Environment and Natural Resources Trust Fund

M.L. 2025 Approved Work Plan

General Information

ID Number: 2025-215

Staff Lead: Noah Fribley

Date this document submitted to LCCMR: June 9, 2025

Project Title: Affordable Statewide Tracking of Forestry Fragmentation and Degradation

Project Budget: $331,000

Project Manager Information

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Project Reporting

Date Work Plan Approved by LCCMR: June 24, 2025

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

Project Completion: June 30, 2028

Final Report Due Date: August 14, 2028

Legal Information

Legal Citation: M.L. 2025, First Special Session, Chp. 1, Art. 2, Sec. 2, Subd. 03t

Appropriation Language: $331,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to merge aircraft and satellite LiDAR data to build a model and an interactive real-time web dashboard of forest boundaries that provides business-ready information about statewide forest fragmentation and degradation due to human activities and natural disasters.

Appropriation End Date: June 30, 2028

Narrative

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.

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.

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

Activities and Milestones

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

Activity Budget: $108,988

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: $108,507

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
Complete 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: $113,505

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 online after removing private and sensitive information. 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 - Advising the team on machine learning techniques	No
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

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.
The results of our study will be an online interactive dashboard presenting the statewide forest boundaries and their changes. This dashboard will directly benefit private land owners and land managers. The dashboard will allow users to customize the time of interest and zoom into the regions of interest to check the status of forest fragmentation and degradation. We are going to publish this interactive dashboard online after removing private and sensitive information. We will also publish the data via the data archives at the Remote Sensing and Geospatial Analysis Laboratory in UMN (rs.umn.edu) and the Minnesota Natural Resources Atlas ((https://mnatlas.org/) for long-term access.

Our project will provide a spatially and temporally explicit reference for an ongoing LCCMR project (2023-092) to collect plot-based inventory data from private landowners. Meanwhile, this ongoing LCCMR project can support us in reaching out to private landowners and helping them monitor their land remotely. We are looking into opportunities to forge the resources between two projects and optimize the accessible information for the public.

We will advertise the dashboard to federal and public agencies. For example, we will provide areas with large changes based on the dashboard to Dr. Corcoran and her Resource Assessment Team at MN DNR, who are strategically procuring new aircraft LiDAR. We will advertise the dashboard and associated data to Dr. Brian Schwingle and the Forest Health Team at MN DNR, who conduct annual aerial surveys on forest health mainly by visual inspection. This product supports more accurate and efficient surveys on natural resources.

We will publish a peer-reviewed article to present the advances of cross-scale LiDAR in monitoring forest resources in Minnesota. We will present the article and our project at NASA Global Ecosystem Dynamics Investigation (GEDI) science team meetings, where we will seek technical feedback for enhancing our product and funding opportunities for long-term implementation.

We will acknowledge the Environment and Natural Resources Trust Fund in all our results via including the trust fund logo and attribution language. We will include the trust fund logo in any electronic media on our online dashboard, any format of presentations and communications, and online documents. The trust fund logo will be added to any diagrams on printed flyers and posters. The attribution language will be included in the acknowledgement section in publications and posters. All formats of acknowledgement will closely follow the ENRTF Acknowledgement Guidelines.

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.

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 and postdoctoral researcher in terms of data processing, field validation, and web development			37.1%	0.3		$51,873
1 Research Scientists		Mentoring the graduate research assistant to conduct image segmentation with optical reflectance data			37.1%	0.45		$43,271
1 Graduate Research Assistant		Conducting machine learning models and image segmentation, analyzing optical and LiDAR data, and building the web dashboard			46.5%	3		$173,637
1 Postdoctoral Researcher		Mentoring the graduate research assistant with LiDAR point cloud data analysis.			27.1%	0.72		$52,631
							Sub Total	**$321,412**
Contracts and Services								
Remote Sensing and Geospatial Analysis Laboratory, UMN	Internal services or fees (uncommon)	Geospatial software use fee for data analysis, visualization, and publish ($1200/year) in the Remote Sensing and Geospatial Analysis Laboratory, UMN				0		$3,600
							Sub Total	**$3,600**
Equipment, Tools, and Supplies								
	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	**$3,500**
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	**$331,000**

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: $331,000

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

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

1. To match the recommended funding amount, we will fund an experienced postdoctoral researcher with both machine learning and LiDAR knowledge (0.24 FTE/year for 3 years) and not fund Collaborator Youbing Wang. Collaborator Youbing Wang will advise the project without the time commitment. This change will enhance our project with more technical support, more committed personnel, and fewer requested funds (increasing from 4.2 FTE to 4.47 FTE in total).

2. We corrected the budget category for lab use fees at the Remote Sensing and Geospatial Analysis Laboratory Lab from “Tools and Supplies” to “Internal Services and Fees”.

3. We revised Activity 3 to address the question raised during the presentation about private information. We changed “... publish… a publicly accessible website” to “...publish … online after removing private and sensitive information”.

4. Collaborator Youbing Wang recently changed his affiliation to the University of Minnesota - Department of Bioproducts and Biosystems Engineering from the Minnesota Robotics Institute. We corrected his information on the collaborator page.

5. We fixed a typo in the Milestone #2 in Activity 2.

6. We added a dissemination plan.

7. The dissemination plan is revised with detailed plans to acknowledge the Environment and Natural Resources Trust Fund.

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?

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 project:

Wendy Moylan, UMN-CFANS

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