Environment and Natural Resources Trust Fund

M.L. 2022 Approved Work Plan

General Information

ID Number: 2022-167

Staff Lead: Mike Campana

Date this document submitted to LCCMR: June 15, 2022

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

Date Work Plan Approved by LCCMR: June 27, 2022

Reporting Schedule: March 1 / September 1 of each year.

Project Completion: June 30, 2025

Final Report Due Date: August 14, 2025

Legal Information

Legal Citation: M.L. 2022, Chp. 94, Art. , 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
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		$144,000
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%	1.1		$71,000
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	**$509,000**
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)				0		$25,000
Northwestern University Quantitative Bio-element Imaging Center (QBIC)	Professional or Technical 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 work with pollinator parts, averages $15/sample. Paid through UMN-NW purchase order.				0		$18,000
Synchotron Use	Professional or Technical	Soil chemistry analysis				-		$10,000

	Service Contract							
							Sub Total	**$53,000**
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					$15,000
							Sub Total	**$15,000**
Capital Expenditures								
		Microscope and camera attachment for fluorescence measurements	Existing microscopes in the Snell-Rood lab (original cost $30K) will be outfitted with attachments for fluorescence. These updates are necessary for staining and visualization of microplastics in insect, plant, and mammal samples.					$18,000
							Sub Total	**$18,000**
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					$7,000
							Sub Total	**$7,000**
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.					$8,000
							Sub Total	**$8,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$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
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
In-Kind	University of Minnesota	In-kind services -- indirect costs associated with the requested funds.	Secured	$307,000
			Non State Sub Total	**$727,000**
			Funds Total	**$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....

Optional Attachments

Support Letter or 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

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?

Yes

Do you agree travel expenses must 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 agree to the UMN Policy.

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

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

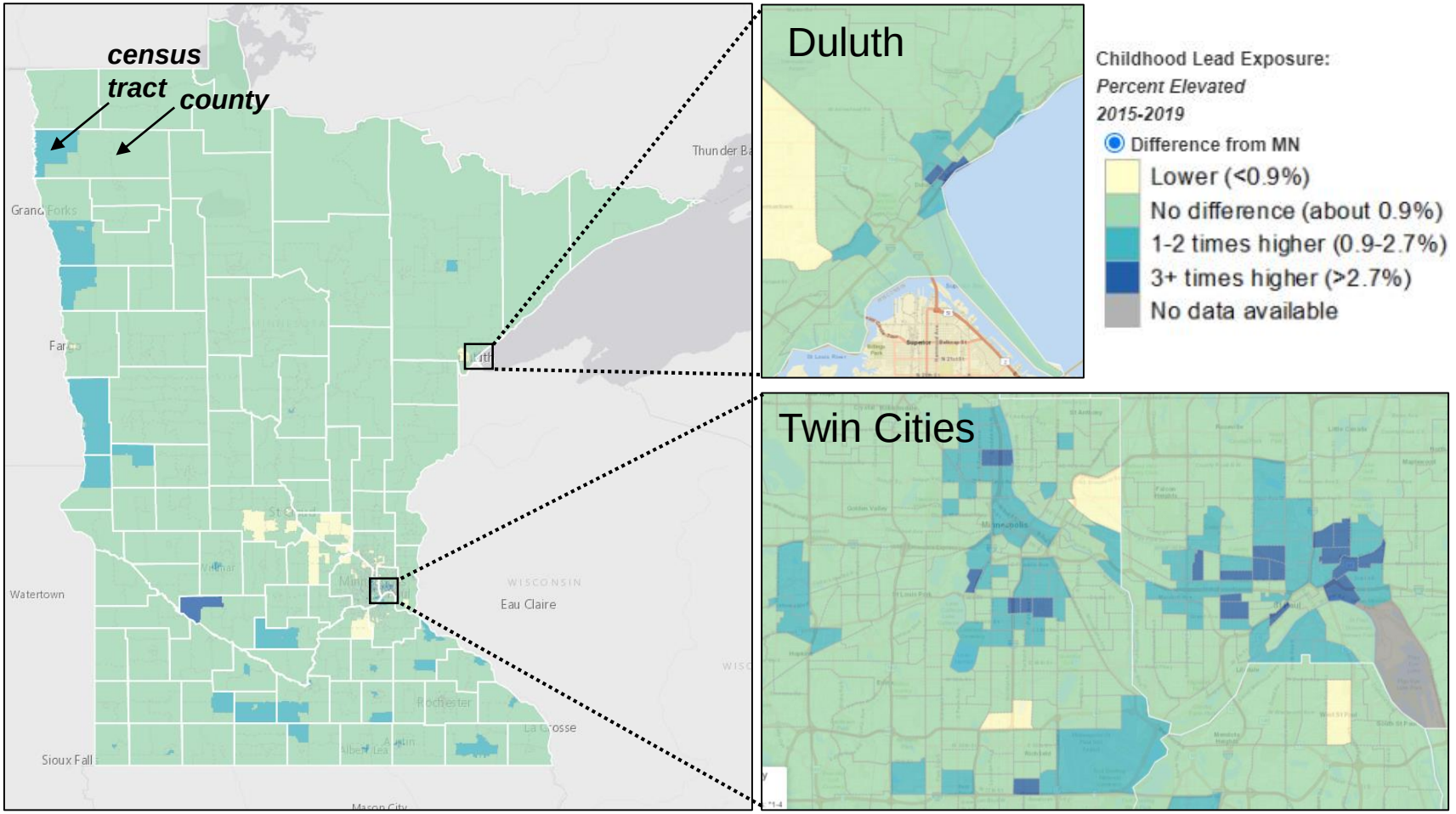
Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Minnesota regions of elevated childhood blood lead levels (by census tract)



Each data block corresponds to a census tract (generally 600-3000 people); white lines indicate county boundaries. Dark blue indicates >2.7% of child blood lead tests are elevated; light blue indicates 0.9-2.7% of child blood tests are elevated. Elevated child blood lead is often correlated with elevated soil lead (from residual leaded paint or gasoline).
All data from – MN Dept. of Health: https://mndatamaps.web.health.state.mn.us/interactive/leadtract.html