Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-581

Proposal Title: Mapping Forest Species Composition

Project Manager Information

Name: Jennifer Murphy

Organization: MN DNR - Forestry Division

Office Telephone: (651) 259-5898

Email: jennifer.murphy@state.mn.us

Project Basic Information

Project Summary: Hyperspectral imagery has success in mapping forest species composition when combined with lidar. We'll research scalability, develop baseline maps and decision-support tools to detect emerging threats to our forests.

ENRTF Funds Requested: $729,000

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, NE, NW, SE, SW, Central,

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

Statewide

When will the work impact occur?

During the Project

Narrative

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

Remote sensing has been used successfully by the DNR's Resource Assessment Program (RAP) to map forests for decades. Due to the diversity of our forests and limitations of traditional aerial or satellite imagery, we have fallen short of the level of individual tree species mapping. When joined with lidar structural data and high quality field measurements, hyperspectral imagery has shown success in mapping tree species in other regions.
Newly acquired high-density lidar and a network of plot-based forest inventory (PBI) provides valuable forest structure data. Combining hyperspectral imagery at more than one spatial scale with these structural data provides power for predicting individual tree level species, structure and composition.
This project has implications across forestry and beyond, as species level tree mapping and lidar derived metrics can be used for forest health, fire prevention, and habitat management decisions, for example, and providing decision support for understanding site-to-landscape scale forest species composition. We will use these data to reach the overall goal of improving forest inventory, stand and landscape scale planning, and management decision processes at operational scales. This project offers opportunities to explore modeling techniques, utilize emerging technologies, and provide improvements in long-term forest inventory maintenance and forest management planning.

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.

Hyperspectral Imagery is a remote sensing technology that captures information across the electromagnetic spectrum using numerous wavelength bands to produce spectral "signatures". These spectral signatures can be used to identify differences between individual trees, unlocking the ability to create species level mapping. Combining hyperspectral data with recently acquired high density lidar data provides the structural and spectral information needed for predicting tree level species, structure, biomass, volume, and overall forest composition.
We will research and develop an approach to combine these technologies to map individual trees and associate species and forest inventory estimates per tree. Through research of hyperspectral image collection platforms (site: UAV and PhenoCam; landscape: aircraft; state: satellite), we'll develop a nested approach potentially applied statewide, and ultimately provide both species composition estimates and forest structure information down to the individual tree. This level of detail is highly valuable to those developing and implementing land management plans across ownerships and disciplines. We'll also estimate costs and make equipment investment decisions and recommendations to maintain applied use of these combined technologies at a statewide scale over time within the Resource Assessment Program (RAP).

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 research on applications of remote sensing technologies at multiple scales to map individual tree species and structural information. This research will build a strong and feasible framework that meets several needs, can expand statewide, and get programmatically integrated. Forest structure and species composition is a large driving factor in determining management objectives for forest resilience, planning and preservation efforts. By combining hyperspectral and lidar data with field-based data, these results will provide valuable decision support and monitoring information. The outcomes of this project will have broad impacts across the public and private sectors.

Activities and Milestones

Activity 1: Strategic Planning and Design of Hyperspectral Imagery Collection Locations and Methods

Activity Budget: $29,000

Activity Description:
Strategic design and collaboration will begin and continue throughout the first year of the project, with heavy emphasis in the first six months. The strategic planning phase will include research into available hyperspectral datasets from a range of sources and scales, and site selection corresponding with existing PBI plots and high density lidar derived metrics and model coverage. This will also include research and development of methods for lidar data and hyperspectral imagery fusion.
Consideration for statewide expansion will be explored and cost analysis at varying scales will be developed, including estimates of cost for equipment investment. The Resource Assessment Program (RAP) will conduct consultations with vendors and resource professionals doing parallelling work. The University of Iowa, in particular, is a major contributor to this science. We may pursue contracts during this time, any acquisitions needed will be planned during this time. Preliminary test workflows for the integration of hyperspectral imagery and lidar data will be explored and test datasets will be acquired from existing data sources (if applicable). A strategic plan will guide the work by RAP.

Activity Milestones:

Description	Approximate Completion Date
Create and Document Strategic Plan and document project management tasks/goals	December 31, 2027
Develop organizational roles and responsibilities; project organizational chart.	December 31, 2027
Determine Pilot Study Scales and Locations	December 31, 2027

Activity 2: Hyperspectral Imagery Acquisition

Activity Budget: $500,000

Activity Description:
Acquiring the needed hyperspectral imagery or the equipment to collect it ourselves in the available formats (e.g., UAV, aerial, satellite) is the goal for this activity. Scaling these results from site-scale to the landscape or larger is dependent on the source availability of the hyperspectral imagery. The intent is to collect site level hyperspectral imagery at three scales: 1) UAV or field based equipment (e.g., hyperspectral trail camera) across a selection of existing PBI locations where high density lidar data exists, 2) hyperspectral imagery acquired in an aircraft using either a newly purchased equipment, University of Iowa partner camera system, or vendor contracted, across a selection of different forested landscapes (~50,000 total acres), and 3) satellite derived hyperspectral imagery across the same landscapes and expanded to a larger county or lidar acquisition block scale. Acquisition costs in this activity may be applied toward contractor acquisitions, direct purchase of equipment, or purchased access to existing data. Data acquisition methods, process, scaling of cost and processing data are all considerations during this data collection phase. Data storage and processing speed will be analyzed at the project scale and considerations for scaling to a statewide collection will be analyzed.

Activity Milestones:

Description	Approximate Completion Date
Plan and Acquire PhenoCam Network and Data Collection	September 30, 2029
Plan and Acquire UAV Acquisition and Data Collection	September 30, 2029
Plan and Acquire Aerial Acquisition and Data Collection	September 30, 2029
Plan and Acquire Satellite Acquisition and Data Collection	September 30, 2029

Activity 3: Process Hyperspectral Data for Lidar Fusion

Activity Budget: $50,000

Activity Description:
Processing hyperspectral data and perform lidar-hyperspectral fusion to create data frame for modeling. Processing data into a data frame requires large processing capacity and the approach for data storage and processing speed/capacity should be explored during strategic planning. The data collected will be tested under a variety of processing approaches to determine reliable methods prior to modeling.

Activity Milestones:

Description	Approximate Completion Date
Test data processing methods (Phenocam, UAV, Aerial, Satellite)	December 31, 2029
Process data at relevant scales for integration into data frame	December 31, 2029
Document and Test Methods for Data Processing	December 31, 2029
Produce final processed data and organize results for model intake	December 31, 2029

Activity 4: Modeling and Validation

Activity Budget: $100,000

Activity Description:
Using the existing lidar plot level cloud metrics, pixel level grid metrics and forest inventory models in conjunction with hyperspectral data, we will assess modeling options regarding data fusion. Processing and modeling applications and methods will be explored and modeling workflows tested. Validation work will be performed to test modeling accuracy and applicability. Field level validation may be done through site visits, holdout plot data sets and other field level data will be considered and outlined during the strategic planning process. Developing a model workflow that can be applied to the statewide level will be considered and scaled.

Activity Milestones:

Description	Approximate Completion Date
Test modeling strategies developed during strategic planning	March 31, 2030
Create model data frame for model development and analysis	March 31, 2030
Develop full model workflows and create modeled results	March 31, 2030
Validate model results based on strategic planning approaches	March 31, 2030

Activity 5: Operational Planning and Recommendations Reporting

Activity Budget: $50,000

Activity Description:
Building on the modeling and validation results, this activity focuses on synthesizing project outcomes into actionable guidance for statewide operational planning. Findings from all previous activities will be consolidated into a comprehensive recommendations report. The report will address the feasibility and cost-effectiveness of scaling hyperspectral and lidar fusion workflows from pilot study areas to a statewide implementation, including analysis of return intervals, coverage strategies, and platform considerations (UAV, aerial, and satellite).
The overall summary will be documented to illustrate how the developed workflows can be applied to operational forest

inventory, tree species classification, and related resource assessment programs. All methods, workflows, and lessons learned will be thoroughly documented to ensure reproducibility and transferability. The final deliverable will serve as a practical roadmap for the Resource Assessment Program (RAP) and partner programs considering statewide hyperspectral data integration.

Activity Milestones:

Description	Approximate Completion Date
Document project results	June 30, 2030
Consider scaling of return interval, statewide coverage for each method developed	June 30, 2030
Develop Cost-Benefit, Use Cases and Recommendations Report for Statewide Expansion	June 30, 2030

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 produced during this project will be made available to the public and information will be shared via conferences and workshops. Dissemination will be done via web mapping application and using the Minnesota Geospatial Commons. At all points, the ENRTF will be acknowledged as a funding provider.

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?
Research on feasibility of combined hyperspectral and lidar data at varying scales will guide level and nature of ongoing effort, the costs and funding source(s), and equipment investment considerations. This may impact the types of remotely sensed data collected, who collects these data, and whether the data can be integrated into current program workflows. The conclusions will focus on feasibility of mapping individual tree species and structural information and how to integrate these results in a programmatic way across scales for site level management and landscape level planning.

Project Manager and Organization Qualifications

Project Manager Name: Jennifer Murphy

Job Title: Remote Sensing Program Consultant

Provide description of the project manager's qualifications to manage the proposed project.
Jennifer Murphy (Corcoran, fmr) has been with the MN DNR for 11 years and is the Remote Sensing Program Consultant in the Resource Assessment Program in the Division of Forestry. She is also an Adjunct Assistant Professor in the UMN Natural Resource Science and Management Program. Her work focuses on aerial photography and lidar acquisition planning and managing several large projects that involve image collection and processing, forest disturbance and hydrologic feature mapping, as well as many other small projects. She received her undergraduate degree from the Evergreen State College in 2006; her M.S. degree with a Minor in GIS from the UMN in the Climatology track in the Soil, Water, and Climate Department in 2009; and in 2013 she earned her PhD degree with a Minor in Water Resource Science from the UMN in Natural Resource Science and Management Program. Jennifer has two decades of experience in project management and her leadership skills are more than applicable to lead this project.

Organization: MN DNR - Forestry Division

Organization Description:
MN DNR's mission is to work with citizens to conserve and manage the state's natural resources, to provide outdoor recreation opportunities, and to provide for commercial uses of natural resources in a way that creates a sustainable quality of life.

The Division of Forestry's mission is to provide a shared expertise to understand, sustain, and manage Minnesota's trees, woodlands, and forests; provide a sustainable supply of multiple forest resources and opportunities; protect lives and property from wildfires; and fulfill responsibilities to the permanent school trust.

The Resource Assessment Program (RAP) supports the Division of Forestry's and DNR's overall goals to maintain and

improve the health of Minnesota's forests and natural resources. RAP provides natural resource managers with critical support for decision-making by providing expertise in natural resource field inventory, aerial photography, spatial analysis, remote sensing analysis, including lidar and satellite image processing. These products and services are critical in supporting management of forest health, timber yields and wildlife, among other uses. These rich data and analysis are important to help deal with the effects of widely variable forest change patterns, invasive species and disease, disruptive forest events, and impacts of climate change.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Project manager		RAP will provide overall project coordination, hiring, data analysis and assessment development. Project deliverables will be produced directly by RAP			25%	3.75		$228,468
							Sub Total	**$228,468**
Contracts and Services								
Aerial photo collection	Service Contract	Collection of Aerial Hyperspectral data by University of Iowa across pilot areas totaling ~50,000 acres				-		$300,000
							Sub Total	**$300,000**
Equipment, Tools, and Supplies								
	Equipment	Purchase of a Hyperspectral capable UAV for Plot and site level hyperspectral data collection	TO collect hyperspectral imagery at the field scale					$150,000
	Equipment	Purchase of 6-8 Trail cams for site level hyperspectral data collection at PBI plot locations	To collect hyperspectral imagery at the site scale					$30,000
							Sub Total	**$180,000**
Capital Equipment								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
							Sub Total	**-**
Travel Outside Minnesota								

							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
		MN DNR Direct and Necessary	DNR's direct and necessary costs pay for activities that are directly related to and necessary for accomplishing appropriated projects. People Support (~$3055), Safety Support (~$401), Financial Support (~$5164), Communication Support (~$2086), IT Support (~$8283), and Planning Support (~$1,543).					$20,532
							Sub Total	**$20,532**
							Grand Total	**$729,000**

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: $729,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: bb0c04a4-488.docx

Alternate Text for Visual Component

This figure shows a color-coded surface classification map of a test site using a Headwall Nano HP-518 sensor (taken September 14, 2023 using 2.2 cm resolution). Each color shown in the legend represents one of 15 surface types automatically identified by matching light signatures across 441 wavelength bands....

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?

N/A

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?

No

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:

Keb Guralski, MN DNR

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