Environment and Natural Resources Trust Fund
2017 Request for Proposals (RFP)

Project Title: **ENRTF ID:** **023-A**

Tracking Minnesota Plant Life below Winter Snow

Category: A. Foundational Natural Resource Data and Information

Total Project Budget: $ 380,000

Proposed Project Time Period for the Funding Requested: 3 years, July 2017 - June 2020

Summary:

This project will combine automated measurements of conditions below snow and plant photosynthesis to develop a model of Minnesota plant activity during the winter.

Name: Daniel Stanton

Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

A schematic of the project is showing the sensor system to be used to measure conditions above and below snow from locations across the state. This data is then sent to a a website where is can be publicly accessed as well as analyzed.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Tracking Minnesota plant life below winter snow

I. PROJECT STATEMENT

Minnesota has experienced dramatic changes in snowfall in recent winters, yet we still lack fundamental understandings of how snowpack affects winter-hardy plants. In addition to its importance for the winter activities economy, snow plays a major role in protecting perennial plants from cold damage and is a major water resource. With snow-pack varying greatly between years and decades, there is a need to assess and predict the impacts that changes in snow-pack may have on winter-hardy plants, especially those active under snow. These winter-active plants are of particular importance in the Minnesota landscape, since they provide winter forage for moose and other mammals, as well as representing one of the pathways to a more sustainable agriculture (winter and perennial crops such as those developed by the University of Minnesota Forever Green Initiative). The **main goal** of this project is to obtain a better picture of plant activity under winter snow and assessing how reductions in snow depth and frequency may affect current and future ecosystem survival. The **products** of this research will be foundational natural resource data that will serve in monitoring current and predicting future changes in Minnesota winter vegetation. In addition, this project is pioneering continuous measurements of plants activity under the snow and will constitute a valuable resource for current and future land managers.**To achieve our goals**, we propose to install automated sensor systems to remotely monitor conditions at plant-level in sites representative of different types of Minnesota vegetation (e.g. prairie, bog, field, forest, etc). In addition, leaf-level photosynthetic activity under the snow will be measured using advanced fiber-optic systems. Sensors will monitor temperature, humidity and light intensity above and below the snow and live broadcast data using local mobile network to a central database. We have identified research stations across the state affiliated with the University of Minnesota where we can easily deploy and maintain our sensor systems, allowing us to describe the winter activity of plants of key importance to wildlife (moose forage plants), ecosystem services (prairie plants and sphagnum moss) and sustainable agriculture (winter crops).

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Engineering and deployment of Below Snow Sensors **Budget: $146,000**

The first component of this project will be to construct and deploy automated sensors to record conditions at leaf-level under snow. Project collaborator (Dr. Paul Gauthier of Princeton University) has designed a low cost automated system that collects data and send it over the mobile network to a central database. **The main goal** of this activity is to engineer the sensors to allow concurrent measurements above and below snow on an minute basis over the winter. Briefly, the automated systems will be deployed in sets of three, supplied by long life batteries and solar panels. Prior to being deployed outdoors, the system will be tested in the laboratory. The series of tests will include temperature sensitivity, water resistance and energy efficiency of the system. Before deploying across 10 location across Minnesota, the automated system will be submitted to a final field test on University of Minnesota Campus.

Outcome	Completion Date
1. Datalogger System for measurement under snow	*November 2017*
2. Operating Network of under Snow environmental sensors	*December 2017*

Activity 2: Collection and Synthesis of data **Budget: $171,000**

The second aspect of the project is the remote collection of environmental and photosynthetic data and the synthesis of the outcomes into a publicly accessible database. Data collected during winter 2017-2018 and winter 2018-2019 will constitute the initial core of the database. At the early stage of the project, data will be available on request. At the achievement of this activity, data available to download on its own website. Maps of below

snow annual/monthly/weekly activity of Minnesota vegetation will be created.

Outcome	Completion Date
1. Environmental and photosynthetic data	*April 2019*
2. Publicly available Website and database	*September 2018*

Activity 3: Modeling Under Snow Ecosystem **Budget: $63,000**

The Modeling aspect of this project is its final outcome. From the data collected in activity 2, trends in temperature, humidity, light penetration and photosynthetic activity with the variation in snow depth, frequency and density will be drawn. These initial empirical information will constitute the foundation of the first below-snow vegetation model. The outcome of this model will be the estimate of ecosystem productivity below snow and highlight the sensitivity of perennial vegetation to changes in temperature, humidity, light intensity and snow-pack.

Outcome	Completion Date
1. Model of Ecosystem productivity below Winter Snow	*June 2020*
2. Prediction of the evolution of below Snow Ecology Under Future Climate Changes	*June 2020*

III. PROJECT STRATEGY

A. Project Team/Partners

Project leader: Dr. D. Stanton (University of Minnesota-Twin Cities). Dr Stanton will lead the project, participating in all aspects and leading the analysis of data and creation of models predicting conditions and plant activity below snow. Dr. Stanton will receive 1 month salary/year from the ENRTF request.

Project team: A Research Associate (Dr. P. Gauthier, currently at Princeton University, to be based at U. of Minnesota-Twin Cities) will be hired using ENRTF funds to carry out the construction, deployment and regular monitoring of the equipment. He will be responsible for the design, construction and maintenance of sensor systems, as well as the monthly measurements of below-snow plant activity and mathematical modeling of plant growth during the winter.

-An electronic and computer technician (U. of Minnesota-Twin Cities) will be responsible for developing the website and database on which the data collected by the sensors will be made publicly available. She/he will be involved in programming the datalogger systems and the maintenance of the sensor systems.

B. Project Impact and Long-Term Strategy

The project will provide publicly useful outputs in two timeframes. Firstly, the data collected will be uploaded to a publicly accessible (and easily navigated) website. After the 2.5 years of the project, the dataloggers collecting the data can be left in place should continue to generate extra data at low maintenance costs. The costs for continued operation can be assumed by the lead investigator. The data and especially the models of winter plant activity generated will be of continued use not only to plant and crop scientists, but also to farmers and game managers interested in winter conditions.

C. Timeline Requirements

The proposed project is expected to last 2.5 years. The project is divided in 3 phases: (1) the construction and deployment of the below Snow sensors Systems (July to November 2017), (2) the collection and processing of the data (December 2017 to March 2019) and (3) synthesis and modeling of the outcomes (March 2019 to November 2019). Engineering and proof-testing the sensor systems requires several months but the instruments should be ready before the first snowfall (often late October). Once installed, the sensors will be left in place to measure through two consecutive winters. A minimum of two winters are required to identify impacts of environmental parameters on physiological properties. Measurements will continue during the growing season (March to November). After the collection of data of the second winter, several months are needed to process the data and statistically identify trends in the data in order to create a robust vegetation model relating snow depth to below snow conditions and plant photosynthetic activity.

2017 Detailed Project Budget

Project Title: Tracking Minnesota plant life below winter snow

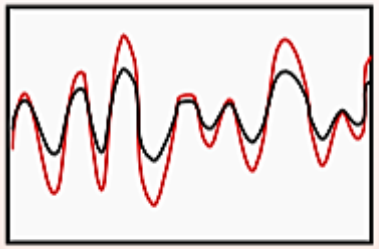
IV. TOTAL ENRTF REQUEST BUDGET [Insert # of years for project] years

BUDGET ITEM	AMOUNT
Personnel:	
Daniel Stanton, Project Manager (75% salary, 25% fringe benfits); 1month salary per year for coordination and participation in field work and analysis of results	$ 17,000
Paul Gauthier, Associate Research Scholar, Plant Physiologist, Sensor system development, data collection, data analysis, model development (75% salary, 25% benefits); 50% FTE for each of 2.5 years. 33% Activity 1, 33% Activity 2, 34% Activity 3	$ 146,000
2 Undergraduate Students, sensor deployment and data collection (100% salary, 0% benefits); 15% FTE for each year. 100% Activity 1	$ 14,000
Electronic and computation technician, data monitoring, sensor maintenance, Website and database management, Sensor programming (79% salary, 21% benefits) 100%FTE for each of 2 years Year-round employment is justified by the continuation of plant measurements and equipment upkeep during snow-free months, as well time for data analysis. 50% Activity 1, 50% Activity 2.	$ 104,000
Database Scientist, Database creation and Website design (79% salary, 21% benefits); 30% FTE for year 1. 100% Activity 2.	$ 35,000
1 Research Assistant, data monitoring and analysis (79% salary, 21% benefits); 20% FTE for each of 2 years. 50% Activity 2, 50% Activity 3.	$ 16,000
Equipment/Tools/Supplies:	
Small Electronic supplies: Electronic Supplies for Sensors system. ($600 each). 100% Activity 1.	$ 18,000
10 Low Cost Solar Panels: ($100 each per site). 100% Activity 1.	$ 1,000
10 aluminum Polls to mount the Sensors ($200 each). 100% Activity 1.	$ 2,000
3 Fiber-optics System to measure below snow photosynthesis ($4000 each). 100% Activity 2.	$ 12,000
Miscellaneous tools and safety gear for construction, installation and maintenance of sensors 50% Activity 1, 50%Activity 2.	$ 4,000
Travel:	
Mileage (~10000 miles), lodging and meals for travel between University of Minnesota and data collection sites for deployment and maintenance of Sensors. 30% Activity 1, 70% Activity 2.	$ 10,000
Additional Budget Items:	
Database and Website Hosting Annual fee for 2.5 years. 100% Activity 2.	$ 1,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 380,000

V. OTHER FUNDS (This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)

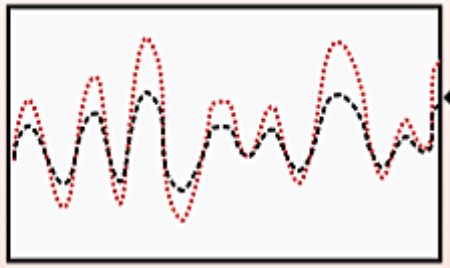
SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: N/A	N/A	
Other State $ To Be Applied To Project During Project Period: N/A	N/A	
In-kind Services To Be Applied To Project During Project Period: Indirect Costs associated with this proposal	$ 203,000	*Secured*
Funding History: N/A	N/A	
Remaining $ From Current ENRTF Appropriation: N/A	N/A	

Snow microclimate data is collected and made publicly available online in real time

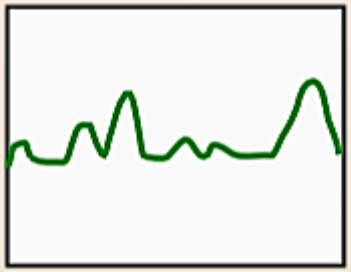


Data sent hourly over cell-phone network

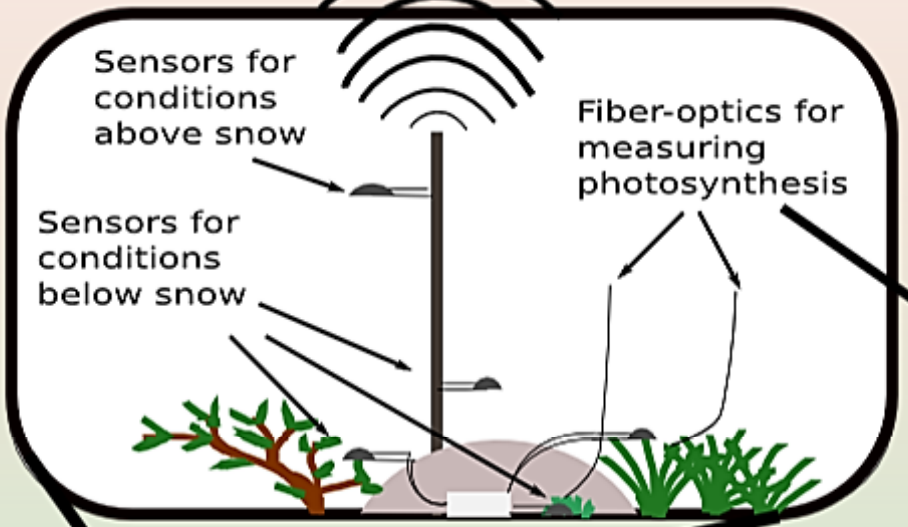
Predictive models of conditions below-snow based on snow depth and air temperature

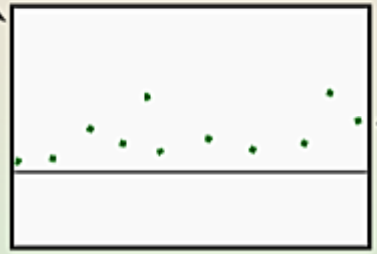


Activity 1:
Real-time monitoring of conditions below snow



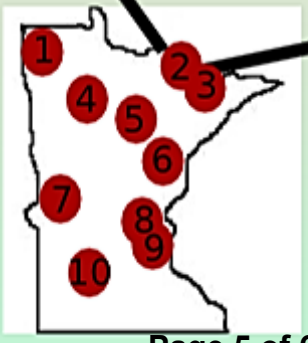
Predictive models of plant photosynthesis and growth during winter





Monthly direct measurements of plant activity below snow

Activity 2:
Measurement of plant activity under snow



Sensors deployed across state at U of Mn research stations:
native vegetation and winter-hardy crops

Project Manager Qualifications and Organization Description:

Daniel Stanton, Dept. of Ecology, Evolution and Behavior, University of Minnesota

Dr. Stanton's research focuses on how some plants cope with, and even thrive, in extreme environments. He uses a wide range of techniques to measure the conditions that plants directly experience (which can be quite different from what is recorded by a weather station), and how that impacts their performance. He then combines these measurements made in the field or lab into mathematical models that describe plant interactions with their environment. He is particularly interested in evaluating how much plant activity actually takes place in conditions (extreme heat, cold, salinity) that are usually overlooked. This research has led him to conduct research on plants in extreme environments around the world, from tropical forest canopies to the High Arctic. Dr. Stanton has a Ph.D. in Ecology and Evolutionary Biology from Princeton University (2011) and a double B.S. in Botany/Biochemistry from University of Wisconsin-Madison.

Department of Ecology, Evolution and Behavior, University of Minnesota
The Dept. of Ecology, Evolution and Behavior (EEB) of the University of Minnesota is one of the nation's leading research institutions in the discipline. The Department trains undergraduate and graduate students of the highest caliber, and conducts cutting-edge research in ecology, evolution and behavior at sites in Minnesota, the US and abroad. The University of Minnesota operates a number of research stations across the state dedicated to research into agricultural and natural systems, where the