Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-233

Proposal Title: Determining Urban Forest Patch Health and Regeneration

Project Manager Information

Name: Christina Smith-Martin

Organization: U of MN - College of Biological Sciences

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Project Basic Information

Project Summary: The future of urban tree canopy depends on forest health, regeneration, and resilience to perturbation, which are currently unknown. We will determine these factors that are key to active management and

ENRTF Funds Requested: $577,000

Proposed Project Completion: June 30, 2030

LCCMR Funding Category: Resiliency (A)

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

Narrative

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

Urban forest patches and other green spaces in cities are fundamental for human mental health and wellbeing, mitigate climate change through carbon sequestration, and provide urban cooling through evapotranspiration. Despite their importance, urban forest patches are not actively managed and monitored. Thus, we do not know for certain the state of these patches now and how they will change in the future. Size and disturbance of urban forest patches are expected to dictate tree health, forest regeneration, and resilience. Smaller urban forest patches with greater edge effect and with a higher number of invasive species are expected to have less healthy trees that will be more likely to die from extreme weather events (e.g., heatwaves and drought), pest outbreaks, and degrade over time, making these forest patches less resilient than larger urban forest patches with smaller edge effect that have less buckthorn and earthworms. However, we do not know if it is true that trees in smaller urban forest patches are actually less healthy than those in larger patches, and research is needed to determine the overall health of these patches and how they can be managed for their long-term resilience.

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.

We will determine urban forest health, regeneration, and resilience by monitoring 50 pre-established plots in forest patches with different degradation levels based on patch size, canopy cover, and abundance of invasive species (buckthorn, earthworms). We will conduct annual damage and mortality surveys of all canopy trees in the 50 plots, understory vegetation census to determine canopy tree seedling recruitment, and buckthorn and earthworm abundance. We will measure high-resolution growth and physiology of the eight dominant tree species in the plots (Box elder, Black ash, American elm, Red oak, Bur oak, Basswood, Pin oak, and Sugar maple) to determine each species' performance in relation to forest patch degradation.

To upscale these measurements at landscape level, we will use remote sensing to determine canopy cover, forest structure, and patch productivity over time. To determine canopy cover fraction and forest structure (i.e., canopy height, leaf area index), we will use airborne and terrestrial Light Detection and Ranging (LiDAR). Patch productivity over time will be estimated using Sentinel-2 multispectral imagery and vegetation indices (e.g., Normalized Difference Vegetation Index). National Agriculture Imagery Program (NAIP) images will be used to calculate landscape composition and configuration metrics related to habitat fragmentation and edge effects.

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?

Findings from this project will provide valuable insight into how disturbance pressure affects the health and regeneration of canopy trees in urban forest patches. Determining which canopy tree species perform better or worse in the face of pressures from edge effects and patch invasion by buckthorn and earthworms, as well as which canopy trees are being naturally recruited. This will allow us to make recommendations to stakeholders who manage the studied urban forest patches, as well as other forest patches across the metro area and statewide, regarding patch management in the face of disturbance and species selection for restoration.

Activities and Milestones

Activity 1: Remotely sensed monitoring of urban forest patches and surrounding landscape

Activity Budget: $265,000

Activity Description:
Urban forest structure will be measured in the field using a terrestrial laser scanner (LiDAR) annually. We will estimate tree diameter at breast height (dbh), canopy height, and leaf area index, which are variables defining forest productivity. A reduction in forest canopy cover over time indicates forest degradation. We will measure forest canopy cover using airborne lidar in combination with Sentinel-2 multispectral imagery. Airborne lidar was collected for the metro area in 2022 with very high point density (high-quality data). Patch canopy productivity will be monitored annually using Sentinel-2, which provides multispectral imagery with a pixel size of 10 m in a biweekly cycle. In addition to describing forest patch structure and function using lidar and Sentinel-2, we will describe the surrounding landscape. Landscape composition and configuration influence forest patch dynamics strongly. Using very-high spatial resolution imagery from NAIP, we will calculate forest patch size, perimeter, density, distance to roads and trails, and connectivity. Data used in this activity is publicly available and free, and we will provide the resulting code and maps as open access.

Activity Milestones:

Description	Approximate Completion Date
Measuring urban forest patch structure with airborne LiDAR	July 31, 2028
Calculating forest canopy fraction using LiDAR and Sentinel-2 data	July 31, 2028
Measuring urban forest patch structure with terrestrial LiDAR annually during tree census	August 31, 2029
Estimating forest patch productivity using Sentinel-2 multispectral imagery	December 31, 2029
Determining composition and configuration of the surrounding landscape using NAIP	June 30, 2030

Activity 2: Annual damage and mortality surveys of canopy trees, understory vegetation census, and measure earthworm abundance

Activity Budget: $169,000

Activity Description:
The objective of this activity is to determine the health of the canopy trees, the regeneration of the canopy tree species through recruitment, and the degree of invasion by buckthorn and earthworms of urban forest patches. We will tag all ~700 canopy trees in the 50 plots to continuously monitor each tree. Annually, we will conduct damage and mortality surveys of all canopy trees in the plots, assessing tree mortality and, for alive trees, broken branches, signs of pests, and diseases. In each of the 50 plots, we will conduct annual understory vegetation censuses in eight 1x1m subplots, counting canopy tree seedlings and percent cover of buckthorn. Annually, in two 1x1m subplots per plot, we will measure earthworm abundance. These activities will track canopy tree health and mortality across plot degradation levels and determine which canopy species are performing better and which worse, whether any are recruiting, and changes in buckthorn and earthworm invasion over three years. These outcomes will show forest patch health and to what degree this is influenced by forest patch size and buckthorn and earthworm invasion, and can be used to manage these and other urban forests for their long-term resilience.

Activity Milestones:

Description	Approximate Completion Date
Tag the approximate 700 canopy trees in the 50 plots and take GPS point	August 31, 2027
Conduct tree annual damage and mortality surveys	August 31, 2029
Conduct understory vegetation censuses and measure earthworm abundance	August 31, 2029

Write a report with recommendations on best management practices for ensuring urban tree canopy health	June 30, 2030
Write a manuscript to submit to a scientific peer-reviewed journal with the results from Activity	June 30, 2030

Activity 3: Measuring high-resolution growth and plant physiology of the dominant tree species in the 50 plots

Activity Budget: $143,000

Activity Description:

The objective of this activity is to determine growth and physiology of the most abundant canopy tree species across forest patches with different degradation levels based on patch size, canopy cover, and abundance of buckthorn and earthworms. Using the eight most common canopy tree species in the 50 plots (Box elder, Black ash, American elm, Red oak, Bur oak, Basswood, Pin oak, and Sugar maple), we will select 18 trees per species growing in plots with levels of degradation (144 trees in total). On each tree, we will install a point dendrometer, which will continuously log the growth of each tree trunk. Once per year, at the beginning of winter, we will extract a small increment core of sapwood to measure stored products of photosynthesis (soluble sugars and starch), which will tell us how healthy a tree is. Trees with more growth and more stored products of photosynthesis are healthier than trees with lower growth and less stored reserves at the beginning of winter. This activity will allow us to determine which of the eight dominant tree species in the urban forest patches are performing better and which worse, depending on the degree of degradation of the forest patches.

Activity Milestones:

Description	Approximate Completion Date
Install point dendrometers on the 144 trees that will continuously measure the growth of the	September 30, 2027
Extract yearly increment cores of sapwood from the 144 trees at the beginning of each	December 31, 2029
Extract soluble sugars and starch in the laboratory from the sapwood increment cores. Completion	March 31, 2030
Write a report for urban forest managers detailing which tree species respond better to degradation	June 30, 2030
Write a manuscript to submit to a scientific peer-reviewed journal with the results from Activity	June 30, 2030

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Adriana Uscanga	University of Minnesota	PI	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.
All data and results will be disseminated through multiple complementary channels serving both the scientific community and Minnesota's resource managers:

University of Minnesota Data Repository (DRUM): All collected data and produced remote sensing products with full metadata will be deposited under a Creative Commons Attribution license. This ensures permanent, free, publicly accessible archiving with sufficient documentation for future use by any ecologist without requiring direct contact with the original research team.

Peer-Reviewed Publication: The PIs, postdoc, and students will prepare two peer-reviewed manuscripts with the results from the research, submitted to an open-access or hybrid journal.

Plain-Language Public Report: The PIs, postdoc, and students will prepare non-technical reports with recommendations on best management practices for ensuring urban tree canopy health and recruitment, and which tree species respond better to degradation. These reports will be distributed to the Minnesota DNR Division of Forestry, the stakeholders who manage the studied urban forest patches, the LCCMR project portfolio, and published through the UMN digital conservancy.

Professional Presentations: Results will be presented at the annual meeting of the American Geophysical Union.

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?
We will seek additional funding to continue to conduct damage and mortality surveys, understory vegetation censuses, measure earthworm and buckthorn abundance annually, download the tree growth data from the point dendrometers, and estimate patch productivity with remote sensing technology. This will allow us to continue to monitor the health of the forest patches and of individual canopy tree species over time and determine changes in buckthorn and earthworm invasion. This information can be used by practitioners to manage urban forest patches and to select the best canopy tree species for planting into the patches for long-term urban forest canopy resilience.

Project Manager and Organization Qualifications

Project Manager Name: Christina Smith-Martin

Job Title: Assistant Professor

Provide description of the project manager's qualifications to manage the proposed project.
PI Dr. Chris Smith-Martin is an Assistant Professor in the Department of Plant and Microbial Biology at the University of

Minnesota College of Biological Sciences, with research expertise in forest ecology and plant ecophysiology, with more than 12 years of research experience in these fields. She has led large research projects funded by the National Science Foundation in Puerto Rico, and since starting her position at UMN, has been conducting research on the effect of heat and drought on the transition zone (ecotone) between the boreal forest and the temperate forest, which runs through Minnesota. She has published 34 peer-reviewed articles in top journals in her field, including Ecology Letters, Ecology, Functional Ecology, New Phytologist, and Nature Communications. Dr. Smith-Martin has a fully equipped plant ecophysiology laboratory and will oversee the annual damage and mortality surveys, high-resolution growth, and tree physiology measurements, and will advise the postdoctoral researcher who will conduct this portion of the research. She will co-supervise the undergrad and temp/casual worker.

PI Dr. Adriana Uscanga is an Assistant Professor in the Department of Forest Resources at the University of Minnesota College of Food, Agricultural and Natural Resource Sciences, with eight years of experience integrating remote sensing data and vegetation surveys to study forests and human-modified ecosystems. Dr. Uscanga is affiliated with the Remote Sensing and Geospatial Analysis Lab, which has access to equipment and software needed to conduct the geospatial analysis proposed in this project. She currently teaches Geographic Information Systems for Natural Resource Management and has six years of experience mapping natural resources. Dr. Uscanga will oversee project progress on remote sensing and mapping and advise the graduate student. Supervise undergrad and temp/casual worker. She will co-supervise the undergrad and temp/casual worker.

Organization: U of MN - College of Biological Sciences

Organization Description:
University of MN, College of Biological Sciences : The mission of the College of Biological Sciences is to deliver cutting-edge, internationally recognized research and teaching at all levels of biological organization from molecules to ecosystems. While preparing today's students to create the biology of tomorrow, CBS promotes collaborative research within and beyond the University to advance knowledge and find solutions that improve human health and the environment locally, nationally, and globally.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
PI		Oversee the annual damage and mortality surveys, high-resolution growth, and tree physiology measurements, and will advise the postdoctoral researcher who will conduct this portion of the research. Co-supervise undergrad and temp/casual worker.			26.79%	0.3		$41,409
PI		Oversee project progress on remote sensing and mapping and advise the graduate student. Co-supervise undergrad and temp/casual worker.			26.79%	0.3		$40,675
Post doc		The postdoc will lead the annual damage and mortality surveys of all the canopy trees, the annual understory vegetation census, installation of the point dendrometer on the 144 focal canopy trees, annual collection of sap wood cores from the 144 focal trees, extraction of soluble sugars and starches from the cores in the laboratory, analyze data, and write manuscripts for scientific publications.			79.3%	2		$163,216
Grad student		The graduate student will be in charge of setting up the protocols for collecting repetitive data using remote sensing technology, and collecting data to measure canopy height and leaf area index using airborne and terrestrial Light Detection and Ranging to determine canopy cover and forest structure. Some of these activities will be conducted in the field. The graduate student will also study forest patch productivity over time using satellite imagery, and will calculate landscape composition and configuration metrics related to habitat fragmentation and edge effects.			45.63%	1.5		$172,928
Undergrad		The undergrad will help the postdoc and the graduate student conduct fieldwork and laboratory work.			0%	0.75		$27,076
Temp/Casual		The temp/casual worker will help the postdoc and the graduate student conduct fieldwork and laboratory work.			7.4%	0.75		$33,696

							Sub Total	**$479,000**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Tools and Supplies	Laboratory Analyses ($6,000/year), Field Equipment ($8,000 in Year 1): One-time purchase of two Haglof GPS Calipers ($7,500 total), Tree Census Tags ($2,000/year): Durable, industry-standard identification tags, Field Supplies & Hardware ($3,800/year): Includes plot corner stakes ($800), plot maintenance hardware such as nails, wire, and specialized forestry tools ($3,000), and high-visibility tree spray paint ($1,700), and one research bicycle ($500), PPE & Safety ($500/year), Forestry Consumables & Maintenance ($1,300/year)	Laboratory analysis Dedicated to nonstructural carbohydrate analyses of tree tissues, providing critical data on tree physiological health and carbon allocation in response to environmental change, calipers, for high-precision tree measurement and mapping, bicycle for efficient plot navigation between the Itasca Biological Station and research sites. Tags essential for maintaining long-term individual tree records across the census plots. Corner stakes for permanent location tracking, spray paint for marking sample trees during census activities. PPE: Essential protective gear, including permethrin-treated field jackets and insect repellent, to ensure personnel safety from tick-borne illnesses and other hazards in remote field conditions. General forestry supplies (e.g., flagging, sample bags) and annual maintenance/tune-ups for the research bicycle fleet to ensure operational readiness for daily fieldwork.					$50,000
							Sub Total	**$50,000**
Capital Equipment								
							Sub Total	**-**

Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Conference Registration Miles/ Meals/ Lodging	2 people to AGU	conference					$12,000
	Miles/ Meals/ Lodging	field trips	sample collection					$30,000
							Sub Total	**$42,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Publication of results	publication					$6,000
							Sub Total	**$6,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$577,000**

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				
In-Kind	Unrecoverable indirect costs	infrastructure, admin staff, space use, electricity	Secured	$311,364
			Non State Sub Total	**$311,364**
			Funds Total	**$311,364**

Total Project Cost: $888,364

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: d48e949b-e95.pdf

Alternate Text for Visual Component

Map of urban forest patches with the 50 pre-established plots, illustration of the three activities, and illustration of the urban forest patch degradation level....

Supplemental Attachments

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

Title	File
Map of urban forest patches with the 50 pre-established plots, illustration of the three activities, and illustration of the urban forest patch degradation level.	36457fd7-e13.pdf
University Letter of Endorsement	46c8ff27-27c.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care,

treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

Lori Nicol, University of Minnesota

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

N/A