this technique could be useful for continent-scale contaminant monitoring.

This activity will further a past LCCMR proposal which looked at PFAS exposure in raptors. Through this activity we will be able to see if there are geographic locations that make raptors more likely to be exposed to these environmental contaminants.

Outcome: Quantify the relative exposure risk of MN raptors to mercury and PFAS based on breeding location.

Activity Milestones:

Description	Approximate Completion Date
Select samples for analysis based on individuals previously analyzed for contaminants.	September 30, 2023
Feather samples sent to the lab for stable isotope analysis.	October 31, 2023
Begin data analysis: assign geographic locations based on stable isotopes.	March 31, 2024
Comparative analysis of isotope and contaminant data to determine geographical locations of exposure.	August 31, 2024
Make completed maps of exposure available to decision makers and the public.	April 30, 2025

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Dr. Alexis Grinde	Natural Resources Research Institute	Dr. Grinde was a part of the project conception and will be involved in decision-making, project planning, data analysis, and result dissemination.	No
Dr. Matthew Etterson	Hawk Ridge Bird Observatory	Dr. Etterson was a part of the project conception and will be involved in decision-making, project planning, data analysis, and result dissemination.	No

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.
We expect that our results will help identify breeding locations and breeding habitats for Minnesota birds while providing important information related to risk of contaminant exposure. The proposed techniques will prioritize habitat restoration and mitigation efforts across the state and will serve as a model for methodology that can be used for continent-scale contaminants. The findings and products developed from this project will be directly conveyed to project stakeholders through formal and informal meetings. Updates on the project will be posted to the Hawk Ridge Bird Observatory website, newsletter, Facebook, and Instagram accounts. Attribution language will be included in all of these posts which will also mention and/or tag ENRTF so that project updates can be shared with LCCMR followers. We will acknowledge the ENTRF funding in publications, signage, and other public communications and outreach related to work associated with the project using the trust fund logo or inclusion of language attributing support from the trust fund as appropriate.

Scientific publications: We anticipate that this project will produce at least two peer reviewed journal articles focusing on migratory connectivity and habitat use.

Presentations: Results will be disseminated through local, regional, and national conferences.

Data: Publicly available data will be hosted through the Hawk Ridge Bird Observatory website. After the publication of the results, all isotope data will be added to IsoBank, a collaborative isotope data repository and all transmitter data will be added to MoveBank, an online animal-tracking data repository.

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?
Hawk Ridge Bird Observatory researchers and project manager will analyze project data and publish results both locally and at a national scale. Results and findings will be shared with land managers, state and federal government agencies, and non-profit organizations working to conserve these species. Additional funding sources will be acquired if needed for continuing work. These funding sources may include local grants and donor solicitation.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded

Quantifying Exposure of Minnesota's Raptors to Mercury and PFAS	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 03c	$250,000

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount	$ Amount Spent	$ Amount Remaining
Personnel										
Passerine Bander		Operate passerine banding during summer and fall season			0%	2		$11,670	-	-
Raptor Bander		Operate raptor banding during the fall season			0%	0.5		$6,668	-	-
Project Coordinator		Manage project and finances			0%	0.1		$3,569	-	-
Primary Researcher		Coordinate data collection, analysis, and final reports			0%	0.33		$18,930	-	-
							Sub Total	**$40,837**	**$40,837**	**-**
Contracts and Services										
Stable Isotope Analysis	Service Contract	Feathers from ~1000 individuals will be analyzed for stable isotope analysis. The cost of the analysis will be $25 for hydrogen stable isotope analysis and $200 for strontium isotope analysis.				0.2		$89,300	$89,249	$51
Emily Pavlovic, Primary Researcher	Service Contract	Primary research duties including project design, development, management, technical skills (data, reporting, analyses).				0.17		$2,163	$2,163	-
							Sub Total	**$91,463**	**$91,412**	**$51**
Equipment, Tools, and Supplies										
	Tools and Supplies	Transmitters	Transmitters will be deployed on MN birds to learn about movements and create connectivity between breeding and migration. Cost of transmitters ranges from $250-1500. We plan to attach about 45 transmitters to species of interest over the course of two years. These					$62,100	$62,098	$2

			numbers may change due to the general yearly fluctuations in birds banded.							
	Tools and Supplies	Field Supplies	Purchase of tools and supplies needed for collecting samples including envelopes for feathers and tools needed for transmitter deployment.					$600	$552	$48
	Tools and Supplies	ArcGIS	Subscription to ArcGIS for 3 years for data analysis					$500	$200	$300
							Sub Total	**$63,200**	**$62,850**	**$350**
Capital Equipment										
							Sub Total	**-**	**-**	**-**
Acquisitions and Stewardship										
							Sub Total	**-**	**-**	**-**
Travel In Minnesota										
	Miles/ Meals/ Lodging	Estimate ~5 trips per year to breeding bird stations and other habitats. Trips will range in distance from 30-200 miles. Estimated based on government rate of 58.5 cents/mile.	A few trips will be made each year to train personnel and collect samples from birds on their breeding grounds. Additional trips may be taken to deploy transmitters if samples size is low during migration at Hawk Ridge. This involves driving to suitable habitats where birds are likely to be present.					$3,000	$2,862	$138
	Miles/ Meals/ Lodging	Multiple trips for one person to present findings from project to other organizations in Minnesota. Estimate about 700 miles total at the federal mileage reimbursement rate (0.67 - 0.725 cents/mile).	Dissemination of results from the project to other organizations in Minnesota.					$500	-	$500
							Sub Total	**$3,500**	**$2,862**	**$638**

Travel Outside Minnesota										
							Sub Total	**-**	**-**	**-**
Printing and Publication										
							Sub Total	**-**	**-**	**-**
Other Expenses										
							Sub Total	**-**	**-**	**-**
							Grand Total	**$199,000**	**$197,961**	**$1,039**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

Non ENRTF Funds

Category	Specific Source	Use	Status	$ Amount	$ Amount Spent	$ Amount Remaining
State						
			State Sub Total	**-**	**-**	**-**
Non-State						
			Non State Sub Total	**-**	**-**	**-**
			Funds Total	**-**	**-**	**-**

Attachments

Required Attachments

Visual Component

File: 65685ad1-bdf.pdf

Alternate Text for Visual Component

A map showing the most probable breeding location for a sample of Sharp-shinned Hawks banded at Hawk Ridge in 2020 based on stable isotope analysis. An example of feathers that will be collected and a red-tailed hawk with a transmitter attached. Text describing the objectives of the project....

Financial Capacity

File: e885ff7b-794.pdf

Board Resolution or Letter

Title	File
HRBO Board Resolution	227b942e-3a5.pdf

Supplemental Attachments

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

Title	File
Background Check Certification Check	20992118-dd9.pdf
Pavlovic 2023-217 Research Addendum	a33d634d-5a6.pdf
HRBO eNews Research Update	608f6a6d-aba.png
October 2025 Status Update	8aa39ecb-ad6.pdf
April 2026 Status Update	de74232f-a32.pdf
Final Status Update	426aa7f5-a79.pdf
Virtual Presentation - Winter Series	cf20fdc9-cca.pptx
Raptor Research Foundation Conference Abstract	767dd643-6c1.docx
Presentation - MPCA	5fd7f523-96c.pptx
PFOS Exposure in Raptors	1b195dcc-c45.pdf

Media Links

Title	Link
Hawk Ridge Bird Observatory	https://www.hawkridge.org/
MoveBank - Data Repository - American Goshawk - Data will be public after publication	https://www.movebank.org/cms/webapp?gwt_fragment=page=studies,path=study8654574272
MoveBank - Data Repository - Sharp-shinned Hawk - Data will be public after publication	https://www.movebank.org/cms/webapp?gwt_fragment=page=studies,path=study8660160355
MoveBank - Data Repository - Northern Harrier - Data will be public after publication	https://www.movebank.org/cms/webapp?gwt_fragment=page=studies,path=study8660165091
IsoBank - Data Repository for Isotope Data - Will be added after publication	https://isobank.tacc.utexas.edu/

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

Added additional milestones to the activities to describe that early project planning stages as well as the final report generating stages.

I'm confirming that none of the personnel will be paid benefits.

Stable isotope analysis funding was moved to Professional, Technical, Services Contracts. Estimated number of samples was included.

Added estimated number of transmitters and approximate cost per unit.

Revised budget to include funds for travel within Minnesota to collect samples and deploy transmitters if necessary. We cannot predict how many individuals will be caught and banded so this is a backup in case sample sizes are low.

A comment had been made about the Administrative personnel costs. Clarified the text to make it more clear that this is for project coordination, not administrative costs.

Rewrote the narrative section to hopefully make it more clear what the problem and solution is that we are trying to address with this project.

Added two collaborators who have been instrumental in the project conception and will be integral for decision making and data analysis.

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 Commissioner's Plan 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?

No

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

Yes, I understand

Work Plan Amendments

Amendment ID	Request Type	Changes made on the following pages	Justification For Amendment Request (word limit 75)	Date Submitted	Approved	Date of LCCMR Action
1	Amendment Request	• Project Collaborators - Project Manager Info • Other • Budget - Capital, Equipment, Tools, and Supplies	The project manager was not a staff member and was changed to staff member at Hawk Ridge Bird Observatory which is the organization associated with this project and is responsible for project updates and reporting.	March 27, 2024	Yes	May 29, 2024
2	Amendment Request	• Other • Budget - Personnel • Budget - Professional / Technical Contracts	Amended budget to reflect change from personnel to contracted work for the Primary Research position as discussed in our grant monitoring review meeting and with Michael Varien. Primary researcher role was done by contracted role for the first part of 2024 until a Researcher Director was hired at Hawk Ridge Bird Observatory to fill this primary researcher role.	November 26, 2024	Yes	December 16, 2024
3	Amendment Request	• Budget - Professional / Technical Contracts • Budget - Capital, Equipment, Tools, and Supplies • Budget - Travel and Conferences • Attachments	Stable isotope contracted work will cost less than anticipated in the original budget and a few areas of the budget are exceeding our projected budget (supplies for transmitter deployment and local travel). Budget has been amended to increase travel funds for 2025 field work and increase supply money to purchase additional transmitters and materials for deployment and sample collection.	March 28, 2025	Yes	April 30, 2025
4	Amendment Request	• Budget • Budget - Professional / Technical Contracts • Budget - Capital, Equipment, Tools, and Supplies • Budget - Travel and Conferences • Attachments	We are requesting the approval of an amendment to move $500 of the travel budget from sample collection to travel for outreach and dissemination of results from the project. Dissemination of results will be made to organizations within Minnesota and will amount to about 2 trips for a total of ~700 miles reimbursed	April 16, 2026	Yes	April 23, 2026

			at the federal mileage reimbursement rate. Travel to disseminate project results is an acceptable and approved use of funds.			

Status Update Reporting

Final Status Update August 14, 2026

Date Submitted: September 23, 2026

Date Approved: September 28, 2026

Overall Update
Through this project, we have developed maps using transmitter and isotope data to identify breeding, stopover, and non-breeding locations and habitats for Minnesota birds, including Sharp-shinned Hawks, Northern Harriers, American Goshawks, and passerine species. Landscape use varied considerably among individuals, with some using Minnesota only during spring and fall migration, while others remained in the state throughout their full annual cycle. Analysis of home-range size and habitat identifies priority areas for conservation and management within Minnesota. We have also analyzed isotope data from raptors tested for mercury and per- and polyfluoroalkyl substances (PFAS) to assess geographic patterns in contaminant exposure. This data suggests a low risk of exposure within Minnesota to mercury and a higher risk of exposure to PFASs. Since the last update, we have presented preliminary results from this project at several events, helping share findings with researchers, conservation professionals, and the public.

Activity 1
We collected feathers from over 600 individual passerines banded during the breeding season at MAPS (Monitoring Avian Productivity and Survivorship) stations across Minnesota. Feathers were analyzed for both hydrogen and strontium isotopes by contracted labs and the resulting values were analyzed to determine variation in isotope values within Minnesota. Data analysis of isotope values from feathers collected from MAPS stations are shown in the attachments, with good variability in values between sites. This analysis improves our ability to use this technique of isotope analysis to determine breeding location of migrants banded during the fall at Hawk Ridge, but can be used at any other site across the state and beyond.
(This activity marked as complete as of this status update)

Activity 2
We identified breeding, non-breeding, and stopover locations for birds banded during the fall migration season at Hawk Ridge by doing isotope analysis of feathers and by deploying transmitters. Over 500 samples collected during fall migration across two seasons were sent for stable isotope analysis. Data was received since the last update and preliminary analyses are included in the attachments. The use of both hydrogen and strontium isotopes add resolution to geographic assignments. A total of 42 transmitters were deployed on three species over the course of the project. While some of these devices are no longer collecting data due to the life of the transmitters, some remaining deployed transmitters continue to collect movement and habitat data. Data analysis of the movement data will be ongoing with these transmitters. New maps and analyses were conducted since the last status update to visualize migratory paths and determine home-range size and habitat use in key areas for these species.
(This activity marked as complete as of this status update)

Activity 3
Birds can bioaccumulate environmental contaminants in their tissues. In addition, these contaminants can bio-magnify across trophic levels meaning that organisms feeding at higher trophic levels may experience the greatest exposure. We analyzed feathers from 68 raptors of seven different species that had been previously tested for mercury and PFOS concentrations to determine if there were geographical patterns in their exposure. A correlation test between the PFOS concentration and the isotope ratio of hydrogen indicates that there is a strong correlation between latitude and PFOS concentration (p-value=9.7x10^-6). This indicates that species breeding at lower latitudes are at a greater risk for contaminant exposure likely due to the increased presence of urban environments where they may come into contact with these chemicals. Additional studies could look at the urban association of birds like Cooper's Hawks and whether

this increased exposure is having a negative health impact on the species. Conversely, mercury concentration had the opposite relationship with latitude as determined by hydrogen stable isotopes. Birds breeding in higher latitude regions outside of Minnesota had higher levels of mercury than those at lower latitudes. This indicates little risk of exposure to mercury in Minnesota for those individuals tested.
(This activity marked as complete as of this status update)

Dissemination
Formal and informal meetings with project partners (Natural Resources Research Institute, US Forest Service, Wolf Ridge, etc.) to share results have occurred and will continue as we work towards publication of the results. Our results will help identify breeding locations and breeding habitats for Minnesota birds while providing important information related to risk of contaminant exposure. The proposed techniques will prioritize habitat restoration and mitigation efforts across the state and will serve as a model for methodology that can be used for continent-scale contaminants. Data from transmitters has been uploaded to MoveBank (a movement data repository) so that this data can be used beyond the life of this project by others. We are in the process of uploading isotope data to IsoBank for the same reason. Both of these repositories are essential for the sharing and dissemination of this work and will allow other researchers to use the data if applicable for their research. We anticipate that this project will produce at least two peer reviewed journal articles focusing on migratory connectivity and habitat use within the next two years.

Status Update Reporting

Status Update April 1, 2026

Date Submitted: April 16, 2026

Date Approved: April 23, 2026

Overall Update
We have created preliminary maps and will continue to update with more data a series of maps identifying breeding, stopover, and non-breeding locations and habitats for Minnesota birds (Sharp-shinned Hawk, Northern Harrier, American Goshawk, passerine species). Maps are created from both isotope and transmitter data. We have also analyzed isotope data from raptors that were tested for both mercury and per- and polyfluoroalkyl substances to assess whether there are geographic patterns in contaminant exposure. Since the last update we completed our second season of collecting feathers for isotope analysis during the fall migration season in which we collected another 300 feather samples. In addition, we were able to deploy an additional 15 transmitters between the three target species: American Goshawk, Sharp-shinned Hawk, Northern Harrier. Data collection was completed on November 30th and analysis of results is in progress. We presented preliminary results from this project at a few different events since the last update.

Activity 1
Outcome 1: Create a map of isotope values based on feathers from birds on their breeding locations. This map will be utilized in Activities 2 and 3. We collected 321 feathers in 2024 and about 300 in the 2025 breeding season from passerine species banded during the MAPS program at stations across Minnesota. Feathers from 2024 (153 samples) have been analyzed for hydrogen and strontium isotopes, but 2025 samples are still in the queue to be analyzed. Initial data analysis of feathers from MAPS stations are shown in the attachments, with good variability in values between sites. Activity 1 will be complete by May 31st, 2026. See Attachment for more details.

Activity 2
Outcome 2: Identify breeding, non-breeding, and stopover locations for birds banded during the fall migration season at Hawk Ridge. Samples collected during fall of 2024 were sent for stable isotope analysis (181 raptor samples from Sharp-shinned Hawk, Northern Harrier, and American Goshawk and 100 from passerine species). Data was received since the last update and preliminary analyses are included in the attachments. 15 transmitters were deployed during fall 2025 on raptors, including 7 on American Goshawk. Deployed transmitters continue to collect movement and habitat data. Data analysis of the movement data is ongoing with current work focusing on important habitats and overall migratory connectivity. New maps and analyses were conducted since the last status update. See Attachment for more details.

Activity 3
Outcome 3: Quantify the relative exposure risk of MN raptors to mercury and PFAS based on breeding location. Feather samples from 68 individual raptors of seven different species that were previously analyzed for mercury and per- and polyfluoroalkyl substances were analyzed for hydrogen stable isotopes to determine probable natal origins. Initial analysis suggests that contaminant exposure in these individuals is correlated with natal origin to some extent. Individuals breeding in more northern latitudes appear to have lower contaminant exposure than those breeding in more southern latitudes. Further data analysis is in progress to create maps showing the natal origins that had individuals with the highest contaminant concentrations. These areas are likely to be in urban environments within Minnesota. What impact if any these contaminants have on raptor populations will involve further study. Activity 3 will be finalized by the end of April. See Attachment for more details.

Dissemination
We presented project results at multiple formats since the last status update. Presentation was given on preliminary results to the Minnesota Pollution Control Agency at Plymouth Library on December 3, 2025. Data of raptors outfitted

with transmitters was shared at the Minnesota Ornithologists' Union Paper Session - December 6th, 2025. A virtual presentation on 2/28/26 was presented about transmitter results so far through Hawk Ridge Bird Observatory. See attachments for some of the maps shared and social media post about presentations. Dissemination and analysis of results is the primary role for the remainder of the project.

Status Update Reporting

Status Update October 1, 2025

Date Submitted: October 1, 2025

Date Approved: October 31, 2025

Overall Update
We have created preliminary maps and will continue to update with more data a series of maps identifying breeding, stopover, and non-breeding locations and habitats for Minnesota birds (Sharp-shinned Hawk, Northern Harrier, American Goshawk, passerine species). Maps are created from both isotope and transmitter data. We have also analyzed isotope data from raptors that were tested for both mercury and per- and polyfluoroalkyl substances to assess whether there are geographic patterns in contaminant exposure. Since the last update we finished our second feather sampling session during the breeding season in which we collected another 300 feather samples. Data collection will end for this project on November 30th which will be followed by the remainder of samples being analyzed for isotope ratios and subsequent analysis of isotope and transmitter data to create finalized maps of landscape usage for Minnesota birds.

Activity 1
Outcome 1: Create a map of isotope values based on feathers from birds on their breeding locations. This map will be utilized in Activities 2 and 3. We collected 321 feathers in 2024 and about 300 in the 2025 breeding season from passerine species banded during the MAPS program at stations across Minnesota. Feathers from 2024 (153 samples) have been analyzed for hydrogen and strontium isotopes, but 2025 samples are still in the queue to be analyzed. Initial data analysis of feathers from MAPS stations are shown in the attachments, with good variability in values between sites. Activity 1 will be complete by December 31st, 2025. See Attachment for more details.

Activity 2
Outcome 2: Identify breeding, non-breeding, and stopover locations for birds banded during the fall migration season at Hawk Ridge. Samples collected during fall of 2024 were sent for stable isotope analysis (181 raptor samples from Sharp-shinned Hawk, Northern Harrier, and American Goshawk and 100 from passerine species). Data should be received within the next 2 months. Four additional transmitters have been deployed this fall on raptors with an additional six to be deployed in the next two weeks and up to 10 deployed by the end of November on American Goshawk. Already deployed transmitters (10 on Northern Harriers and 18 on Sharp-shinned Hawks) continue to collect movement and habitat data. Data analysis of the movement data is ongoing with current work focusing on important habitats and overall migratory connectivity. See Attachment for more details.

Activity 3
Outcome 3: Quantify the relative exposure risk of MN raptors to mercury and PFAS based on breeding location. Feather samples from 68 individual raptors of seven different species that were previously analyzed for mercury and per- and polyfluoroalkyl substances were analyzed for hydrogen stable isotopes to determine probable natal origins. Initial analysis suggests that contaminant exposure in these individuals is correlated with natal origin to some extent. Individuals breeding in more northern latitudes appear to have lower contaminant exposure than those breeding in more southern latitudes. Further data analysis is in progress to create maps showing the natal origins that had individuals with the highest contaminant concentrations. These areas are likely to be in urban environments within Minnesota. What impact if any these contaminants have on raptor populations will involve further study. Activity 3 will be finalized by the end of the year. See Attachment for more details.

Dissemination
Project updates are included in Hawk Ridge Bird Observatory monthly e-newsletters (attached). Informal presentations

during our fall visitor operations have informed the public of the research we are conducting with funding from LCCMR ENRTF.

Status Update Reporting

Status Update April 1, 2025

Date Submitted: March 28, 2025

Date Approved: April 30, 2025

Overall Update
The outcome of this project will be a series of maps showing locations and habitats throughout Minnesota that are important for the conservation of several understudied species of special conservation concern. The proposed project will help identify breeding, stopover, and non-breeding locations and habitats for Minnesota birds while also evaluating areas of greatest risk of contaminant exposure for raptors. We have successfully deployed 25 transmitters on Sharp-shinned Hawk and Northern Harriers providing novel movement and habitat use. Data analysis of this work is still pending. Analysis of feathers from both breeding and migratory individuals is in progress for strontium and hydrogen isotopes. Initial data analysis will begin in April 2025.

Activity 1
Feathers collected during the breeding season have been analyzed for strontium and hydrogen isotope ratios and data analysis will begin shortly. Data was just received for hydrogen isotope analysis on March 27, 2025. We are currently in the process of preparing for the second year of data collection. In April, we will meet with MAPS stations to review the data so far and discuss any changes in data collection for the second season (June-August 2025).

Activity 2
A total of 25 transmitters have been deployed on Northern Harriers and Sharp-shinned Hawks. These birds are providing novel movement and habitat use data for these two species. Analyses are ongoing and will continue until the birds complete the breeding season (August 2025). Feathers were collected from migration passerine and raptor species August - December 2025. These samples are waiting to be analyzed for strontium and hydrogen isotope analysis. Data analysis will be completed when results have been received.

Activity 3
Data analysis will begin as soon as final data has been received. This data was just received from the contractor on March 27, 2025. This activity will further a past LCCMR proposal which looked at PFAS exposure in raptors. Through this activity we will be able to see if there are geographic locations that make raptors more likely to be exposed to these environmental contaminants. This activity is now projected to be complete by July 2025.

Dissemination
In November 2024, we presented preliminary data from the project at the Hawk Migration Association 50th Conference in Duluth, MN. An update on the project was provided in the Hawk Ridge Bird Observatory March eNews (attachment).

Status Update Reporting

Status Update October 1, 2024

Date Submitted: October 1, 2024

Date Approved: October 23, 2024

Overall Update
The outcome of this project will be a series of maps showing locations and habitats throughout Minnesota that are important for the conservation of several understudied species of special conservation concern. The proposed project will help identify breeding, stopover, and non-breeding locations and habitats for Minnesota birds while also evaluating areas of greatest risk of contaminant exposure for raptors. As of April 2024, progress has been made in data collection through transmitter deployment on raptors and feather collection from passerines during the breeding season and feather collection during migration from both passerines and raptors. See more detailed updates below.

Activity 1
A training and information session was held at the end of April for MAPS stations. Sample collection of feathers for stable isotope analysis began in June 2024 across MN at eight different MAPS stations. Over 300 individual birds were sampled and a subset of feathers (~100) were prepped and sent for stable isotope analysis. Data will be analyzed to create base isotope maps for breeding assignment. Fall feather collection began in August and will continue until the end of the fall passerine banding season (mid to late October).

Activity 2
Ten transmitters were deployed on Sharp-shinned Hawks and two were deployed on Northern Harriers in April and May. All of the Sharp-shinned Hawks went out of cellular range for the breeding season. If they make their migration back south during this fall the transmitters will download all of the stored data. This fall, we have deployed three more transmitters on Northern Harriers and one more on a Sharp-shinned Hawk. We plan to deploy an additional five to seven transmitters on Northern Harriers and five more on Sharp-shinned Hawks over the course of the fall season. Fall feather collection from passerines began in August and will continue until the end of the fall passerine banding season (mid to late October). Fall feather collection from raptors began August 15th and will continue until the end of November.

Activity 3
No additional update from last status update. Feathers from individual raptors previously analyzed for PFAS and mercury contaminants were selected from the feather archive at HRBO. Feathers were sent for hydrogen stable isotope analysis at Central Appalachian Stable Isotope Facility. Data analysis will begin as soon as final data has been received. This activity will further a past LCCMR proposal which looked at PFAS exposure in raptors. Through this activity we will be able to see if there are geographic locations that make raptors more likely to be exposed to these environmental contaminants.

Dissemination
Social media posts from last spring were posted to the Hawk Ridge Bird Observatory social media pages. A project report will be completed at the end of the fall season.

Status Update Reporting

Status Update April 1, 2024

Date Submitted: March 27, 2024

Date Approved: May 29, 2024

Overall Update
The outcome of this project will be a series of maps showing locations and habitats throughout Minnesota that are important for the conservation of several understudied species of special conservation concern. The proposed project will help identify breeding, stopover, and non-breeding locations and habitats for Minnesota birds while also evaluating areas of greatest risk of contaminant exposure for raptors. Current project progress has been focused on development of protocols, acquiring necessary supplies and equipment, and coordinating with collaborating bird monitoring stations. Most of the project activities will commence April 2024 with major progress toward project outcomes in 2025.

Activity 1
Progress made towards Activity 1 includes preparatory work for the beginning of data collection this summer. We completed data collection protocols and ordered supplies for feather sampling at MAPS stations during the breeding season. Target passerine species were selected and added to State and Federal permits for feather collection. Across MN, 8 MAPS stations in addition to the one at Hawk Ridge have agreed to participate in feather collection. A training and information session will be held at the end of April for MAPS stations. Sample collection will begin May 2024 and feathers collected will be sent to a stable isotope facility for analysis. Data will be analyzed to create base isotope maps for breeding assignment.

Activity 2
Three raptor species were selected for transmitter deployment and were added to State and Federal Permits. Protocols for sample collection and transmitter deployment were developed. Transmitters were ordered from Cellular Tracking Technologies in January 2024 and are set to arrive at the beginning of April 2024. Additional supplies were ordered for transmitter deployment and sample collection.

Activity 3
Feathers from individual raptors previously analyzed for PFAS and mercury contaminants were selected from the feather archive at HRBO. Feathers were sent for hydrogen stable isotope analysis at Central Appalachian Stable Isotope Facility. Data analysis will begin as soon as final data has been received. This activity will further a past LCCMR proposal which looked at PFAS exposure in raptors. Through this activity we will be able to see if there are geographic locations that make raptors more likely to be exposed to these environmental contaminants.

Dissemination
No dissemination has been done up to this point. With our main project activities beginning in mid-April of 2024, we expect to start regular dissemination activities in the next month. Regular social media postings will be given with project updates to our members and followers as data collection for the project continues.