Environment and Natural Resources Trust Fund

2025 Request for Proposal

General Information

Proposal ID: 2025-215

Proposal Title: Affordable Statewide Tracking of Forestry Fragmentation and Degradation

Project Manager Information

Name: Rui Cheng

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

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Project Basic Information

Project Summary: To support forest management, the project provides interactive real-time business-ready information about forest fragmentation and degradation due to human activities and natural disasters by merging aircraft and satellite LiDAR data.

ENRTF Funds Requested: $346,000

Proposed Project Completion: June 30, 2028

LCCMR Funding Category: Foundational Natural Resource Data and Information (A)

Project Location

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

Statewide

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

Statewide

When will the work impact occur?

During the Project and In the Future

Narrative

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

Small-parcel forests (<20 acres) are more vulnerable to climate change and natural disasters than large forests. Such vulnerabilities are especially challenging for Minnesota because more than 125,000 landowners own small-parcel forests. Moreover, various land management decisions have been fragmenting private forests into small parcels, posing even higher risks to Minnesota forestry and the economy. To advance the effective management of private forest lands, it is critical to monitor forest fragmentation and degradation e.g., remote sensing.

Yet, existing remote sensing data are challenging for business-ready decision-making. Conventional satellite imagery may fail to detect forest fragmentation if the divide between fragments is finer than image resolutions. Instead, the 3-D structure information from LiDAR is more effective. For example, the USGS 3DEP aircraft LiDAR provides statewide information at high spatial resolution (<100 feet) suitable for capturing small-parcel forests. However, the aircraft LiDAR data only contains outdated snapshots and can't capture continuous changes in time. Meanwhile, the technical terminology of the USGS 3DEP LiDAR output, e.g., point clouds and canopy height statistics, challenges decision-making for non-technical experts. Thus, we aim to enhance the public usability of LiDAR data and provide real-time, accountable, and business-ready information about forest fragmentation and degradation.

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

To facilitate efficient forest management, we propose to develop a real-time interactive web dashboard for statewide forest fragmentation and degradation with business-ready and accountable information. This dashboard will highlight where, when, and how much forests statewide are fragmented and degraded. Our project highlights two main innovations:

1. Translating technical LiDAR data into business-ready information at high spatial resolution. Our dashboard will directly show the forest boundaries and their area changes as an intuitive illustration of forest fragmentation and degradation. We will develop algorithms to derive forest boundaries from LiDAR data and the outcome from previously funded LCCMR projects. The web dashboard includes an interactive map so that users can accurately retrieve the information at a finer than 1-acre resolution.

2. Statewide continuous updates. We are going to incorporate the high-resolution spatial details from USGS 3DEP LiDAR snapshots into NASA's satellite continuous statewide LiDAR measurements using machine learning. This will yield us the time series of statewide forest boundaries from 2018 to the present at a monthly/quarterly scale. By tracking the changes in forest boundaries, we will deliver direct measurements of forest fragmentation and degradation in history and real time.

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?

For natural resource management, our proposed dashboard will show business-ready information about where, when, and how much forests statewide are fragmented and degraded. This outcome directly benefits land management through rapid detection and historic tracing of changing forests due to human activity and natural disasters. We offer affordable and up-to-date information on private land which is often inaccessible for field surveys. For federal and public agencies, e.g., the Forestry Resource Assessment Team at the Department of Natural Resources, our dashboard will serve as a handy tool to pinpoint regions with significant changes and strategically procure new aircraft LiDAR data.

Activities and Milestones

Activity 1: Collect LiDAR data in Minnesota and draw forest boundaries

Activity Budget: $113,840

Activity Description:
A previous LCCMR-funded project (by our collaborator Mr. Pelletier) used satellite images to detect landscape changes over time. Because these images only provide 2-D canopy color information, fine-scale changes such as forest boundaries can be challenging to distinguish. 3-D structural information from LiDAR data is a more direct measurement of forest boundaries. Therefore, we would like to develop a machine learning model to draw forest boundaries based on LiDAR data.

First, as the ground truth, we are going to draw forest boundaries based on the landscape change product from the previous LCCMR project. Then, we will collect USGS 3DEP aircraft LiDAR point clouds as machine learning input and overlap them with the ground truth forest boundaries in both time and space. Finally, we will train the semantic segmentation neural network to draw forest boundaries based on the USGS 3DEP aircraft LiDAR. Throughout this activity, we will additionally validate the boundaries in publicly accessible lands using GNSS equipment.

During Activity 1, we will informally consult Dr. Jennifer Corcoran from the Forestry and Resource Assessment Team at the Department of Natural Resources with USGS 3DEP aircraft LiDAR data.

Activity Milestones:

Description	Approximate Completion Date
Finish preprocessing USGS 3DEP LiDAR and spatiotemporally matched satellite imagery for semantic segmentation	September 30, 2025
Finish compiling ground truth forest boundaries based on image segmentation	December 31, 2025
Complete the training of semantic segmentation model using supervised learning	March 31, 2026
Complete the development of a LiDAR model to draw forest boundary	June 30, 2026

Activity 2: Build deep learning models to predict statewide forest boundaries from 2018 to the present

Activity Budget: $113,505

Activity Description:
Because USGS 3DEP aircraft LiDAR is only a snapshot of forests, the forest boundaries derived in Activity 1 are not representative over the long term. Meanwhile, repeatedly flying the aircraft is costly. To overcome this challenge and facilitate real-time monitoring of forest resources cost-effectively, we propose to utilize deep learning models to produce high-resolution 3D models of canopies based on available affordable satellite LiDAR, e.g., NASA's Ice, Cloud and land Elevation Satellite 2 (ICE-SAT2) and Global Ecosystem Dynamics Investigation (GEDI) mission.

First, we are going to train neural networks to correlate the raw LiDAR data, i.e., point clouds, from both aircraft and satellite LiDAR from Activity 1. Next, built upon the trained neural networks, we can spatially extrapolate the 3-D canopy statistics and define forest boundaries over the entire state since satellite LiDAR has state-wide coverage. Additionally, satellite LiDAR is updated on a monthly/quarterly basis so we can predict state-wide forest boundaries as a continuous time series between 2018 and the present. Throughout this activity, we will validate the boundaries in publicly accessible lands using GNSS equipment to track the seasonal changes in forest boundaries.

Activity Milestones:

Description	Approximate Completion Date
Finish preprocessing satellite LiDAR data to the same spatial-temporal range as aircraft LiDAR	September 30, 2026
Compete developing and training deep learning models to correlate aircraft LiDAR and satellite LiDAR	December 31, 2026
Complete the state map of forest boundaries and its time series	June 30, 2027

Activity 3: Web development for the interactive dashboard

Activity Budget: $118,655

Activity Description:

We will publish the statewide forest boundaries and their changes in an interactive dashboard, which consists of an interactive map, an animation of forest change, and two time-series panels. The interactive map will give users options to select time and zoom into the regions of interest to check the status of forest boundaries. In a selected region, the animation will automatically display the forest changes from 2018 to the present. We will use different visualizations to highlight three scenarios 1) forest fragmentation by splitting a forest into disconnected components, 2) forest degradation by shrinking forest boundaries, and 3) a combination of forest fragmentation and degradation. Simultaneously, the time series will present how much of the area has been changed in the three scenarios. In an additional time series panel, we will add climate data (e.g., precipitation, fire risk, freezing days) for reference. We are going to publish this interactive dashboard to a publicly accessible website. We will advertise the dashboard to federal and public agencies through conferences and informal conversations. For example, we will provide areas with large changes based on the dashboard to Dr. Corcoran and her team, who are strategically procuring new aircraft LiDAR scans.

Activity Milestones:

Description	Approximate Completion Date
Finish building web infrastructure	September 30, 2027
Complete a preliminary database	December 31, 2027
Finish the automatic data update pipeline	March 31, 2028
Compete testing and officially deploy the website	June 30, 2028

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Youbing Wang	University of Minnesota - Minnesota Robotics Institute	Collaborator - Research Scientist - Mentoring the graduate student to develop and conduct machine learning algorithms	Yes
Keith Pelletier	University of Minnesota - Department of Forestry Resources	Collaborator - Research Scientist - Mentoring the graduate student to conduct satellite imagery segmentation and supporting analyses with geospatial software in the Remote Sensing and Geospatial Analysis Laboratory, UMN.	Yes

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?

A web-based interactive dashboard of forest boundaries in Minnesota will be delivered at the end of the project. The database of the dashboard will be updated monthly by an automatic query algorithm which can keep the dashboard running after the project completion. We will work closely with the Minnesota DNR Forestry Resource Assessment Team to identify opportunities to improve the dashboard and add useful features for public and governmental agencies. Since the database can facilitate fundamental research projects, we are going to apply for NASA, NSF, and USDA NIFA grants to financially support future dashboard development and updates.

Project Manager and Organization Qualifications

Project Manager Name: Rui Cheng

Job Title: Assistant Professor

Provide description of the project manager's qualifications to manage the proposed project.

Dr. Rui Cheng is an Assistant Professor in the College of Food, Agricultural and Natural Resources Sciences at the University of Minnesota. Dr. Cheng finished her Postdoctoral training at the Massachusetts Institute of Technology (MIT) on detecting illicit logging in Southeast Asia. She received her PhD from the California Institute of Technology (Caltech) in environmental science and engineering and aerospace engineering. She has 8 years of experience in monitoring forest health using multi-stream sensing, especially in conifers and evergreen forests. Dr. Cheng develops remote sensing algorithms for challenging environments and reveals unseeable land surface changes. She is also an expert on interactions between climate and land. In her past and current projects, Dr. Cheng has led international collaborations with more than 15 universities/institutes. These collaborations have yielded data products and publications in high-profile journals e.g., Proceedings of the National Academy of Sciences, Current Climate Change Reports, Environmental Research Letters, and Agricultural and Forest Meteorology. She advocates dissemination of science to the general public through research outreach, public talks, and social media.

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

Organization Description:

In the College of Food, Agricultural and Natural Resources Sciences (CFANS) at the University of Minnesota, we look at the bigger picture. When we envision a better tomorrow, it includes disease resistant crops, products that protect our health, lakes free from invasive species, and so much more. We use science to find answers to Minnesota and the world's grand challenges and solve tomorrow's problems. Almost 93 percent of students who earn CFANS

undergraduate degrees find jobs in their career field or enter graduate school within six months of graduation.

The Department of Bioproducts and Biosystems Engineering, in CFANS, discovers and teaches solutions for the sustainable use of renewable resources and the enhancement of the environment. We discover innovative solutions to address challenges in the sustainable production and consumption of food, feed, fiber, materials, and chemicals by integrating engineering, science, technology, and management into all degree programs. We have a public impact through community engagement and extension efforts. We develop and deliver high quality, regionally and nationally-recognized research-based programs to meet current and emerging needs of industry and communities. We also have a long-standing tradition of close partnerships with alumni, industry professionals, organizations, government agencies, donors, and community members.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
1 Assistant Professor		Project manager - Overseeing the project and mentoring the graduate research assistant data processing, field validation, and web development			37.1%	0.3		$51,873
2 Research Scientists		Mentoring the graduate research assistant to develop machine learning models, image segmentation, and data analyses			37.1%	0.9		$110,902
1 Graduate Research Assistant		Conducting machine learning models and image segmentation, analyzing geospatial data, and building the web dashboard			46.5%	3		$173,637
							Sub Total	**$336,412**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Tools and Supplies	Geospatial software use fee ($1200/year) in the Remote Sensing and Geospatial Analysis Laboratory, UMN	Analyzing and visualizing geospatial data					$3,600
	Equipment	1 R26-V2 GPS RTK Surveying System with Base and Rover GPS Receiver GNSS Measurement Equipment	Draw forest boundaries in regional parks to validate machine learning algorithms.					$3,500
							Sub Total	**$7,100**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**

Travel In Minnesota								
	Miles/ Meals/ Lodging	12 trips with 34 miles/trip in year 1 and 10 trips with 32 miles/trip in year 2 for two travelers	In regional parks in Twin Cities (less than 17 miles from campus), validate the machine learning algorithms for drawing forest boundaries					$500
							Sub Total	**$500**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	1 publication fee	peer-reviewed journal publication fee					$1,988
							Sub Total	**$1,988**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$346,000**

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				
			Non State Sub Total	**-**
			Funds Total	**-**

Total Project Cost: $346,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: f3bb6761-785.pdf

Alternate Text for Visual Component

An overview of the hypothesis/methodology and the project deliverable...

Supplemental Attachments

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

Title	File
Letter of Approval to Submit	162f4548-898.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

No

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

N/A

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

N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No

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:

Wendy Moylan, UMN-CFANS