



Environment and Natural Resources Trust Fund

M.L. 2023 Approved Work Plan

General Information

ID Number: 2023-066

Staff Lead: Corrie Layfield

Date this document submitted to LCCMR: June 5, 2023

Project Title: Removing Barriers to Carbon Market Entry

Project Budget: \$482,000

Project Manager Information

Name: John Zobel

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

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Project Reporting

Date Work Plan Approved by LCCMR: June 22, 2023

Reporting Schedule: April 1 / October 1 of each year.

Project Completion: June 30, 2026

Final Report Due Date: August 14, 2026

Legal Information

Legal Citation: M.L. 2023, Chp. 60, Art. 2, Sec. 2, Subd. 03b

Appropriation Language: \$482,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to develop ground-tested carbon stock models of forest resources throughout Minnesota to enable better resource management of public and private forests as well as generate reliable tools for landowners seeking to enter carbon markets.

Appropriation End Date: June 30, 2026

Narrative

Project Summary: Carbon markets incentivize carbon sequestration, but significant cost-barriers exist for landowner participation. Leveraging remotely sensed data, cost-effective fieldwork, and robust modeling will enable climate-smart activities that benefit all Minnesotans.

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

The buying and selling of carbon credits (carbon markets) represents a now viable and critical strategy to increase carbon sequestration. Forest landowners are incentivized to manage their properties in order to capture atmospheric carbon above and beyond the normal rate for their land, including delayed harvesting or replacing aging trees with faster growing younger forests. The excess carbon is then sold to companies to offset their carbon emissions. The federal government is currently considering significant investment in carbon market related programs through action by the USDA Climate-Smart Agriculture and Forestry Partnership Initiative. Emerging markets present attractive options for Minnesota landowners to enroll their property, leading to reductions in atmospheric carbon and a reliable income stream. However, traditional markets require landowners to conduct detailed carbon inventories to establish carbon stock baselines. Unfortunately, these exhaustive inventories are prohibitively expensive and time consuming for most landowners and present a barrier to market entry. Alternatively, other markets emerged that seek to soften entry requirements, but these markets lack the transparency of the established markets. Therefore, a crucial opportunity exists to remove the obstacles to entry while providing robust and credible estimates of carbon stocks.

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.

Carbon markets typically involve expensive ground-based inventories to estimate carbon stock baselines. However, Minnesota has invested heavily in acquiring remotely sensed data, including high resolution light detection and ranging (Lidar) data statewide. State, federal, university, county, and ENRTF partners have funded Lidar acquisitions and subsequent modeling of forest carbon and other attributes, making Minnesota a leader among peer states. Leveraging this wealth of publicly available remotely sensed data, we propose to compare remotely derived carbon inventories with the traditional, field-based inventories. Remote sensing will never replace the need for fieldwork and ground truthing, but may significantly reduce the number of data points or field plots necessary to achieve the required precision to enter carbon markets. Rigorous testing across the spectrum of fully remote and fully field-based carbon inventories will quantify the reduction in necessary fieldwork to still achieve the precision targets. Based on proof-of-concept studies in the western states and northern Minnesota, results will quantify the significant reduction in necessary fieldwork, opening the doors for landowners to enter carbon markets at a fraction of the cost. A workflow and decision support tool will provide landowners with clear and reproducible steps to quantify their carbon stocks for entry into the markets.

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?

Deliverables will result in increased participation in carbon markets and thus increased carbon sequestration throughout the state. Lowering atmospheric carbon remains a critical state strategy for addressing climate change. Positioning agency, tribal, and private landowners to capitalize on the rapidly increasing financial opportunities surrounding carbon markets will not only benefit forest landowners throughout the state, but directly all citizens through maintaining favorable climate conditions into the future. Also, significantly decreasing inventory costs will create more achievable management alternatives for Minnesota landowners and will allow better balancing of multiple use objectives that serve the diverse needs of the entire state population.

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: Create baseline carbon stock information across all acres and all ownerships in Minnesota

Activity Budget: \$99,000

Activity Description:

Previous and ongoing ENRTF funded projects provided high quality Lidar data throughout the state and subsequent forest attribute models. This project will extend this work by estimating and mapping carbon stocks for all acres and all ownerships across Minnesota. Many maps have been made that display carbon stocks across an area of interest, but few provide robust measures of uncertainty along with those estimates. California, Oregon, and Washington have recently funded similar wall-to-wall data layer creation using advanced statistical techniques to quantify error (Bayesian hierarchical modeling) that has proven revolutionary in advancing confidence around remotely sensed measurements. This work would be applied to Minnesota using the wealth of publicly available Lidar, satellite imagery, existing maps, forest inventory plots, and other information relevant to estimating carbon stocks. The result will be detailed spatial carbon estimates for every acre in Minnesota, coupled with measures of the reliability of those estimates using an innovative technique not yet explored in the region. Not only will the derived carbon layer remain publicly available on the Minnesota Natural Resource Atlas, but will form a critical component of the remaining activities of this proposal.

Activity Milestones:

Description	Approximate Completion Date
Recruit/hire graduate student and conduct literature review	June 30, 2024
Compile all available statewide ground and aerial/Lidar data, as well as existing carbon information	June 30, 2024
Develop the Bayesian hierarchical model to estimate wall-to-wall carbon stocks across Minnesota	December 31, 2024
Validate the model through cross-validation and Activity 2 data	June 30, 2025

Activity 2: Conduct full-scale carbon market inventories on test locations and compare to the remote approach

Activity Budget: \$339,000

Activity Description:

Leveraging remotely sensed data is critical to provide high resolution estimates of carbon across the state, but remote data alone does not generate the precision necessary to enter carbon markets. To determine the essential level of fieldwork, a complete carbon inventory will be conducted on four test locations in different regions of the state. These include UMN operated Cloquet Forestry Center and Hubachek Wilderness Research Center in northern Minnesota. We will also partner with the Leech Lake Band of the Ojibwe to inventory all their forestland in the central part of the state, as well as portions of the DNR managed Richard J. Dorer Memorial Hardwood State Forest in southeast Minnesota. Results from these traditional inventories will represent the current effort necessary to enter the carbon markets, while the carbon layer from Activity 1 represents a coarse alternative. Data simulations will then sequentially reduce the amount of available data from the fieldwork until the minimum combination of remote data and field data provides the necessary precision to meet carbon market standards. The sample size required will vary depending on forest conditions and regions of the state, so a range of inventory sizes will be identified for diverse applications.

Activity Milestones:

Description	Approximate Completion Date
Conduct carbon inventories on four test locations throughout Minnesota	September 30, 2024
Compile and edit the data for use with the carbon stock layer from Activity 1	March 31, 2025
Run simulations to determine necessary fieldwork to achieve carbon market precision requirements	December 31, 2025

Activity 3: Develop a reproducible and validated workflow for reasonable entry of Minnesota landowners into carbon markets

Activity Budget: \$44,000

Activity Description:

The carbon layer from Activity 1 will remain publicly available for use by all forest landowners across Minnesota. We will develop a clear and straightforward workflow to allow landowners or consultants to determine the necessary fieldwork to couple with the remote estimates to produce a credible carbon inventory that meets market standards for accuracy and precision. Private landowners, agencies, and forestry professionals will have access to data, instructions, and a decision support tool to rapidly implement carbon inventories at significantly reduced costs. The carbon layer and workflow will be housed or linked through the ENRTF funded Minnesota Natural Resource Atlas and UMN resources. These hosts are curated and maintained by the Natural Resources Research Institute and UMN Department of Forest Resources through perpetuity, with the latter providing regular updates as needed. Use of the workflow and tool will be demonstrated to landowners through in-person activities or webinars facilitated by the Sustainable Forests Education Cooperative. By removing the financial barrier and limiting the effort required to enter carbon markets, this should position Minnesota to increase lands enrolled in carbon markets and continue to increase carbon sequestration and other climate-smart activities.

Activity Milestones:

Description	Approximate Completion Date
Upload the new carbon stock layer to the Minnesota Natural Resource Atlas for public use	July 31, 2025
Develop and publish the workflow and decision support tool on University of Minnesota servers	February 28, 2026
Conduct in-person seminars or webinars to demonstrate the importance and reproducibility for carbon market entry	June 30, 2026

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Chad Babcock	University of Minnesota	Co-Principle Investigator (Co-PI)	Yes
Joseph Knight	University of Minnesota	Co-PI	Yes
Jennifer Corcoran	Minnesota Department of Natural Resources	Co-PI	Yes
Scott Hillard	Minnesota Department of Natural Resources	Co-PI	Yes
David Wilson	Minnesota Department of Natural Resources	Co-PI	Yes
John Du Plissis	Natural Resources Research Institute	Co-PI	Yes
Christopher Wright	Natural Resources Research Institute	Co-PI	Yes
Eli Sagor	Sustainable Forests Education Cooperative	Educator	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.

Collaborator Eli Sagor and the Sustainable Forests Education Cooperative (SFEC) will host workshop(s) and webinar(s) targeted to forest landowners across Minnesota, instructing them on how to access and use the workflow and data products in conjunction with their own data. The SFEC is one of the leaders in educating forest landowners in the state and should facilitate widespread visibility of the project deliverables.

The carbon layer will be hosted on the ENRTF funded Minnesota Natural Resource Atlas, providing all forest landowners ready access to the data. In addition, the detailed workflow, portal for uploading landowner field data, and analysis capabilities will be hosted on UMN servers, again making these products widely available to landowners and consultants.

Project details and findings will be distributed widely through publications (e.g., peer-reviewed, technical reports, fact-sheets) and at regional and national meetings and conferences. The ENRTF will be acknowledged on all project deliverables through use of the logo and/or attribution language on any print or electronic media, publications, and other communications following the ENRTF Acknowledgment 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?

Project results will form a comprehensive workflow and decision support tool that enables exact replication by landowners or forestry consultants. This will include a publicly available data layer providing detailed statewide estimates of baseline carbon stocks derived from robust modeling and uncertainty estimates. All data products and layers will be hosted on the Minnesota Natural Resource Atlas, an ENRTF funded clearinghouse for traditional and spatial natural resource data and products. All workflow and decision support tools provided to landowners will be housed on University of Minnesota (UMN) servers, with periodic updates funded through the UMN or external partners.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
J. Zobel/Summer Salary		Project Lead			33.5%	0.18		\$33,000
C. Babcock/Summer Salary		Co-PI			33.5%	0.15		\$27,003
J. Knight/Summer Salary		Co-PI			33.5%	0.02		\$4,014
J. Du Plissis/Summer Salary		Co-PI			33.5%	0.02		\$4,661
C. Wright/Summer Salary		Co-PI			33.5%	0.02		\$3,061
Post Doc/Researcher 5		Field data collection and analysis lead			33.5%	2		\$152,250
Graduate Student		Lidar and modeling lead			23.6%	2		\$96,680
Undergraduate Student Field Techs		Assisting in data collection for Activity 2			0%	2.25		\$74,880
							Sub Total	\$395,549
Contracts and Services								
Minnesota Department of Natural Resources	Sub award	Costs include personnel time and include Jennifer Corcoran, Ram Deo, and Lucas Spaete. Work includes providing critical consultation on methods, deliverables, and dissemination of research to ensure maximum benefit to the pertinent stakeholders and general public.				0.06		\$12,000
UMN - Sustainable Forests	Internal services or fees (uncommon)	Facilitate workshops/webinars for introducing and instructing stakeholders on the use of the workflow, uploading their data, and using the decision support tool.				0.02		\$850

Education Cooperative								
							Sub Total	\$12,850
Equipment, Tools, and Supplies								
	Equipment	Sampling Equipment (7 logger's tapes, 7 clinometers, 7 compasses)	Sampling equipment necessary to collect data in support of Activities 2 and 3. Tapes \$76 ea., clinos \$200 ea., and compass \$90 ea.					\$2,562
	Equipment	1 LaserTech 200x	Accurately and precisely collect tree heights and distances (a second one has already be acquired)					\$2,000
	Equipment	2 tablets	Electronically collect data and include built-in error checking (\$1,252 ea., including field protection)	X				\$2,499
	Tools and Supplies	Safety equipment (7 sets)	Personal protective equipment (hard hats, vests, gloves, glasses, etc.)					\$840
	Tools and Supplies	Consumable Sampling Supplies	Write-in-the-rain paper and other consumable products to support data collection in Activies 2 and 3					\$200
							Sub Total	\$8,101
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Miles/ Meals/ Lodging	We estimate a total of 130 unique travel days to complete the data collection associated with Activities 1 and 2. These days cover travel for two undergraduate field techs the first year (65 days ea.), seven undergraduate field techs the second year (65 days ea.), one researcher (55 days total),	The large in-state travel budget is necessary due to the required effort to conduct the detailed carbon inventories required for carbon market entry and the diverse locations across the state.					\$65,500

		and investigators (15 days total). The cost is estimated at \$100 per day and includes mileage/vehicle rental, lodging, and per diem.						
							Sub Total	\$65,500
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
							Sub Total	-
Other Expenses								
							Sub Total	-
							Grand Total	\$482,000

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Equipment, Tools, and Supplies		2 tablets	Using electronic means to collect field data helps ensure accuracy through built-in error checking and avoidance of data transcription, reduces costs through fewer FTE required for data entry in the office, and substantially increases efficiency through time savings.

Non ENRTF Funds

Category	Specific Source	Use	Status	\$ Amount
State				
In-Kind	Unrecovered Indirect Costs UMN (55% overhead)	Operating costs of the UMN	Secured	\$265,100
			State Sub Total	\$265,100
Non-State				
			Non State Sub Total	-
			Funds Total	\$265,100

Attachments

Required Attachments

Visual Component

File: [8b8e8e4e-90b.pdf](#)

Alternate Text for Visual Component

In addition to the text, pictures of bur oak trees and foliage, small (sapling) red pine, close-up view of medium-sized aspen stems, and mature red pine canopy from below. Background watermark of mature red pine trees....

Optional Attachments

Support Letter, Photos, Media, Other

Title	File
UMN submission approval form	1dc22481-dcf.pdf
Background Check Certification Form - Completed	d9eca481-c80.pdf
Internal Review Documentation	bd6b5708-161.pdf

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

Although the project was reduced from \$590,000 to \$482,000, all project deliverables were preserved. The main changes were in data collection timing (mostly shifted to the second year), reduction of graduate student funding from three years to two years, and removal of some equipment costs.

In addition, the final work plan includes a small change (as of 6/5) to the Researcher 5 position. The funding amount is the same, but is now spread out over three years. Also, the position description was changed to allow for a post doctoral or Researcher 5 to fill this position, in order to meet University job codes and hiring logistics. Again, the scope of work and funding for this position remain the same as in the original work plan.

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 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