Environment and Natural Resources Trust Fund
2015 Request for Proposals (RFP)

Project Title: **ENRTF ID: 111-E**

Soil Frost and Sustainable Forestry Under Varying Climate

Category: E. Air Quality, Climate Change, and Renewable Energy

Total Project Budget: $ 305,000

Proposed Project Time Period for the Funding Requested: 3 years, July 2015 - June 2018

Summary:

Quantify factors that control soil frost with historic data and experimental manipulations. Develop strategies to minimize soil and water impacts during winter forest harvesting now and under a warming climate.

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Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Picture shows extensive rutting of a peatland site that was harvested during winter with insufficient frost present. The factors that control soil frost are also shown including air temperature, soil properties, and snow characteristics.

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

PROJECT TITLE: Soil frost and sustainable forestry under varying climate

I. PROJECT STATEMENT

An improved understanding of mechanisms and processes contributing to soil frost is needed to develop strategies to maintain frozen-ground conditions during timber harvesting operations now and in the future. Logging during winter when soil is frozen is one of the most common methods prescribed to protect forest resources when harvesting timber. Frozen soil is less susceptible to rutting and compaction, which can impair soil productivity and contribute to degraded water quality. In addition, many sites such as peatlands are only accessible when the ground is frozen. As a result, land managers commonly require forest harvesting to occur during winter months, with between 60-70% of the total annual harvest occurring from December through March. Although foresters take precautions to limit rutting and compaction during winter harvesting, impacts to soil and water still occur because of insufficient frost penetration in the ground due to a variety of factors such as air temperature, soil properties, soil moisture, and the timing and amount of snowfall. **Although many of the factors that influence frost depth and occurrence are known, the mechanisms by which they control and interact to produce soil frost in a variety of soil types is unclear, hampering our ability to predict optimal conditions to minimize impacts to forest resources during winter harvesting now and under a warming climate.** An improved understanding of these mechanisms will allow us to develop practices to promote soil frost (e.g., manipulate snow conditions), forecast when operational conditions are optimal for harvesting, and help the DNR develop strategic plans and adaptation strategies for winter harvesting in a future climate.

The goal of this project is to quantify the mechanisms that contribute to soil frost across a range of soil types to improve our ability to predict optimal harvesting conditions and develop practices that minimize impacts to forest resources now and under a warmer climate. We will achieve this goal using a long-term soil frost dataset and a network of experimental treatments that manipulate key factors which influence soil frost.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: **Model the influence of climate variation on frost occurrence** **Budget: $ 115,000**
We will utilize a 50 year dataset from the Marcell Experimental Forest (located in the Chippewa National Forest) that includes data on climate, frost, and snow depth across representative forest cover types and soils of northern Minnesota. We will use this dataset and other available data (e.g., weather records, soil temperature records) to model frost occurrence and depth as a function of snow depth, air temperature, soil properties, and other pertinent variables. Model validation will be conducted using a subset of measurements from the dataset and measurements collected during the project period. Results will be integrated with those from Activity 3 to develop strategies to optimize frost establishment in a warming climate.

Outcome	Completion Date
1. All datasets acquired and pre-processing completed	July 2016
2. Frost-climate models developed	Dec. 2016
3. Frost models checked and validated with real-time weather data	Apr. 2018
4. Effects of climate incorporated into final report and frost management strategies	June 2018

Activity 2: Assess the influence of key factors on soil frost with experimental manipulation throughout Minnesota **Budget: $ 165,000**

We will develop a network of research sites along a temperature gradient from southern to northern Minnesota across a range of soil textures. Soil texture is a key property that influences soil frost because it controls soil moisture dynamics. Experimental treatments that manipulate snow depth, density, and occurrence will be replicated at each site as follows: Control (no treatment – ambient snow present), no snow, double the snow that occurs (2x the control amount), and compacted snow (to approximate operational practices currently employed). Treatments will be applied for three winters to assess the influence of inter-annual variability in climate on soil frost. We will measure and analyze the effect of these treatments on soil temperature and moisture, frost occurrence and depth, soil strength, and variation in response over time.

Outcome	Completion Date
1. 15 sites identified that span the range of climate and soils in MN	Oct. 2015
2. Treatments applied and effects on soil properties and frost measured for 3 winters	Mar. 2018
3. Effect of air temperature, soil texture, and snow on soil frost and strength determined	June 2018

Activity 3: Develop frost management strategies under current and future climate **Budget: $ 25,000**

We will identify key factors and conditions influencing the occurrence of frost to evaluate scenarios for current and future climatic conditions, and develop best practices to maximize frost occurrence. For each scenario, we will develop strategies and recommendations to obtain sufficient frost depth that will minimize impacts during winter harvesting operations. We will communicate our findings to pertinent governmental agencies, policy organizations, and land managers.

Outcome	Completion Date
1. Findings from Activities 1 and 2 synthesized and key frost factors identified	Mar. 2018
2. Scenarios developed for current operational practices and future climate projections	Mar. 2018
3. Best practices to maximize frost occurrence developed	June 2018
4. Recommendations for each operational/climate scenario communicated	June 2018

III. PROJECT STRATEGY

A. Project Team/Partners

Team members who will contribute time and effort to the project are Dr. Robert Slesak (MN Forest Resources Council; who receives funds from the request), Dr. Charlie Blinn (University of Minnesota; who receives funds from the request), Dr. Randy Kolka (US Forest Service) and Dr. Stephen Sebestyen (US Forest Service). The Forest Service will also contribute additional in-kind funds to the project in the form of Drs. Kolka's and Sebestyen's salary, equipment use, and data sets. The Minnesota Department of Natural Resources is also cooperating by providing their lands for study treatments, and will work closely with the project team on Activity 3 so that findings will be more easily incorporated into DNR operations and policies.

B. Project Impact and Long-Term Strategy

The findings will be widely used by private and public land managers to reduce impacts to soil and water that occur during winter harvesting. Furthermore, the results will be used by governmental agencies for long-term planning efforts and development of related policies for addressing climate change. Results will be presented to cooperators and other pertinent parties and submitted to peer review outlets.

C. Timeline Requirements

The proposed project duration of three years is necessary to assess manipulative treatment effects for three winter seasons to account for variability in weather conditions among years.

2015 Detailed Project Budget

Project Title: Soil frost and sustainable forestry under varying climate

PIs: R.A. Slesak (MFRC), C. Blinn (UMN), R. Kolka (USFS), S. Sebestyen (USFS)

IV. TOTAL ENRTF REQUEST BUDGET 3 years

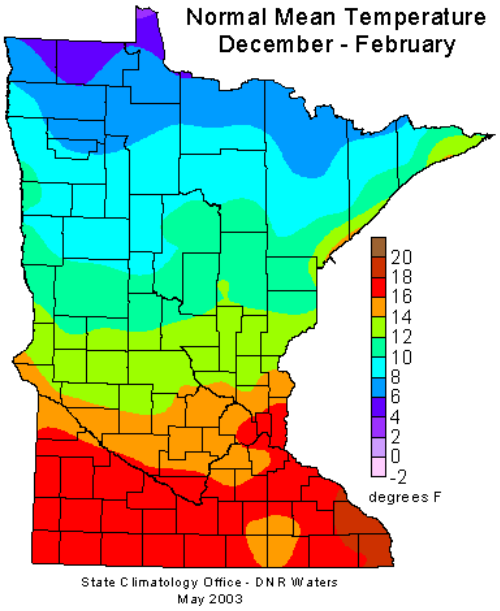
BUDGET ITEM	AMOUNT
Personnel: Salary and fringe (0.8326) for 1 PhD student for 3 years	$ 120,187
Personnel: Salary and fringe (0.307) for 1 Research Associate (1.0 FTE) for 3 years who will coordinate treatment application and data collection at the project sites	$ 149,473
Equipment/Tools/Supplies: Soil temperature and moisture sensors ($10,500), dataloggers ($8,000), soil penetrometer ($700), snow tube and scale ($500), shovels and misc. supplies for treatment application ($640)	$ 20,340
Travel: Travel for mileage (75%) and lodging (25%) within Minnesota for researchers, the Research Associate, and Graduate Student to the project sites. A large amount of travel will be requiried because sites will be located from southern to northern Minnesota and require periodic visits following snow events.	$ 15,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 305,000

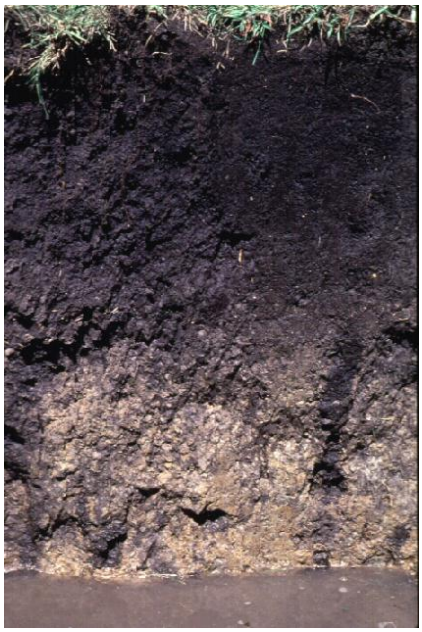
V. OTHER FUNDS

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: In-kind salary from R. Slesak (0.1 FTE) , R. Kolka (0.05 FTE) and S. Sebestyn (0.05 FTE)	$ 76,900	*Secured*
Funding History: Funds used to support Marcell Experimental Forest frost data collection over past 50 years	$ 100,000	
Remaining $ From Current ENRTF Appropriation:	N/A	*N/A*

Insufficient frost during harvesting can result in large impacts to soil and water. This peat land site was heavily rutted when insufficient frost was present during winter harvesting, which could become more common in a warmer climate.

We want to <u>avoid this</u>, by understanding how these <u>factors influence soil frost</u>





<u>Air temperature</u>

Colder air increases frost occurrence

Dependent on soil and snow conditions

<u>Soil properties</u>

Soil water influences frost establishment and depth

Soil water content varies with soil texture and density

<u>Snow characteristics</u>

Presence of snow inhibits frost development

Compacting snow can increase frost

Soil frost and sustainable forestry under varying climate

Project manager qualifications

Robert A. Slesak

Qualifications

Rob is Adjunct Assistant Professor in the Department of Forest Resources, University of Minnesota, and manager of the Site-level Program at the Minnesota Forest Resources Council. He is responsible for evaluation and development of Minnesota's Forest Management Guidelines, assessing their effectiveness with monitoring and research, and conducting research to address existing and emerging threats to sustainable forest management. Rob has extensive experience addressing complex forest resource issues including the identification of information needs for efficient and effective solutions to the challenges of sustainable forest management. He is a principal investigator and project manager on several ongoing projects related to invasive species, soil productivity, and forest sustainability, and has published a number of peer-reviewed journal papers related to these topics. Rob has a Ph.D in Forest Soils from Oregon State University, a M.S.in Forest Ecosystem Science from SUNY Environmental Science and Forestry (ESF), and a B.S. in Forest Resource Management from SUNY ESF. His research and professional interests are broadly focused on sustainable forest management, including identification of processes critical to ecosystem functions, evaluation of the potential for those processes and functions to be altered by management activities, and the application of management practices to restore degraded ecosystem functions.

Organization description

The Department of Forest Resources is part of the University of Minnesota.

The Minnesota Forest Resources Council was established by the Sustainable Forest Resources Act to promote long-term sustainable management of Minnesota's forests.