Environment and Natural Resources Trust Fund
2016 Request for Proposals (RFP)

Project Title: **ENRTF ID: 028-A**

Tracking Minnesota Plant Life Below Winter Snow

Category: A. Foundational Natural Resource Data and Information

Total Project Budget: $ 180,000

Proposed Project Time Period for the Funding Requested: 2 years, July 2016 to June 2018

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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Web Address

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. This data is then sent to a website where it can be viewed in real-time, as well as analyzed to build models of below-snow conditions (Activity 1). The same plants are measured monthly to generate a model of plant photosynthetic activity below snow (Activity 2).

_____ 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

Snow is an essential part of the Minnesota winter experience, be it for human or non-human residents. Despite this importance, we still know surprisingly little about what conditions are like under the snow. Although many plants lose their leaves and shut down their activity over the winter, quite a few remain active even under quite deep snow. In fact, the snow can be quite an effective protective buffer against cold temperatures, and let through enough light for plants to continue growing during the winter and early spring. With snow-pack varying greatly between years and decades, there is a need to be able to predict the impacts that changes in snow-pack might have on Minnesotan winter-hardy plants (native as well as crops like winter wheat and turf grass).

The focus of this project will be on better understanding what the conditions actually are under different depths and types of snow, and snow pack influences winter growth and survival. We will 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), as well as fiber-optic systems for monitoring plant activity below snow. These systems will allow measurements to be made throughout the winter without having to dig up the snow (which would disrupt the conditions we would like to measure). The sensors will record temperature, humidity and light as they reach winter-hardy plant leaves, as well as the conditions in the air above the snow and snow depth. The equipment will then broadcast the results to a central repository, where the data will be made publicly available as it is collected. The University of Minnesota system of research stations provides a wide range of locations, representative of Minnesota's natural and agricultural landscapes) where the measurement systems can be safely deployed and regularly visited for maintenance. Although the focus is on plants, it is important to note that the conditions for plant leaves are also those determining winter survival for many insects, both beneficial and pests.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Real-time monitoring of conditions below snow **Budget: $99,600**

The first component of this project will be to construct, deploy and monitor automated sensors to record conditions at leaf-level under snow. Project collaborator (Dr. Paul Gauthier of Princeton University) has designed a low cost (~$600) fully automated system that is able collect data and send it over the cell-phone network to a central database. This activity therefore will involve 3 phases: (1) building and deploying the sensor systems across Minnesota in representative perennial vegetation; (2) setting up a website and database so where the data collected by the sensors can be visualized by the general public and (3) using the data from two winters of measurements to create a model predicting the conditions at plant level based on snowfall.

Outcome	Completion Date
1. Datalogger deployment	October 2016
2. Website creation	November 2016
3. Model creation	June 2018

Activity 2: Measurement of plant activity under snow **Budget: $80,400**

The conditions under snow are likely to influence the level of activity of plants during the winter. Although one might expect plant-life to be dormant when buried by snow, multiple studies have shown that plants can be photosynthetically active during this period and even grow. Unfortunately, getting a clear idea of how active plants are under snow can be tricky. We will use a technique known as chlorophyll fluorescence which allows us to estimate photosynthetic activity without having to dig the plants out of the snow. The technique involves attaching fiber-optic cables to target leaves so that they

can be measured monthly throughout the winter (and the rest of the year) with minimal interference. We wil make these measurements on the same plants as are being monitored by the sensors in *Activity 1,* with the final goal of producing a model that allows us to predict plant photosynthesis during winter months from snowfall and weather data.

Outcome	Completion Date
1. Fiber-optic cable deployment	*October 2016*
2. Monthly measurements of winter plant photosynthetic activity	*April 2018*
3. Model of below-snow photosynthetic activity	*June 2018*

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 junior scientist (University of Minnesota-Twin Cities) will be hired using ENRTF funds to carry out the construction, deployment and regular monitoring of the equipment. They will be responsible for maintenance of sensor systems, as well as the monthly measurements of photosynthetic activity. When the project leader is unable to assist in fieldwork, the junior scientist will be accompanied by undergraduate assistants.

-A computer specialist (University 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. In addition to the initial set-up of the system, ENRTF funds are also set aside for them to conduct any database upkeep or fix website problems during the 2 years of the project.

-Dr P. Gauthier (Princeton University, New Jersey) will provide in-kind services by assisting with the initial construction of the sensor systems, as well participating in the data analyses and modeling of plant photosynthetic activity. No ENRTF funds are sought for support of Dr Gauthier.

B. Project Impact and Long-Term Strategy

the project should 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 years of the project are completed, the dataloggers collecting the data can be left in place should continue to generate data at low maintenance costs ($1,000-$2,000/year). The costs for continued operation can be assumed by the lead investigator, and contributions will be sought from the field stations where they will be deployed.

The second activity of the project, the measurment of plant activity under snow, is likely to be too costly to be continued after the end of the project funding. However, the large volume of data generated from the 2 years of operation will allow us to produce a model of plant activity under snow, so that plant activity can be predicted from the datalogger outputs, or other information about snow depth and quality.

C. Timeline Requirements

The proposed project will take a little under 2 years. Several months are needed to construct the equipment and deploy it in the field prior to the first snowfall in the autumn (often late October). The sensors will then be left in place to measure through two consecutive winters. Snowfall conditions vary greatly between years, and so single year would probably be insufficient to create a useful model of below-snow conditions. Measurements will continue during the non-snowy months (and the sensors will be left in place after the end of the project, so that data collection may continue). After the second winter, a few months are required to finish analyzing the data and to develop a model relating snow depth to below-snow conditions and plant photosynthetic activity.

2016 Detailed Project Budget

Project Title: Tracking Minnesota plant life below winter snow

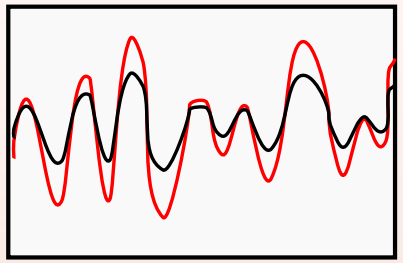
IV. TOTAL ENRTF REQUEST BUDGET - 2 years

BUDGET ITEM	AMOUNT
Personnel:	
Daniel Stanton, PI (75% salary, 25% fringe benefits); One month salary per year for training of the Junior Scientist, coordination and participation in field work and analysis of results. 50% Activity 1, 50% Activity 2	$ 11,000
Jr. Scientist/Technician(79% salary, 21% fringe benefits); The Junior Scientist/Technician who will lead the construction, installation and regular monitoring of the dataloggers and plant measurements. They will also be encouraged to participate in the analysis of data and production of scientific reports. Time includes 11months/year for two years beginning in August 2016 and ending in May 2018, to allow enough time for the construction and deployment of the units ahead of snow-fall in October or November. 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%	$ 83,000
Database Specialist (79% salary, 21% fringe benefits); 15 weeks per year; This project will generate large volumes of data in a continuous fashion. Because one of the primary objectives is to make this data publicly available, a database specialist will be hired at the start of the project to create a database and website where the data collected will be automatically uplodaded and made publicly available. This person will also be responsible for website upkeep and troubleshooting. 100% Activity 1	$ 23,000
Undergraduate student (100% salary, 0% fringe benefits); The fieldwork for this project will often require more than one person for safety and logistics. The principal investigator will participate in fieldwork (as well as all other aspects of the project) when time allows, however, further assistance may be needed at times. Funds are sought for to hire an undergraduate student as a field assistant during winter months, estimating 10 hours/week for 25 weeks (late October though mid-April). 100% Activity 2	$ 7,000
Equipment/Tools/Supplies:	$ -
Lab/Field Supplies: Supplies are needed for assembly and maintenance of the dataloggers (miscellaneous tools, replacement batteries and hard-drives). Funds are also considered for the purchase of field safety gear (first aid kits, cold weather protection), due to the risks of working in remote and often below-freezing conditions. 33% Activity 1, 66% Activity 2	$ 6,000
40 dataloggers - The unit cost of each datalogger unit is ~$600, including sensors, batteries, hard-drive, circuit board, solar panel (for summer months) and protective casing. Four dataloggers will be set up at each of ten field sites representing the diversity of Minnesota vegetation. 100% Activity 1	$ 24,000
2 chlorophyll fluorescence systems - The plant activity measurement systems (chlorophyll fluorescence) have two components: fibreoptic cables that installed on the surface of the study plants with an angled leaf-clip, and will be left in place over the winter such that measurements can be made even with snow present. These are then used in conjunction with a field portable PAM fluorimeter (JUNIOR-PAM, Walz Gmbh, Germany) to measure photosynthetic activity. Because these measurements are time consuming, two machines (~$3,500/each, direct quote from March 9th 2015) are requested, so that multiple leaves can be measured in parallel. $3,500/unit x 2 + $1000 fiberoptics = $8,000. 100% Activity 2.	$ 8,000
Travel:	
Travel funds are sought to support travel to sampling sites across the state of Minnesota. Travel includes car rental for approx. 10 days per month plus mileage (approx. 800 miles per month). Sampling will be done 11 months per year. 20% Activity 1, 80% Activity 2.	$ 18,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 180,000

V. OTHER FUNDS

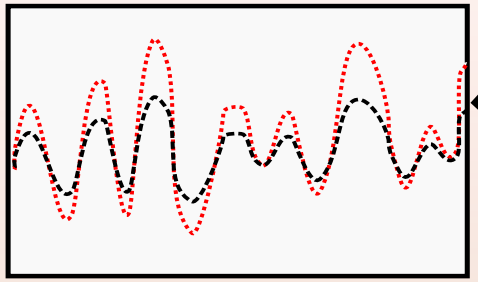
SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: *N/A*	N/A	
Other State $ To Be Applied To Project During Project Period: *N/A*	N/A	
In-kind Services To Be Applied To Project During Project Period: *Indirect Costs (52% MTDC) associated with this proposal*	$ 93,000	*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

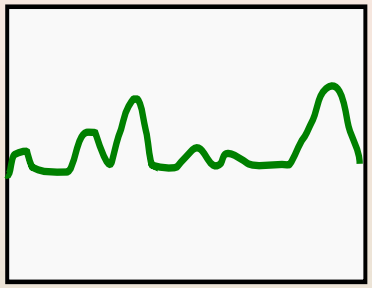


Data sent hourly over cell-phone network

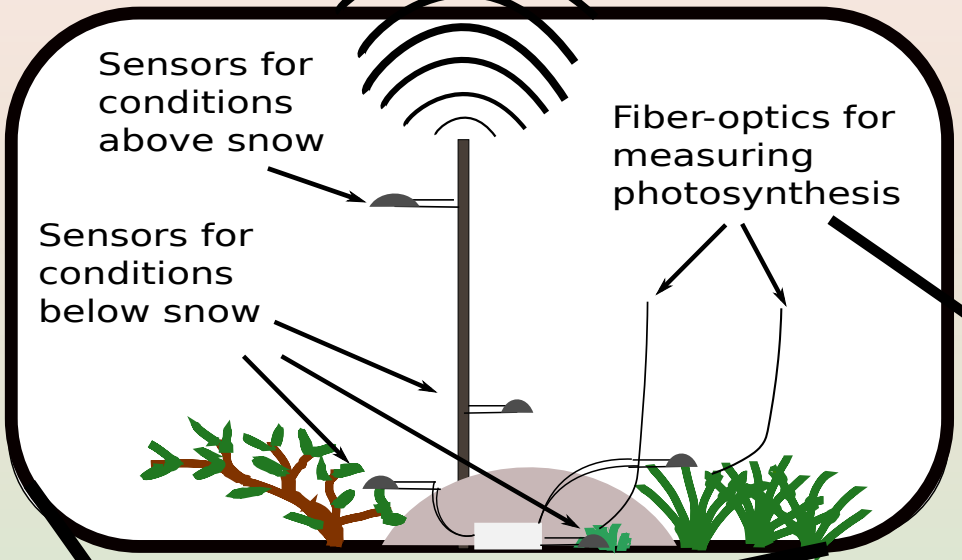
Predictive models of conditions below-snow based on snow depth and air temperature

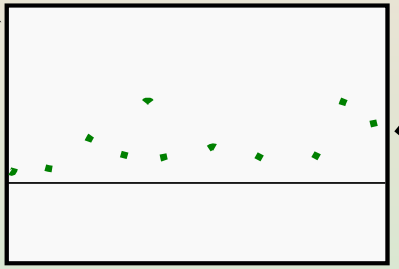


Activity 1:
Real-time monitoring of conditions below snow

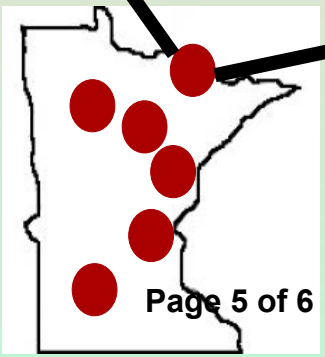


Predictive models of plant photosynthesis and growth during winter





Monthly direct measurements of plant activity below snow



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

Activity 2:
Measurement of plant activity under snow

07/15/2015

ENRTF ID: 028-A

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