Final Abstract

Final Report Approved on January 12, 2026

M.L. 2022 Project Abstract

For the Period Ending June 30, 2025

Project Title: Pollinator Plantings and the Redistribution of Soil Toxins

Project Manager: Emilie Snell-Rood

Affiliation: U of MN - College of Biological Sciences

Mailing Address: 1479 Gortner Ave Gortner 140

City/State/Zip: St Paul, MN 55108

Phone: (612) 624-7238

E-mail: emilies@umn.edu

Website: https://cbs.umn.edu/

Funding Source:

Fiscal Year:

Legal Citation: M.L. 2022, Chp. 94, Sec. 2, Subd. 08e

Appropriation Amount: $610,000

Amount Spent: $610,000

Amount Remaining: -

Sound bite of Project Outcomes and Results

This project studied and characterized routes of heavy metal exposure for insects and mammals in urban areas and potential mitigation methods. Results highlighted a few hotspots of pollution concern and pointed to heavy metals in soil and air as possible exposure risks.

Overall Project Outcome and Results

Threats from heavy metal pollution have been on the decline thanks to decades of policy and regulation. However, areas of legacy pollution remain, and some products and industries continue to release heavy metals into the environment. In this research, we assessed the risks of heavy metal pollution for Minnesota wildlife and explored potential methods of mitigation. We combined measures of animal metal content with indicators of their health and found that while overall levels of heavy metal pollution are low, there are some hotspots of concern, which we are currently tracing with stable isotopes. Metal loads of insects and mammals were related to local levels of soil and air metal pollution. Insects from areas of elevated blood lead levels in children also carried higher lead loads, suggesting common environmental drivers for humans and wildlife. Time series of Minnesota mammal skins show that overall heavy metal pollution has declined in the state over the last 100 years. In terms of mitigation, we asked whether worm activity might promote lead burial, but

found little support for this idea in the field. Current remediation work is focused on the role of soil amendments like biochar in binding soil heavy metals and microplastics. Additional funding has been secured to complete aspects of this research related to counting and identifying microplastics in the soil samples from this project; but analyses to date suggest that a great diversity of microplastics are found in urban soils with low impacts on pollinators. This research points to a few priority areas for heavy metal risk assessment and mitigation in Minnesota, for both people and wildlife: we should be concerned about areas with not only old infrastructure, but also current aerial deposition. In addition, soil and air pollution are more of a concern for lead exposure than consuming urban plants.

Project Results Use and Dissemination

We have communicated our findings in presentations at conferences, public webinars, seminars to garden clubs and master gardeners' groups, and a segment on Minnesota Public Radio. We have four publications in print, two in revision, and four in preparation, including a handout with UMN extension on general advice for dealing with lead in garden soils. While no management recommendations were produced given that our results did not align with our original management idea, it led to current studies tracing the sources of lead hotspots using stable isotopes and investigating the use of biochar as a soil amendment to bind metals.

Environment and Natural Resources Trust Fund

M.L. 2022 Approved Final Report

General Information

Date: January 30, 2026

ID Number: 2022-167

Staff Lead: Tom Dietrich

Project Title: Pollinator Plantings and the Redistribution of Soil Toxins

Project Budget: $610,000

Project Manager Information

Name: Emilie Snell-Rood

Organization: U of MN - College of Biological Sciences

Office Telephone: (612) 624-7238

Email: emilies@umn.edu

Web Address: https://cbs.umn.edu/

Project Reporting

Final Report Approved: January 12, 2026

Reporting Status: Project Completed

Date of Last Action: January 12, 2026

Project Completion: June 30, 2025

Legal Information

Legal Citation: M.L. 2022, Chp. 94, Sec. 2, Subd. 08e

Appropriation Language: $610,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to map urban and suburban soil toxins of concern, such as heavy metals and microplastics, and to test whether pollinator plantings can redistribute these toxins in the soil of yards, parks, and community gardens and reduce exposure to humans and wildlife.

Appropriation End Date: June 30, 2025

Narrative

Project Summary: This research will test whether plantings for pollinators can remediate soils impacted by metals (like lead) and emerging contaminants (like microplastics) through the redistribution of toxins to safer areas.

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

Human-impacted environments have elevated levels of many toxins, including heavy metals, salts, microplastics, and pesticides. These toxins are problematic for two primary reasons. First, while the levels of these toxins are often low enough to avoid targeted clean-ups, they are high enough that long-term chronic exposure can result in significant health effects in people. For instance, soil lead levels in many residential areas throughout Minnesota are below EPA thresholds of concern, but can still result in elevated blood lead levels in children (Figure 1) and negative impacts on their cognitive development. In addition, toxin exposure is a growing concern with efforts to increase food production in urban and suburban environments as a way to help improve food security and agricultural sustainability. Second, toxins negatively affect local ecosystems. For example, heavy metals and pesticides can disrupt important ecosystem functions, such as pollination, water filtration, and carbon capture. At the same time, ecological processes affect the fate and transport of these toxins, offering hope for beneficial effects of ecological restoration and bioremediation on pollutants. This research will determine how management of green spaces can be used to redistribute urban toxins in ways that are safer for both people and wildlife.

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.

This research will test how ecosystem restoration and management can reduce the negative effects of urban and suburban toxins, because animals and plants move toxins to less accessible places. This work will generate recommendations for the restoration and management of Minnesota yards, parks, and gardens impacted by pollution through three primary activities: a) spatial mapping of soil toxins, b) tests of toxin redistribution in the soil with management for pollinators, and c) tests of toxin movement from soil to plants to pollinators and small mammals. Plantings for pollinators are promising for remediation of soil toxins because the leaf litter promotes activity of worms that bury surface-level contaminants, while open, bright conditions inhibit the activity of worms which contribute little to soil burial. However, such ideas have not been tested in the field, and it is unclear how they will play out in areas with highly variable soil properties. We will also consider how well studied toxins such as lead will interact with contaminants of emerging concern, such as microplastics. This work will build on a recently funded project establishing the Twin Cities as an Urban Long-term Ecological Research (LTER) site, capitalizing on interdisciplinary expertise and emerging research infrastructure.

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?

This project will produce management recommendations to minimize the effects of metal and microplastic pollution on ecosystem services and human health. Spatial mapping will highlight specific geographic areas of concern in the metro area. While present work will be concentrated in the Twin Cities, we expect the outcomes will be relevant to other regions of the state with metal pollution (e.g., Duluth, Iron Range, see Figure 1). Datasets will be publicly available through the Urban LTER website. Regular communication and effort coordination will occur with relevant public health and pollution control agencies (e.g., annual reports and biannual meetings).

Project Location

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

Region(s): Metro

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

Statewide

When will the work impact occur?

During the Project and In the Future

Activities and Milestones

Activity 1: Filling gaps in toxin spatial distribution

Activity Budget: $222,000

Activity Description:
This activity will address three gaps in our knowledge of the spatial distribution of urban toxins of concern. Efforts of the Twin Cities LTER will build preliminary maps of the distribution of common heavy metals across the area. We will collect additional soil cores to address three unknowns. First, while much attention has been paid to the urban core (St Paul-Minneapolis), we have less data on surrounding residential areas. Second, while past sampling has focused on lead, we have less data on other highly toxic metals (arsenic, cadmium) and metals associated with human activity (copper, zinc, nickel) that often have lower toxicity, but still significant effects. Third, we know little about spatial variation in emerging contaminants of concern, especially microplastics, which are increasingly recognized as a risk in terrestrial environments. While we know microplastics are a threat in lakes and rivers, recent research has shown they are elevated in many soils, such as those treated with "biosolids," and that microplastics in these soils can move into plants and animals. We will build on existing soil samples from 1000+ sites by sampling 150 new sites in priority urban and suburban areas and community gardens, and testing for microplastics in existing samples.

Activity Milestones:

Description	Approximate Completion Date
Determine undersampled regions for sampling metals, microplastics	December 31, 2022
Soil sampling of new priority sites, re-analyzing archived soil samples for microplastics	December 31, 2024
Map of spatial distribution of metals, microplastics across Twin Cities	May 31, 2025

Activity 2: Ecological restoration and toxin redistribution

Activity Budget: $238,000

Activity Description:
This activity will test the idea that pollinator gardens promote toxin movement away from surface soils where they are most likely to affect human health. We hypothesize that management that promotes deep earthworm activity (to 30+ cm) will promote the downward movement and dilution of both metals and microplastics. Pollinator plantings should favor such worm activity as the leaf litter of these plants have higher calcium content than grass, which promotes worm activity. In addition, open, sunny areas discourage activity of the invasive jumping worm, which is restricted to the upper 5 cm of soil and outcompetes worm species active at deeper levels (e.g., nightcrawlers). We will work with managers of yards, parks, and community gardens to contrast how within-site variation in management techniques relate to worm activity and soil toxin profiles over time. Within three sites with high soil lead, we will establish plots with traditional mowed lawn and contrast those with pollinator plantings (e.g., "bee lawns" with many fast growing legumes) where leaves decompose-in place, predicting that the distribution of soil lead will shift to greater depths (>30 cm) after 1-2 years.

Activity Milestones:

Description	Approximate Completion Date
Work with landowners to find sites and determine management tests	April 30, 2023
Sample worm communities over time with management methods	May 31, 2025
Sample soil profiles of metals, microplastics over time with management methods	June 30, 2025

Activity 3: Movement of toxins from soil to animals

Activity Budget: $150,000

Activity Description:

Activity 3 will address how the soil toxins studied in Activities 1 and 2 move into plants and animals in urban and suburban green spaces. Addressing this question has implications for understanding ecosystem services and wildlife health, in addition to acting as a warning system for how these toxins may also be moving into humans using the same spaces. We will focus on the hypothesis that ground-dwelling insects and mammals will show greater accumulation of soil toxins (metals and microplastics). Within insects, we will contrast ground-dwelling species of bees (e.g., Bombus) with stem- and cavity-boring species; within mammals, we will contrast ground-dwelling rodents (mice, voles) and tree-dwelling species (squirrels). We will collect specimens in areas that contrast in management strategies (see Activity 2 -- in areas with high to moderate soil contamination, five sites with extensive pollinator plantings and five sites with traditional lawns). We will measure metal content in legs from bees and fur samples from mammals; microplastics will be measured in mammal fecal samples, and through internal sampling of insects (e.g., studies suggest an accumulation in excretory organs). Finally, we will measure toxins in three focal plant groups common in these plantings (grasses, clovers, milkweeds),

Activity Milestones:

Description	Approximate Completion Date
Collect plants, pollinators to measure metals and plastics	May 31, 2024
Collect mammal samples (hair, feces, blood) to measure metals and plastics	May 31, 2024
Relate metal and microplastic load to spatial variation in management strategy	June 30, 2025

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Nic Jelinski	University of Minnesota (Soil, Water & Climate)	Lead soil sampling and analysis (Activity 1). Oversee lab work with research technician (who will receive funding).	No
Sarah Hobbie	University of Minnesota (Ecology, Evolution & Behavior)	Collaborate on worm sampling and experimental manipulation of worm communities (Activity 2).	No
Lee Frelich	University of Minnesota (Forest Resources)	Collaborate on worm sampling and experimental manipulation of worm communities (Activity 2). Co-mentor postdoctoral associate who will lead Activity 2.	Yes
Lee Penn	University of Minnesota (Chemistry)	Collaborate on microplastics sampling, analysis, interpretation, experimentation (Activities 1-3).	Yes
Matt Simcik	University of Minnesota (Public Health)	Collaborate on microplastics sampling, analysis, interpretation, experimentation (Activities 1-3).	Yes
Susannah Lerman	USDA (Forest Service)	Collaborate on pollinator studies (Activity 2, 3).	No
Adam Kay	University of St Thomas (Biology)	Collaborate on sampling, especially in community gardens (Activity 1-3)	No
Sharon Jansa	University of Minnesota (Bell Museum, EEB)	Collaborate on mammal sampling (Activity 3) and coordination with sample accessions at Bell Museum collections.	No
Cara Santelli	University of Minnesota	Direct soil chemistry analyses	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.
We will disseminate our findings to the academic community, relevant stakeholders, and the general public. We will communicate our findings to other scientists researching in this area through 5-8 publications, and 8-10 academic presentations, in addition to promotion of work on social media, and through the LTER network. We will communicate our findings to relevant stakeholders through webinars for specific audiences (e.g., lead and public health, bioremediation and ecological restoration) and regular email, report and meeting contacts with specific groups. We plan on regular (1-2 times a year) communication with local agencies concerned with the pollutants in this proposal, including the Minnesota Department of Health and the Minnesota Pollution Control Agency. We will continue growing existing contacts with these agencies. We will additionally communicate regularly with individual landowners, community gardens, parks, and other managers of sites where we will collect data. For instance, we are in regular contact with the Lower Phalen Creek Organization (corresponding every 1-2 months), sharing soil and plant data on heavy metal contamination at their site. We will more generally share the results of the research with the general public through public talks (e.g., Cedar Creek's "Lunch with a Scientist" series, which is also posted online), and through specific modules that communicate our research. For instance, through existing collaborations with the Bell Museum of Natural History, we plan to make a small exhibit in their pollinator demonstration garden about soil toxins, redistribution by

worms, and movement of toxins from soil to plants to pollinators. Finally, we expect that our publicly accessible toxin database will be of broad interest to not only researchers, but also individual landowners ("is my garden soil likely high risk?") and agencies interested in pollution exposure (e.g., what regions of the Twin Cities are high risk for other heavy metal exposure such as cadmium). As part of parallel work, we will be developing materials to distribute to landowners and garden managers on how to deal with metal contamination (e.g., soil amendments). In all presentations and publications, we will acknowledge ENRTF support through attribution language and/or the ENRTF logo, when applicable (e.g., in presentations, signs, or handouts). Distribution of findings on social media will tag ENRTF.

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?

This research builds on a recently funded project to establish the Twin Cities as a Long-term Ecological Research Station. The National Science Foundation LTER program is intended to build research infrastructure and support ecological research sites over decades. Faculty involved in the present proposal (Snell-Rood, Jelinski) are leading a component of the larger LTER project focused on responses of urban nature to spatial variation in soil toxins. ENRTF funding would support new research and data collection nested within the longer-term ecological research program. This structure, along with regular communication with relevant agencies, ensures the implementation and sustainability of this work.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Optimizing the Nutrition of Roadside Plants for Pollinators	M.L. 2017, Chp. 96, Sec. 2, Subd. 08a	$815,000

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount	$ Amount Spent	$ Amount Remaining
Personnel										
Emilie Snell-Rood		Project leader			36.5%	0.15		$25,000	-	-
Lee Frelich		Co-lead worm sampling (Activity 2)			36.5%	0.18		$12,000	-	-
Matt Simcik		Microplastics collaborators (Activities 1-3)			36.5%	0.05		$14,000	-	-
Lee Penn		Collaborator on microplastics (Activities 1-3)			36.5%	0.15		$22,000	-	-
Postdoctoral Associate		Direct Activity 2			25.4%	2.3		$162,000	-	-
Graduate student		Lead insect and mammal sampling (Activity 3)			43.5%	1.5		$85,000	-	-
Kat LaBine -- Soils research technician		Direct soil analyses (Activity 1)			36.5%	1		$69,071	-	-
Undergraduate field assistants		Assist in summer field work			0%	3		$36,000	-	-
Tim Mitchell -- Research Associate		Direct field design, yr 1 sampling			36.5%	1		$85,000	-	-
Cara Santelli		Direct soil chemistry analysis (Activity 1,2)			36.5%	0.1		$15,000	-	-
							Sub Total	**$525,071**	**$525,071**	**-**
Contracts and Services										
University of Minnesota Research Analytical Lab	Internal services or fees (uncommon)	(Laboratory Services): Soil N, P,K, organic matter ($12/sample) and metals (Pb, As, Cd = $15/sample). Estimate based on remaining soil and plant samples to process.				0		$33,676	$33,676	-
Northwestern University Quantitative Bio-element Imaging Center (QBIC)	Service Contract	ICP-MS analysis for heavy metal residues of small mass samples (insect legs, fur, plant pollen), charge by hour for instrumentation ($184/hr), technician time ($136/hr). Estimates based on current sample				0		$19,829	$19,829	-

		cost (about $15/sample) and projected samples to process. Paid through UMN-NW purchase order.								
Synchotron Use	Service Contract	Soil chemistry analysis. Costs less than originally anticipated as they fall without our personnel costs (our staff are running the samples at the facility)				0		$2,000	$2,000	-
							Sub Total	**$55,505**	**$55,505**	**-**
Equipment, Tools, and Supplies										
	Tools and Supplies	Lab and field supplies	Field and lab supplies for all activities: chemical reagents for soil testing, Materials and Supplies: Soil Texture = $3/sample, Soil pH = $2/sample, Electrical conductivity = $2/sample; For worm community sampling: shovels, tarps, water bottles, mustard powder, alcohol, screw-cap plastic test tubes, and a binocular 10-30x dissecting microscope, holding bins; Supplies for plant and animal sampling: Supplies for sampling communities of pollinator gardens: traps for mammals, holding bags for squirrels, sample vials/containers, nets and sampling vials for insects, bags/presses for plant parts, forceps, scissors and gloves for taking hair/fecal samples					$17,783	$17,783	-
							Sub Total	**$17,783**	**$17,783**	**-**
Capital Expenditures										

							Sub Total	**-**	**-**	**-**
Acquisitions and Stewardship										
							Sub Total	**-**	**-**	**-**
Travel In Minnesota										
	Miles/ Meals/ Lodging	Local travel to field sites for collecting specimens and soil sampling. All sites will be in the metro area, so mileage/gas is only of concern. We will be visiting at least 100 sites over the three activities, between 1 and 9 times each (depending on the activitiy)	Sampling for soil, toxins in soil (over time), pollinators/worm (over time), and small mammals					$3,326	$3,326	-
							Sub Total	**$3,326**	**$3,326**	**-**
Travel Outside Minnesota										
							Sub Total	**-**	**-**	**-**
Printing and Publication										
	Publication	Publication fees for resulting publications	Page charges associated with publication of results and management recommendations. Open access when possible.					$8,315	$8,315	-
							Sub Total	**$8,315**	**$8,315**	**-**
Other Expenses										
							Sub Total	**-**	**-**	**-**
							Grand Total	**$610,000**	**$610,000**	**-**

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						
Cash	National Science Foundation	NSF support of the toxins "sub-aim" of the recently funded MSP-Long-term-Ecological-Research project. Direct costs of $70,000 annually (plus IDC) will primarily support personnel to direct a related question on variation across pollinator species in tolerance of urban toxins, in addition to building spatial maps of toxins from existing data sets. These funds will also support efforts to establish field sites of pollinator plantings across the Twin Cities that will be the basis of sites in the present proposal.	Secured	$420,000	$420,000	-
In-Kind	University of Minnesota	In-kind services -- indirect costs associated with the requested funds.	Secured	$307,000	$307,000	-
			Non State Sub Total	**$727,000**	**$727,000**	-
			Funds Total	**$727,000**	**$727,000**	-

Attachments

Required Attachments

Visual Component

File: 8644881b-5b3.pdf

Alternate Text for Visual Component

This map shows areas of concern for elevated blood lead in children. Despite the 4-decade ban on lead, this toxin persists in many residential areas across Minnesota due to residual soil lead from leaded paint and gasoline. Elevated blood lead content -- at any level -- is a significant concern for cognitive development in children. Our research offers a possible method of ecological restoration that could reduce soil toxicity in green spaces across the state....

Supplemental Attachments

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

Title	File
Background check form	d1c0b0e1-d09.pdf
2022167 Snell-Rood research addendum	7549af87-00a.pdf
SPA authorization on updated budget	33e06af4-e03.pdf
Snell-Rood et al 2024: Pronounced declines in heavy metal burdens of Minnesotan mammals over the last century	bc942010-5ff.pdf
Agnew 2024: Using predictive risk assessment to aid bee conservation in heavy metal polluted landscapes	71c71d3e-69b.pdf
Darst et al, 2025: Geographic Range Size Predicts Butterfly Species' Tolerance to Heavy Metals More Than Evolutionary History With Toxic Larval Diets	1a0eafdb-bd8.pdf
Kemmerling et al 2025: Lead (Pb) concentrations across 22 species of butterflies correlate with soil and air lead and decreased wing size in an urban field study	ade5d0c9-47e.pdf

Media Links

Title	Link
Pig's Eye Regional Park: opportunities for ecological restoration and bioremediation. Public webinar with Great River Passage Conservancy.	https://www.youtube.com/watch?v=n7KbmXrhL50
2025 Minnesota Public Radio story on "U of M study finds lead contamination threatens butterflies"	https://www.mprnews.org/story/2025/06/20/lead-contamination-threatens-butterflies-u-of-m-study
2024 "Fill to capacity" podcast on monarch urban habitat and pollinator conservation	https://www.patbenincasa-art.com/fill-to-capacity-podcast/the-butterfly-effect-making-butterfly-magic
2023. The ecology and evolutionary biology of urban contaminants. August 2023. Cedar Creek Lunch with a Scientist Series	https://mediaspace.umn.edu/media/t/1_4dzx97c0
Darst et al, 2025: Geographic Range Size Predicts Butterfly Species' Tolerance to Heavy Metals More Than Evolutionary History With Toxic Larval Diets	https://onlinelibrary.wiley.com/doi/10.1111/eva.70114
Kemmerling et al 2025: Lead (Pb) concentrations across 22 species of butterflies correlate with soil and air lead and decreased wing size in an urban field study	https://www.sciencedirect.com/science/article/pii/S0048969725005352
Snell-Rood et al. 2024: Pronounced declines in heavy metal burdens of Minnesotan mammals over the last century	https://link.springer.com/article/10.1007/s11356-024-34667-y

Agnew et al. 2024: Using predictive risk assessment to aid bee conservation in heavy metal polluted landscapes	https://conservancy.umn.edu/items/7e8cf8c2-ecb9-4b76-8d73-c374ac36e7e2

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

In response to peer review, we have expanded the soil chemistry analysis to include the bioavailability of metals in the soil. To do so, we have added collaborator Cara Santelli, along with additional soil measurements. This has resulted in changes to the text and shifts in the budget (we reallocated expenses for grad student summer funding and supplies to cover these additional costs and will draw on other sources of support for the former).

Updated 6/15/22: I have added two sentences to "dissemination" to detail the ENRTF acknowledgment requirements and guidelines. I have also corrected the site discrepancy (to 150 additional sites for sampling). Thank you for catching this difference.

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

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	Explanation & justification for Amendment Request (word limit 75)	Date Submitted	Approved	Date of LCCMR Action
1	Amendment Request	• Other • Budget - Capital, Equipment, Tools, and Supplies • Budget - Personnel • Budget - Professional / Technical Contracts	We outfitted existing lab microscopes with external lights and filters to visualize microplastics, avoiding a capital expenditure cost. This method takes more time, so we have reallocated those funds to personnel time. We have also shifted categories for our external sample processing given spending so far.	December 3, 2024	Yes	December 4, 2024
2	Amendment Request	• Budget • Budget - Personnel • Budget - Professional / Technical Contracts • Budget - Capital, Equipment, Tools, and Supplies • Budget - Travel and Conferences • Budget - Printing and Publication • Budget - Non-ENRTF Funds Contributed • Attachments	We needed to spend less sample processing fees at external labs, running more at internal labs. Some personnel were supported less on this grant as originally anticipated. Publication fees were slightly higher for one journal than expected, while our final travel allocation to mostly nearby sites was less than budgeted for. We needed more supplies for microplastics extractions than expected this year. Final outcomes unaffected by changes.	August 12, 2025	Yes	November 3, 2025

Status Update Reporting

Final Status Update August 14, 2025

Date Submitted: October 24, 2025

Date Approved: November 3, 2025

Overall Update

Our research found that most sites in the Twin Cities have low levels of heavy metal pollution, with the exception of some hot spots in St Paul. We also found correlations between soil and air metal pollution and metal loads of insects and mammals living in those areas. Correlations between insect metal loads and areas where children have elevated blood lead levels suggest common environmental drivers. Time series of Minnesota mammal skins show that overall heavy metal pollution has declined in the state over the last 100 years. In terms of mitigation, our hypothesis that worm activity might promote lead burial in natural areas did not hold in the field. However, that study found unexpected links between tree cover and soil lead, suggesting interactions with air pollution. Overall, this research points to areas of concern for heavy metal pollution in Minnesota, for both people and wildlife: we should direct risk assessment and mitigation in areas with old infrastructure and current aerial deposition. We are following up with current investigations of the sources of current hotspots of lead pollution, using stable isotope tracers, and the use of biochar as a potential method of mitigating heavy metals and microplastics in urban soils.

Activity 1

Our first activity sought to fill in gaps in heavy metal and microplastic pollution across the region. We sampled over 200 new sites in urban and suburban areas as part of this work, combining data with over sampling from over 1500 samples from other studies. Analyses to date have shown that levels of heavy metal contamination in parks and other metro sites tends to be low, and high lead levels are associated with a few hotspots (e.g., East St Paul). Some of these soil analyses play an integral part of our studies with metal movement through the food chain (Activity 3; Kemmerling et al. 2025), while ongoing analyses will provide more detailed maps of contamination. While most surveys of metal pollution focus on lead, we have also been considering other heavy metals. Our findings suggest that cadmium and arsenic may be of more concern than previously appreciated in the metro area (Darst et al. 2025). Additional funding has been secured to complete microplastic sample processing by May 2026, but analyses to date suggest that a great diversity of microplastics are found in urban soils, although primary sources are unclear (possibly compost sources).
(This activity marked as complete as of this status update)

Activity 2

In this activity, we sought to test the hypothesis that worm activity may cause pollution deposited at the soil surface to move deeper into soil layers where it would be less accessible to humans and wildlife. Across 20 parks in the Twin Cities, we surveyed worms and soil lead in pollinator plantings, lawns and forests. In a manuscript currently in revision, we report generally low levels of lead pollution across these parks, with a few hotspots in East St Paul. While we found some evidence of lead burial, we found no evidence that differences in worm activity across parks was causing these differences in burial rates. We did find that lead levels were higher in wooded parts of parks than open areas, leading to follow-up research on the role of trees in aerial deposition of metals from polluted air. Additional analyses on the bioavailability of lead from these soil samples is in progress, aiming for publication in 2026. Because we did not find support for the idea of worms as mitigators of lead pollution, our current remediation work is focused on the role of soil amendments like biochar in binding soil heavy metals and microplastics.
(This activity marked as complete as of this status update)

Activity 3

We sought to understand movement of heavy metals into urban wildlife. We found that lead in soil and air, but not plants, is related to metal loads in urban butterflies, but butterfly species vary in metal tolerance. We found that species

of bees that nest in the ground carry higher heavy metal loads than those that nest in stems (Agnew 2024) and insects in areas of elevated childhood blood lead levels also have elevated body lead (Kemmerling in revision). A time series of mammals from the Bell Museum Natural History collection showed declines in lead levels in Minnesota over the last 100 years (Snell-Rood 2024) and higher metal loads in carnivores than herbivores. Analyses in progress will relate behavioral variation in squirrels to differences in lead exposure (Devitz, dissertation) and effects of soil chemistry on lead bioavailability. Overall, our results suggest (a) shared environmental drivers of lead exposure in humans and insects, and point to soil and air pollution as more of a concern than eating urban plants and (b) heavy metal pollution was more stressful to Minnesota wildlife a century ago than today, but continued exposure (including in humans) is a concern in some areas.
(This activity marked as complete as of this status update)

Dissemination
Across this project, we have communicated our findings in talks, webinars, media releases and peer-reviewed publications. Recently, Minnesota Public Radio highlighted two of our 2025 publications on lead pollution in Twin Cities butterflies. We have given over a dozen talks on this work, including at international and national conferences, public webinars, and seminars to garden clubs and master gardeners groups. We have four publications in print (to date), two in revision, and four in preparation for submission in the next year. Published papers and links to online media are included in the supplement. While no management recommendations were produced given that our results did not align with our original hypothesis, it led to two current studies (a) tracing the sources of lead hotspots using stable isotopes and (b) investigating the use of biochar as a soil amendment to bind metals. With these follow-up studies, we have longer term plans to write pieces for more general audiences (e.g., through UMN extension and/or news media) on local sources of pollution and recommendations for how to deal with metal and microplastic pollution in their yard or gardens.

Status Update Reporting

Status Update March 1, 2025

Date Submitted: March 1, 2025

Date Approved: March 11, 2025

Overall Update

Over the last six months, we have made substantial progress in data analysis and manuscript submission. Three papers have been submitted, all with associated data that will be publicly available, and several more are in preparation to be submitted later this year. Lab analyses continue on microplastics in urban soils and animals (to be completed this spring). Major findings to date show correlations in heavy metal pollution -- areas where humans have high blood lead levels, insects in that space also have high levels, suggesting common environmental drivers. Correlations with soil and air indicators (lichens) confirm this idea. Most parks in the Twin Cities have low levels of metal pollution, with the exception of some hot spots in St Paul that we are investigating in more detail.

Activity 1

Mapping metals and microplastics across the Twin Cities -- Soil data on heavy metal variation across the Twin Cities is being published alongside the paper on worm activity (currently in review). The dataset has been submitted to the Environmental Data Initiative and also has been shared with the Minnesota Pollution Control Agency. In the meantime, the paper testing correlates of spatial variation in soil metals is being led by a graduate student and should be submitted this year, containing more extensive maps of the metal pollutants. In addition, we are in the process of lab analysis of soil microplastic variation across about Twin Cities sites, to be completed by May.

Activity 2

Worms, habitat and soil metals -- We submitted our manuscript on soil lead (Pb) levels with depth, and correlations with worm activity to Science of The Total Environment. The paper reports generally low levels of lead across Twin Cities parks, with a few hotspots in East St Paul. While we found some evidence of lead burial, we found no evidence that differences in worm activity across parks was causing this differences in burial rates. Our findings suggest we need future studies to determine why lead levels were higher in some wooded areas, e.g., whether trees are increasing aerial deposition in places with lead as an air pollutant. A second paper led by the lab of co-PI Santelli is in progress, focusing on the bioavailability of lead in these soils.

Activity 3

Variation in metals across species -- In the last six months, we submitted two papers summarizing our work on urban pollinators and heavy metal loads. In one paper (in press), we show that individuals in areas with high human blood lead levels have high body lead content, and that soil and air routes of exposure are of concern for pollinators in the Twin Cities. In the second paper (in revision), we show that butterfly species with wider ranges and an evolutionary history with plant toxins are both more tolerant of urban metal pollution. We are also close to submitting a paper on lead levels in wasps and other insects in pollinator plantings, also showing spatial correlations with human lead exposure, suggesting common environmental drivers of lead exposure across animals in the city. A paper on squirrel heavy metal content should be submitted this year.

Dissemination

PUBLICATIONS

Kemmerling, LR, AL Darst, M Adabag, NM Koch, EC Snell-Rood. Lead (Pb) levels in soil and air correlate with lead concentrations and decreased wing size across 22 species of butterflies in an urban field study. In press, Science of the Total Environment.

Darst, AL, L Kemmerling, M Tilsen, A Eilts, EC Snell-Rood. Geographic range size predicts butterfly species' tolerance to heavy metals more than evolutionary history with toxic larval diets. In revision, Evolutionary Applications.

Mitchell, TS, J Duncan, K Koraleski, G Marti, G North, L Frelich, N Jelinski, EC Snell-Rood. Vertical distribution of lead in park soils, and the role of earthworms as bioturbators. In review, Science of the Total Environment

TALKS

Heavy metal pollution in the Twin Cities and relevance for invertebrates. Sept 2024. Xerces Society workshop on soil invertebrates. St Paul, MN.

Pig's Eye Regional Park: opportunities for ecological restoration and bioremediation. Public webinar with Great River Passage Conservancy. https://www.youtube.com/watch?v=n7KbmXrhL50

Making use of pockets of habitat for pollinators. Presentation to Anoka County Master Gardneners.

Status Update Reporting

Status Update September 1, 2024

Date Submitted: August 31, 2024

Date Approved: September 16, 2024

Overall Update

Over the last six months, we have concluded field work for Activity 3 and continued and finished processing samples for Activity 2. We published our first paper resulting from this grant (see attachments) and presented findings on insects and mammals at three national conferences. We have continued communication with the Minnesota Pollution Control Agency in addition to individual community partners related to findings in particular sites (e.g., Great River Passage Conservancy, Urban Roots, Como District 10 neighborhood association). We are deep in the writing of papers, including two on butterfly metal loads, two on spatial variation in soil heavy metals, two on pollinator plantings and effects on worm activity and soil metal bioavailability, two on squirrel behavior and effects on pollutant exposure, and one on bee metal loads across the Twin Cities.

Activity 1

Mapping toxins -- In the last six months of our project, we have continued to grow our database of soil samples of the Twin Cities, in particular with high resolution sampling of the Pig's Eye Regional Park, a past landfill and superfund site in East St Paul (350 samples) and a handful of other new sites sampled summer 2024. We shared data updated through 2023 with the Minnesota Pollution Control Agency and have staged data collected through 2022 (about 2000 samples) with the Environmental Data Repository. We anticipate data to be publicly available through this site with annual updates. co-PI Jelinski is working on a manuscript summarizing spatial variation in metal lead levels.

Activity 2

Worms, habitat and soil metals -- We have completed analysis of experiments conducted in the first two years of the project, and the resulting manuscript is close to complete. Analyses show that worm activity is not correlated to metal redistribution; instead, metal distribution seems fairly uniform across soil depths and worm activity fairly uniform across parks and habitat types. In addition, lead levels were low overall across parks. If worm activity does redistribute soil toxins in the Twin Cities, it is likely across a time scale of years as opposed to months, although this may depend on local drought conditions. A second paper led by the lab of co-PI Santelli focuses on the bioavailability of lead in these soil, and how that may be influenced by leaf litter variation between lawns, pollinator plantings, and woodland.

Activity 3

Variation in metals across species -- In the last six months, we published out findings on metal content of mammals across species and over the last 100 years in Minnesota (see attachments). We presented findings at two conferences summarizing butterfly heavy metal loads across the Twin Cities and we are working on the two papers summarizing this work (hoping to submit them both in the next six months). In this work, we ask how soil and air pollution relate to loads of heavy metals in butterflies (they both do). In addition, we show that species with wider ranges and an evolutionary history with plant toxins are both more tolerant of urban metal pollution. This summer we finished field work on urban squirrel behavior and pollutant exposure, relating spatial variation in lead exposure to fear responses using field flight-initiation distance measures in different urban parks. An honors student on this project presented findings relating soil lead levels to squirrel body lead content (this paper is also in prep for submission).

Dissemination

Conference presentations:

L. R. Kemmerling,, A Darst, M Adabag, and E. C. Snell-Rood. Heavy metal loads of urban butterfly species and correlations with body condition. Research talk. Ecological Society of America's Annual Meeting. Aug 2024.

Snell-Rood, EC, L Kemmerling, A Darst. July 2024. The effects of evolutionary history with mutagens on the tolerance of butterflies to heavy metal pollution in urban environments. Society for the Study of Evolution, Montreal, Canada.

Devitz AC. Squirrels and the city: Behavioral variation as a mediator of performance in two urban squirrel species. Animal Behavior Society Annual Meeting. Research talk. July 2024.

Publications
Research on temporal and spatial variation in heavy metal burdens in Minnesota mammals was published: https://link.springer.com/article/10.1007/s11356-024-34667-y

Honors Thesis Presentation
Rachel Schulz, Amy-Charlotte Devitz, Emilie Snell-Rood. From Soil to Squirrel: The Legacy of Lead Pollution & Its Effects on Urban Wildlife Behavior. May 2024.

Outreach
Project lead Snell-Rood discussed general ideas about pollinator plantings in this podcast: https://www.buzzsprout.com/2228761/15589402

Status Update Reporting

Status Update March 1, 2024

Date Submitted: March 18, 2024

Date Approved: May 30, 2024

Overall Update

Over the last six months, we have concluded field work and experiments for Activity 2, and finishing processing samples from the 2023 field season for Activity 1 and Activity 3. We have submitted one paper (on mammal heavy metal loads) and are in progress on analysis and/or writing for an additional nine papers. Results to date have highlighted how metal levels of urban wildlife are lower today than 100 years ago, but are elevated in areas where people also have high blood lead levels. It is likely that residual soil lead levels and new atmospheric deposition are combining to affect current exposure. We are in regular communication with MPCA to share our findings. We have leveraged additional funding to take this research in new directions, including sampling stormwater pond pollutants (which started in January) and investigating biochar as an amendment to mitigate urban metal pollution (in progress). Note that additional funding supports new work that does not overlap with the work in the present proposal (e.g., extends it to stormwater ponds and urban farms).

Activity 1

Mapping toxins -- In the last six months of our project, we have continued to grow our database of soil samples of the Twin Cities, with the addition of about 100 soil samples from 40+ new sites sampled in 2023. We are updating our spreadsheets and preparing to draft new maps of soil metal distribution; updated data will also be shared with the Minnesota Pollution Control Agency (who mapped it to childhood blood lead levels). While we will continue to add soil data to this database during upcoming field seasons, we are planning to write, this spring and summer, the initial paper summarizing our findings to date. Leveraging funding from the Institute on the Environment, we have hired another technician to expand microplastics measurements in soils (and leaves) from urban farms and roadsides. Levering funding from the Minnesota-Futures program, we have expanded our mapping efforts to include stormwater ponds. These projects represent new (complementary) research directions. All spatial data will eventually be available as one composite database. Finally, we have continued to grow partnerships with community organizations related to contaminant sampling, including starting collaborations with Great River Passage and St Paul Parks at Pig's Eye Regional Park.

Activity 2

Worms, habitat and soil metals -- We have completed field work and experiments with respect to this aim. In October and November, we sampled the worm communities of our 20 field sites (180 subsites). In January, we completed the initial measurements (pXRF of Pb) of the almost 2000 soil samples collected from different depths at these soil sites, and are currently measuring organic content, pH, soil texture, and bioavailability of lead. In December we concluded a microcosm experiment of worm activity in the lab, finishing soil measurements from this experiment in January. Preliminary analyses suggest that levels of lead pollution in urban parks is overall very low (which is good) with the exception of several parks in East St Paul, which we have flagged in other studies. Overall, worm activity does not seem to differ much between habitat types, contrary to expectations, and lead levels were much more uniform than expected across soil depths. In addition, we found lead levels to be higher under tree canopies, a result we will follow-up with experiments this summer. We are currently testing whether organic matter input in prairies versus lawns affects lead bioavailability. Resulting papers are in progress.

Activity 3

Variation in metals across species -- We submitted the manuscript studying variation in metal content of mammals across species and over the last 100 years in Minnesota. We have completed analysis of butterfly heavy metal loads

from our 2023 field season and are currently writing two papers summarizing these findings. All analyses to date support our initial observation that pollinators from areas with high human blood lead levels, also have high body lead content, suggesting common environmental drivers of metal exposure. Relative to the start of this project, we are now more concerned with air deposition of lead from hot spots like the St Paul Regional Airport, e.g., https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-lead-emissions-aircraft. This summer we are finishing up collections related to current urban mammal pollution exposure, complementing yard and park sampling of squirrels and chipmunks (completed summer 2023) with using road kill to measure metal loads of animals from less sampled areas. Finally, leveraging funding from Institute on the Environment, we have also begun experimenting with microplastic exposure effects on butterfly development, completing an experiment on polyethylene particle exposure in caterpillar development (surprisingly, it had minimal effects).

Dissemination

Since our last report, we have submitted one paper ("Pronounced declines in heavy metals within Minnesota mammals over the last century." In review, Environmental Science and Pollution Research) and participated in a public event on microplastics (https://cbs.umn.edu/blog-posts/fantastic-plastic-you). Postdoc Lindsey Kemmerling presented a talk "Butterfly heavy metal tolerance predicts long-term trends in species abundance" at the Ecological Society of America Conference (August 2023, neglected to report in last update). We are actively working one papers on butterflies (2), bees (2), squirrels (1), worms (1-2) and soil mapping (2). Finally, we published a related paper on using cabbage white butterflies to measure metal tolerance in insects that includes open access video resources: https://www.jove.com/t/65383/rearing-cabbage-white-butterfly-pieris-rapae-controlled-conditions.

Status Update Reporting

Status Update September 1, 2023

Date Submitted: August 23, 2023

Date Approved: September 27, 2023

Overall Update

In the second six months our project, we have made significant progress processing samples from the 2022 field season, in addition to sampling additional soils, plants, and animals from the 2023 field season. We have made particular process on Activity 2, collecting 1500+ soil samples to measure the effects of worm activity and metal redistribution in areas that vary in landscape management (e.g., lawn versus prairie planting for pollinators). We have worked with community partners to remediate soil in sites with high lead levels (leveraging additional external funding) and met with MPCA to share data and leverage sites of concern in our sampling efforts. We have presented preliminary data to the public at the Lunch with a Scientist Cedar Creek series, and are actively working on several manuscripts with more formal data analyses. Recent preliminary analyses highlight concerns with lead in air pollution in East St Paul (e.g., from the regional airport) and on average lower levels of lead in urban parks and community gardens relative to some yards in high lead areas. Over the next six months, we will be working to process the samples amassed during the 2023 summer field season and running worm field sampling.

Activity 1

We have made progress in five major areas with respect to Activity 1. First, we have continued our analysis of and addition of soil samples to our growing database of soil chemistry (data back from 75+ 2022 sites and samples from 50+ new sites in 2023). Second, we have made progress building maps of soil metals in the Twin Cities and shared findings and data with the MPCA. Third, we have setup protocols and equipment in the lab to measure microplastics in soil and leaf samples. Finally, we have submitted a proposal for synchrotron time to measure metal bioavailability and chemistry. Finally, we have further developed relationships with several community organizations related to their soil contamination, including Urban Roots in East St Paul (concerns with lead contamination), the Como district 10 association (concerns with chromium contamination at a past superfund site), and the Tamales y Bicicletas community garden in the the Phillips neighborhood (concerns with lead and arsenic). For the latter garden, we have also helped with soil and garden remediation through purchasing of soil and raised bed supplies through an external grant from the Engaged Scholarship Consortium.

Activity 2

We have made progress in three areas with respect to Activity 2. First, we have established 20 field sites -- with three subsites that vary in land management. All sites were sampled for soil in July/August 2023, with 1500+ total samples -- we are in the process of using XRF to measure soil Pb and metal content in 5-cm increments through all of the cores we have taken. Worm communities will be sampled at these sites in September and October (when all species are adults and can be identified). Second, we have designed and setup a microcosm experiment testing how two worm species (jumping worms and nightcrawlers) redistribute lead from contaminated soil surfaces depending on the leaf litter present (corresponding to our three habitat types -- lawn, pollinator prairie plantings, woods). This experiment is in process and the worms will have a few months to work the soil prior to measuring the Pb concentration throughout the buckets they are in.

Activity 3

We have made progress in three areas with respect to Activity 3. First, we have analyzed metal content data from butterflies and bees collected in 2023 and added new samples from the 2023 field season. With initial findings that bee and butterfly lead levels were higher in areas with high childhood blood lead levels, we have been collecting a few other insect species to test whether the whole community is generally experiencing similar environmental exposure to lead.

We are in the process of writing up two butterfly papers from the 2022/2023 field seasons, one focused on variation across species in tolerance to metal exposure, and one focused on ecological questions, e.g., that more metal susceptible species are suffering greater declines. Second, we have added more small mammal field sampling in 2023 targeted towards areas of the cities with higher metal pollution. Finally, we have started to write up our analysis of metal content of four species of mammals which shows high metal body content 100 years ago, especially for lead.

Dissemination

During the last six months, we have communicated our ideas, plans, and data-to-date in a variety of presentations. We have had two meetings with people at the Minnesota Pollution Control Agency, sharing data, learning about regions of the cities that might need more monitoring, and getting input on risk assessment for metals like chromium. We also presented this work to 100+ people attending the Cedar Creek Ecosystem Science Reserve "Lunch with a Scientist" series (the recording can be found here: https://mediaspace.umn.edu/playlist/details/0_vgw1dd3y/categoryId/170150001). We are actively working on four publications related to the data we have so far (mammals over time, two butterfly papers, one on bees), and expect work to start on another three this winter (one on worms, one on squirrels, one on soil).

Status Update Reporting

Status Update March 1, 2023

Date Submitted: February 27, 2023

Date Approved: March 6, 2023

Overall Update

In the first six months of our project, we have made progress sampling soils, plants, and animals from over 60 new sites from across the Twin Cities Metro area. Mapping efforts so far have highlighted pollution from metals aside from lead and have confirmed correlations between soil lead content and childhood blood lead levels in collaboration with the MPCA. We are in the process of analyzing the bioavailability of lead and other metals from many of these sites. Analysis of animal samples (pollinators, some mammals) from the Twin Cities and greater Minnesota has so far shown that metal concentrations have declined drastically over the last 100 years for metals such as lead and arsenic, but some metals such as copper and zinc have shown increases. Pollinators vary in their bioaccumulation and tolerance to metals, with hints that species undergoing stronger declines are also less tolerant of metal pollution. Finally, we are getting sites and experiments setup for upcoming tests linking worm activity to metal redistribution in the soil.

Activity 1

We have made progress in four major areas with respect to Activity 1. First, we have added soil samples from over 75 new sites to our growing database of soil chemistry. Many of these sites are from under-sampled areas, such as green spaces, community gardens, and suburban sites. Second, we have begun mapping efforts for our soil datasets for 1000+ sites. While previous analyses have focused on lead, we have expanded to other metals, finding some appear to be correlated with lead (e.g., zinc) while others are much patchier (e.g., copper, chromium). We are working to expand our current maps (which focus on St Paul) to the entire Twin Cities Metro Area, in addition to coordination with the Minnesota Pollution Control Agency around data of human health concern. Third, most of our analyses to date have focused on heavy metals, but we have made progress on the methodology for measuring microplastics in our growing library of soils. Finally, we have taken more frozen samples from a subset of sites for more detailed analysis of metal bioavailability and metal chemistry (about 40 sites, analysis in progress).

Activity 2

We have made progress in four areas with respect to Activity 2. First, we did pilot sampling at 12 sites (fall 2022) that included lawn, prairie, and wooded habitats within the site. As much prior worm work in the area has focused on wooded habitats, we were interested differences in worm abundance in the habitat types we hoped to compare, in order to design our sampling for 2023. Interestingly, worm abundance was comparable across habitat types, if anything, trending higher in the prairie plantings relative to the wooded areas. Second, we began preparation for a microcosm experiment to complement the field observations, collecting litter from all three habitat types, and planning a setup to measure worm soil pollutant redistribution in the lab (starting in April). Third, we visited 80 lawn sites as part of the “bee lawn” study we are loosely affiliated with, scouting these as potential sites for worm sampling. Finally, we are using winter months to use this information, and data on other sites in the metro area to plan out field sampling for the 2023 worm field season.

Activity 3

We have made progress in three areas with respect to Activity 3. First, we collected extensive invertebrate and plant samples during the 2023 field season (over 700 butterflies, 40 bees, 12 wasps, 30 snails, 50 plants). While we are in the process of data analysis (and awaiting data for a subset of samples), we can say there are significant differences in metal loads across species and sites. Butterflies from areas of high soil metal content tend to have higher body metal content, and some species appear more tolerant of increasing metal loads than others (e.g., cabbage white butterflies). Second, we have built on sampling of wild squirrels and chipmunks with samples from the Bell Museum Mammal collection to

test hypotheses about differences in mammal metal content. While species matters (with higher trophic level species having higher metal contents), perhaps most important is date of sampling – over the last 100 years, body lead content has dropped over 20 times (good news) in Minnesota mammals (so far, a mouse, squirrel, bat and vole). Third, while we do not yet have data on microplastic levels, we have made progress in our methods to extract and measure microplastics from mammal fecal samples. We are

Dissemination

During the last six months, we have communicated our ideas, plans, and data-to-date in a variety of presentations. We have had great communications with the Minnesota Pollution Control Agency, giving a seminar for 50+ people in January, followed by individual connections and meetings with MPCA members with overlapping interests in our contaminants work. We also presented this work to the Como District 10 Community members associated with a pollinator planting they are putting in on a chromium-laden plot. We also continued regular meetings with several community partners where we have sampled soils and invertebrates, including Urban Roots, the Lower Phalen Creek Project, Tamales y Bicicletas, and the Urban Farm and Garden Alliance.