Environment and Natural Resources Trust Fund
2019 Request for Proposals (RFP)

Project Title: **ENRTF ID: 022-A**

Mapping Climate and Insect Threats for Minnesota Pines

Category: A. Foundational Natural Resource Data and Information

Sub-Category:

Total Project Budget: $ 339,474

Proposed Project Time Period for the Funding Requested: June 30, 2022 (3 yrs)

Summary:

Pine trees in Minnesota are increasingly threatened by droughts and insect attacks. The proposed statewide vulnerability map will identify where pine trees are most "at-risk" from changing future conditions.

Name: Xue Feng

Sponsoring Organization: U of MN

Title:

Department:

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Minneapolis MN 55455

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Web Address

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

The two stages of making the pine vulnerability map are shown through a flowchart: first, incorporate information about drought stress; then, add climate-related insect activity.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%
____ If under $200,000, waive presentation?			

PROJECT TITLE: Mapping Climate and Insect Threats for Minnesota Pines

I. PROJECT STATEMENT

Pine trees are iconic to the Minnesota north woods and provide countless benefits: they support wildlife habitats, water purification, recreation activities, and the timber industry. Statewide, pines provide an estimated $3.9 million in annual net revenues from timber (DNR) and stock 22.9 million metric tons of carbon (USDA Forest Inventory Analysis). However, they are also increasingly threatened by warming temperatures. In this project, **we will produce statewide maps that identify where pine trees are most vulnerable to both drought stress and forest insect attacks**. This will be the first such effort to evaluate these emerging threats in tandem, and will provides valuable information to resource managers for planning mitigation and/or adaptation strategies.

Over the last five years, millions of pine trees have died in western U.S. and Canada from drought, fires, and insects, and **the same climate factors that have made pines vulnerable are moving east- and northward.** Drought years in Minnesota are becoming more frequent. This pattern is concerning because insects respond quickly to trees whose immune systems are weakened by drought, and tree-killing activity by our native bark beetles increases in dry years. Increasing temperatures can exacerbate these challenges; warming winters, for example, decrease the mortality rate of overwintering insect pests. Invasive species such as the Sirex woodwasp – not yet present in Minnesota – are also more likely to establish when pines are stressed. By anticipating areas that will become less hospitable to pines, resource managers will have a head start in planning for strategies to mitigate future damages, safeguard existing forests, and plant new species mixes.

What makes pine mortality difficult to predict is the impacts from multiple stressors such as drought, temperature, and insects. These stressors need to be addressed together to make accurate assessment of overall species vulnerability. To do so, we will produce the vulnerability maps through:

(1) *Knowledge of the physiological and biological mechanisms that regulate tree growth, drought stress, and mortality, as well as forest insect lifecycles and proliferation*

(2) *Development and synthesis of detailed computer models with comprehensive datasets on climate, soil, and species distribution that will extrapolate this knowledge into future climate scenarios*

Once the vulnerability maps are developed, we will collaborate with USDA extension specialists at UMN as well as MDA and DNR staff to facilitate the transfer of our results to forest managers.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Collect and analyze data to identify drivers of pine mortality* **Budget: $111,047**

We will compile extensive datasets on soil type, historical climate, pine species distributions, and past dieback events from the DNR, USDA Forest Inventory Analysis and Soil Conservation Service, and statewide weather station networks. We will also measure physiological data on select pine species (red pine, jack pine, and Eastern white pine) that will reveal their intrinsic vulnerability to drought and water use habits. In particular, we will develop estimates of xylem (wood) vulnerability to decreasing soil water availability that will inform us of the drought stress level predicted to cause hydraulic failure (loss of water transport capacity) and mortality. We will then use them to identify correlations between insect outbreaks (e.g., from bark beetles), pine forest diebacks, and related climatological and hydrological causes.

Outcomes	Completion Date
1. Collect and process multiple datasets on soil, climate, and species distribution (for red pine, jack pine, and Eastern white pine), along with historical records of dieback	05/2020

2. Measure physiological data for select pine species during the growing season	10/2020
3. Data analysis to determine the relative contributions of soil, climate, and environmental factors as cause of historical dieback	05/2021

Activity 2: ***Develop 2-stage model for predicting drought and insect vulnerability*** **Budget: $114,772**

Using results from Activity 1, we will develop new models that capture the interaction between pines and their environment (based on soil water supply and atmospheric water demand) that make them vulnerable to drought stress, which further predisposes them to insect attacks. These models will predict how likely outbreaks will occur based on climate extremes.

Outcomes	Completion Date
1. Develop models for predicting drought vulnerability and insect susceptibility	12/2021

Activity 3: ***Construct map of pine vulnerability based on future climate extremes*** **Budget: $113,655**

We will use downscaled climate projections to simulate future weather patterns across Minnesota. Maps of pine vulnerability will be produced based on the predicted likelihood of tree mortality resulting from drought stress, insect attacks, or both (from Activity 2), under multiple future weather simulations. These simulations will be performed using University of Minnesota's super computing facilities. The results will be documented, archived, and made publicly available online to facilitate access and use by resource managers and stakeholders.

Outcomes	Completion Date
1. Produce vulnerability maps based on future climate conditions downscaled to MN	04/2022
2. Document and upload maps for use by resource managers	06/2022

III. PROJECT PARTNERS (receiving ENRTF funding unless otherwise noted)

- Dr. Xue Feng, Assistant Professor, UMN Dept. of Civil, Environmental, and Geo-Engineering, Project-lead
- Dr. Jeanine Cavender-Bares, Professor, UMN Dept. of Ecology, Evolution, and Behavior
  - Lead data collection of Activity 1, advisory role on Activity 2 & 3 (tree physiology and drought response)
- Dr. Brian Aukema**,** Associate Professor, UMN Dept. of Entomology
  - Advisory role on Activity 1,2,3 (insect behavior and population dynamics)
- We will collaborate with DNR Forest Health teams and USDA Forest Service (**not receiving ENRTF funds**) to acquire and interpret data

IV. LONG-TERM- IMPLEMENTATION AND FUNDING

Prof. Feng only recently joined the University of Minnesota, so has never requested funds from LCCMR. This is a new project that will provide foundational information for evaluating future climate-related risks to pines across the state, allowing managers to prioritize monitoring and harvesting efforts as well as to plan for mitigation strategies. This project will incorporate state-of-the-art science on the impacts of drought stress and insect outbreaks. We anticipate that this work will serve as a template for the production of similar maps for other "at risk" species, including tamarack and aspen, with updated information on climate or land-use changes, which may be the focus of future requests after this project is successfully delivered.

V. TIME LINE REQUIREMENTS

Three years of support (July 2019 – June 2022) are requested to collect, process, and analyze data (Activity 1), to construct computer models (Activity 2), to produce vulnerability maps based on future climates (Activity 3), and to ensure proper documentation and communication of results (Activity 3).

2019 Proposal Budget Spreadsheet

Project Title: Mapping Climate and Insect Threats for Minnesota Pines

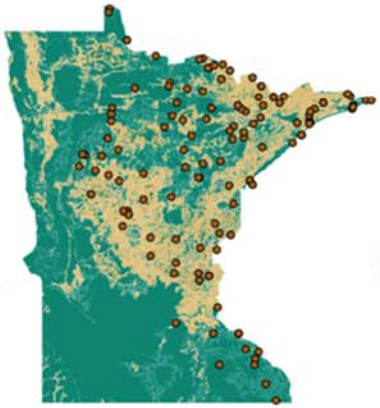
IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel:	
Graduate Research Assistant (Activity 1, 2, and 3, Department of Civil, Environmental, and Geo-Engineering, co-supervised by all PIs) (50% FTE), 85% salary, 15% benefits, plus tuition	$ 143,151
Dr. Xue Feng, PI, 1.5 month summer salary (17% FTE), 67% salary, 33% benefits	$ 61,981
Dr. Jeannine Cavender-Bares, co-PI, 1 month summer salary (11% FTE), 67% salary, 33% benefits	$ 49,270
Dr. Brian Aukema, co-PI, 0.5 month summer salary (6% FTE), 67% salary, 33% benefits	$ 26,336
Research Technician (Activity 1 and 2), 3 month salary (25% FTE), 73% salary, 27% benefits	$ 49,608
Equipment/Tools/Supplies:	
Equipment set-up for using the optical method for quantifying xylem vulnerability of pine species	$ 2,000
Requesting permission for dedicated workstation to simulate future weather patterns and drought response. This station will interface with UMN Supercomputing Institute machines (latter use: no charge).	$ 3,000
Travel: Mileage ($0.54/mile), lodging ($40/night/person), and meals ($40/day/person) for travel to and from field site (UMN Cloquet Forestry Center; approximately 300 miles round trip; 3 days per trip, 4 person teams, estimated 4 trips total) to collect samples, based on the university compensation policy. One trip allocated for graduate research assistant to attend a regional 4-day North Central Forest Pest Workshop (meeting location yet to be decided for 2019 and beyond, but usually located within the Midwestern states), total cost $760 ($300 flight round trip, hotel $100/night, meals $40/day).	$ 4,128
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 339,474

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period:	*N/A*	
Other State $ To Be Applied To Project During Project Period:	*N/A*	
In-kind Services To Be Applied To Project During Project Period: Because the project is overhead-free, laboratory space, electricity, supercomputing access, and other overhead costs are provided in kind. The University of Minnesota overhead rate is 54%.	*N/A*	
Past and Current ENRTF Appropriation:	*N/A*	
Other Funding History: NOAA Climate and Global Change Postdoctoral Fellowship to Feng (developed platforms for modeling drought vulnerability of woody species that will be used for this project)	$ 138,770	*Secured*

Currently, pine trees in MN grow mostly on sandy soils — this **makes them more vulnerable to drought**

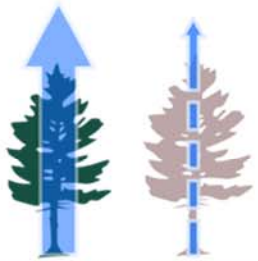


Where will pine trees become **most vulnerable to climate change in the future**? ...

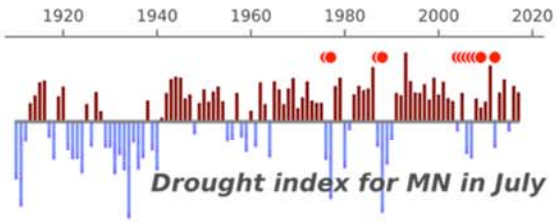
Project outcome:
state-wide pine vulnerability map

... so we can help local resource managers **be prepared** to protect our pine forests.

Stage 1: Drought stress



Project methodology:
Link climate, drought stress, and insect lifecycles to predict mortality risk



Historically, bark beetle outbreaks (red dots) have followed notable drought years in MN.

Stage 2: Insect attacks

QUALIFICATIONS OF PROJECT MANAGER, DR. XUE FENG

Appointments

2017 – present Assistant Professor, University of Minnesota, Twin Cities
Department of Civil, Environmental, and Geo-Engineering
Graduate faculty in Water Resources Sciences program

Education and Professional Preparation

University of California, Berkeley	Postdoc	Ecohydrology	2015 – 2017
Duke University	Ph.D.	Civil & Environmental Engineering	2015
Stanford University	B.S. / Minor	Mechanical Engineering / Biology	2010

Prior Related Experiences

Feng joined the faculty of Civil, Environmental, and Geo-Engineering at the University of Minnesota in 2017. Her research focuses on understanding the hydrological feedback between soils, plants, and the atmosphere through a combination of field-based and computational methods. In her past work as a NOAA Climate and Global Change Postdoctoral Fellow at the University of California, Berkeley, Feng has investigated the climatic, soil-related, and physiological drivers of stress and mortality of woodland species during the historic California drought of 2012 – 2015. She conducted fieldwork to collect a comprehensive set of plant observations made over the course of the drought, and combined it with a model of rainfall and plant water use to quantify hydraulic risk. The models she has developed and intend to use for this project are especially well suited to representing uncertainties and risks stemming from climate variability and extreme water deficit. Her current project at the University of Minnesota studies the effects of forest conversion (from deciduous aspen/birth to coniferous spruce/pine species) on the water yield and carbon emissions from a peatland ecosystem near Grand Rapids, MN, in collaboration with the USDA Forest Service.

PROJECT PARTNERS

Dr. Jeannine Cavender-Bares is a faculty member in the UMN Department of Ecology, Evolution, and Behavior since 2003 and has extensive expertise on tree physiology, drought resistance, and ecological interactions. She has worked to protect the health and ecosystem services of forests in Minnesota, including through recent projects on detecting and treating Oak Wilt (a fungal disease targeting Minnesota oaks). She will be leading the data collection for Activity 1 and co-advising the graduate research assistant on this project.

Dr. Brian Aukema is a forest insect specialist and faculty member in the UMN Department of Entomology since 2010. He works on both native and invasive species in the state of Minnesota and beyond (e.g., emerald ash borer on ash, gypsy moth on oak and aspen, thousand cankers disease on walnut, eastern larch beetle and larch casebearer on tamarack, and more). He will be supervising the technician and co-advising the graduate research assistant on this project.

ORGANIZATION DESCRIPTION

The **Department of Civil, Environmental, and Geo-Engineering** is part of the College of Science and Engineering at the University of Minnesota. Its mission is "…to transform the world by addressing critical challenges in designing and protecting our infrastructure, environment, water and earth resources" through education, research, and outreach. Its 30 full time faculty members are engaged in a wide range of socially relevant research topics, including on the protection and remediation of soil and water resources.