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

Project Title: **ENRTF ID: 011-A**

Assessing Vegetations Control on Minnesota's Groundwater

Category: A. Foundational Natural Resource Data and Information

Total Project Budget: $ 212,964

Proposed Project Time Period for the Funding Requested: 3 years, July 2016 to June 2019

Summary:

Plant response to climate affects groundwater, but current groundwater recharge maps omit this link. Proposed statewide assessment tool predicts vegetation growth and groundwater recharge impacts under climate and land-use change.

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Sponsoring Organization: U of MN

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Web Address

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Map of Minnesota's distinct eco-regions and precipitation contours, with photo-diagrams depicting the vegetation to groundwater recharge system that will be evaluated with the proposed assessment tool.

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

PROJECT TITLE: Assessing Vegetation's Control on Minnesota's Groundwater

I. PROJECT STATEMENT

Vegetation growth depends on climate and land-use conditions; this directly affects groundwater recharge, because plants compete with shallow aquifers for water through evapotranspiration. New statewide groundwater recharge maps are valuable for current water management, but they assume plants to be static and neglect the timing of water table impacts. A biophysical model planned for Minnesota will provide vegetation details but omits data connecting these to groundwater systems. Thus, we lack the ability to predict groundwater recharge when vegetation growing conditions change. **Our proposed project addresses this gap by providing:**

- **Statewide time-lapse maps of plant growth and groundwater recharge estimates**
- **Evaluations of how plant and groundwater impacts are linked under climate and land-use change**
- **Reliability maps indicating where additional data are needed for improving recharge estimates**

Our **statewide assessment will cover Minnesota's diverse eco-regions, natural and managed systems, hydrogeological provinces, and sharp precipitation gradient**. It will address questions such as: how much could above-normal spring temperatures trigger early green-ups that diminish recharge; how much will roots deplete deep soil moisture when summer rains are scarce; and how does this depend on plant and soil type? Answers are most urgent for areas such as: (1) the drier west, where low recharge rates are highly susceptible to climate and vegetation perturbations, (2) the north-central lakes region, where conversion from deep-rooted forests to cropland strongly alters recharge, and (3) northern mixed forests, which will likely shift from conifers to more broadleaf species as temperatures warm. Throughout the state, our maps will benefit ecological and water resources managers in their long-term preparations as land-cover and climate boundaries move.

The challenge in accurately quantifying groundwater recharge is insufficient data. To generate our maps, **we will develop an assessment tool that (1) incorporates multiple datasets spanning the land-surface all the way down to the water table and (2) represents the physical mechanisms of plant growth and water flow to bridge data gaps.** In addition to leveraging widely available weather, soil, and vegetation maps, we will work with the Minnesota Geological Survey to incorporate surface and subsurface geologic maps from the County Geologic Atlas series, and state-wide water well and observation well networks. By connecting the climate-vegetation domain and groundwater systems, our project will help enable critical coordination between ecological and groundwater management in Minnesota.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Compile and analyze data connecting climate and vegetation to groundwater systems. **Budget: $68,323**

We will compile data needed for the vegetation and recharge assessment. This effort will leverage climate and soil data previously gathered for the USGS/MPCA's groundwater recharge maps, and it will add satellite observations of vegetation change and state geological and groundwater well databases from the Minnesota Geological Survey. This will comprise the most comprehensive state-wide dataset to date for information related to groundwater recharge. Data will be formatted and standardized for resource managers anywhere to easily look up information.

Outcome	Completion Date
1. Comprehensive dataset over the entire state for evaluating groundwater recharge	1/31/17
2. Publicly available information in easy-to-use formats for resource managers	6/30/17

Activity 2: Develop and calibrate an assessment tool for computing plant growth and recharge throughout Minnesota **Budget: $119,205**

We will employ the "Community Land Model," a computer model for evaluating water transport through soil, vegetation, and the atmosphere. We will tailor the model to Minnesota's eco-climatic and geological settings using extensive data from Activity 1. The development of this assessment tool requires technological facilities not readily available to resource managers or even most state agency scientists. The project team will utilize the University of Minnesota's super-computing system to create the assessment tool and make accessible its results.

Outcome	Completion Date
1. Assessment tool development using University of Minnesota's computational facilities	10/31/18
2. Execution of assessment tool to estimate vegetation growth and recharge for the entire state.	1/31/19
3. Documentation of assessment tool for use by state agencies and technical managers.	2/28/19

Activity 3: Produce and disseminate statewide time-lapse maps of vegetation growth and groundwater recharge estimates. **Budget: $12,718**

With the assessment tool results, we will produce weekly maps of vegetation growth and groundwater recharge, available on the project's website in multiple forms. GIS formats consistent with the Minnesota Geospatial Commons website can readily plug into resource planning tools. Graphical formats enable easy look-up for any location and time. We will also create maps indicating where plant growth and recharge appear most susceptible to climate variability and land-cover change. For sensitive regions such as drier prairies and recently converted cropland, we will report weather thresholds and critical vegetation types that alter recharge rates.

Outcome	Completion Date
1. GIS and graphical files with statewide maps of plant-growth and recharge estimates	3/31/19
2. Risk assessment maps indicating locations where plant growth and recharge are most vulnerable	4/30/19
3. Reports of weather thresholds and critical vegetation types causing significant recharge changes	4/30/19

Activity 4: Produce reliability maps identifying priority monitoring areas for improving recharge estimates. **Budget: $12,718**

We will provide reliability maps for the vegetation growth and recharge estimates, indicating where the assessment tool is more uncertain. These locations correspond to areas in the state where additional observations are needed. The reliability maps will be important for resource managers, and they will help guide future monitoring efforts.

Outcome	Completion Date
1. Reliability maps alerting managers where assessment tool results are less certain	6/30/19
2. Recommendations for additional monitoring to improve vegetation and recharge estimates	6/30/19

III. PROJECT STRATEGY

A. Project Team/Partners

The project team consists of Principal Investigator (PI) Crystal Ng (University of Minneosta) and co-PI Bob Tipping (Minnesota Geological Survey). Ng will oversee all aspects of the project and has access to super-computing resources at the University of Minnesota. Tipping will help direct the compilation of state databases in Activity 1 and the production of GIS and map outputs in Activity 3.

B. Project Impact and Long-Term Strategy

The upfront investment in developing the assessment tool will facilitate future evaluations of ecological and groundwater resources. The assessment tool will also be valuable for investigating "what-if" scenarios of climate and land-cover change. Reliability maps will help prioritize future observation campaigns. This can lead to continued coordination between state-wide monitoring programs and the project team for assessing vegetation growth and corresponding groundwater recharge.

C. Timeline Requirements

Three years to gather data, develop the assessment tool, and produce and analyze maps.

2016 Detailed Project Budget

Project Title: Assessing Vegetation's Control on Minnesota's Groundwater

IV. TOTAL ENRTF REQUEST BUDGET *3* years

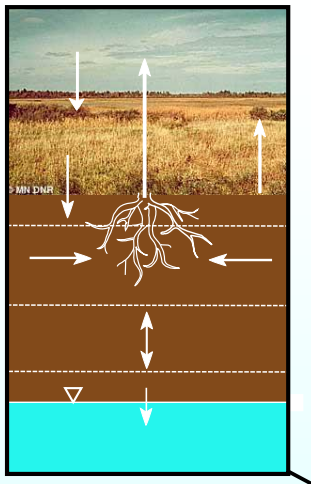
BUDGET ITEM	AMOUNT
Personnel: PI Ng: 75% salary, 25% benefits, 3.75 summers months total	$ 40,066
Personnel: co-PI Tipping: 79% salary, 21% benefits, 3.5 summer months total	$ 24,966
Personnel: Graduate Student; 55% salary, 45% benefits (includes tuition), 3 years, 0.5 time position (begins 9/2016)	$ 126,938
Personnel: Undergraduate Student; 100% salary, 3 years: 10 hr/wk term-time, 40 hr/wk summer	$ 13,994
Equipment/Tools/Supplies: Dedicated desktop computer for use by graduate student on this project. Exception requested because this is a necessity for this computational project. A Linux workstation computer is required because model code-building and pre-testing are not permitted nor practical on the University of Minnesota's super-computing system. (The super-computing system will be used for the final model completion.) The computer requested requires greater performance specifications than typical for standard student computer equipment.	$ 3,000
Equipment/Tools/Supplies: Dedicated external hard-drives for storing assessment tool results and map files	$ 300
Equipment/Tools/Supplies: Computer software and licenses for model development (Intel compilers, Matlab). Specialized software is necessary on the dedicated desktop computer to be used for model code-building and pre-testing (prior to execution on University of Minnesota's super-computing system).	$ 1,700
Equipment/Tools/Supplies: Production cost of info-sheet on assessment tool for use by state agency scientists and technical managers	$ 2,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 212,964

V. OTHER FUNDS

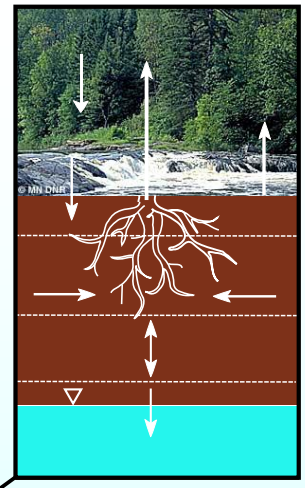
SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: N/A	$ -	-
Other State $ To Be Applied To Project During Project Period: N/A	$ -	-
In-kind Services To Be Applied To Project During Project Period: The University of Minnesota's Facilities and Administrative rate is 52% of modified total direct costs (total direct less graduate student fringe, capital equipment, subawards over $25,000 and on-site facilities rental). The amount, if F&A expenses would have been allowed on the project, would be $82,707. The University will provide office space, IT services, and administrative / financial services in support of the project.	$ 82,707	*secured*
In-kind Services To Be Applied To Project During Project Period: Ng is an project PI at the Minnesota Supercomputing Institute (MSI). Through this affiliation, Ng has access to High-Performance-Computing (computer cluster) resources needed for executing the model calibration and simulations for this project.	-	*secured*
Funding History: None to date. This is a new initiative by the project team.	$ -	-
Remaining $ From Current ENRTF Appropriation: N/A	$ -	-

Assessing Vegetation's Control on Minnesota's Groundwater

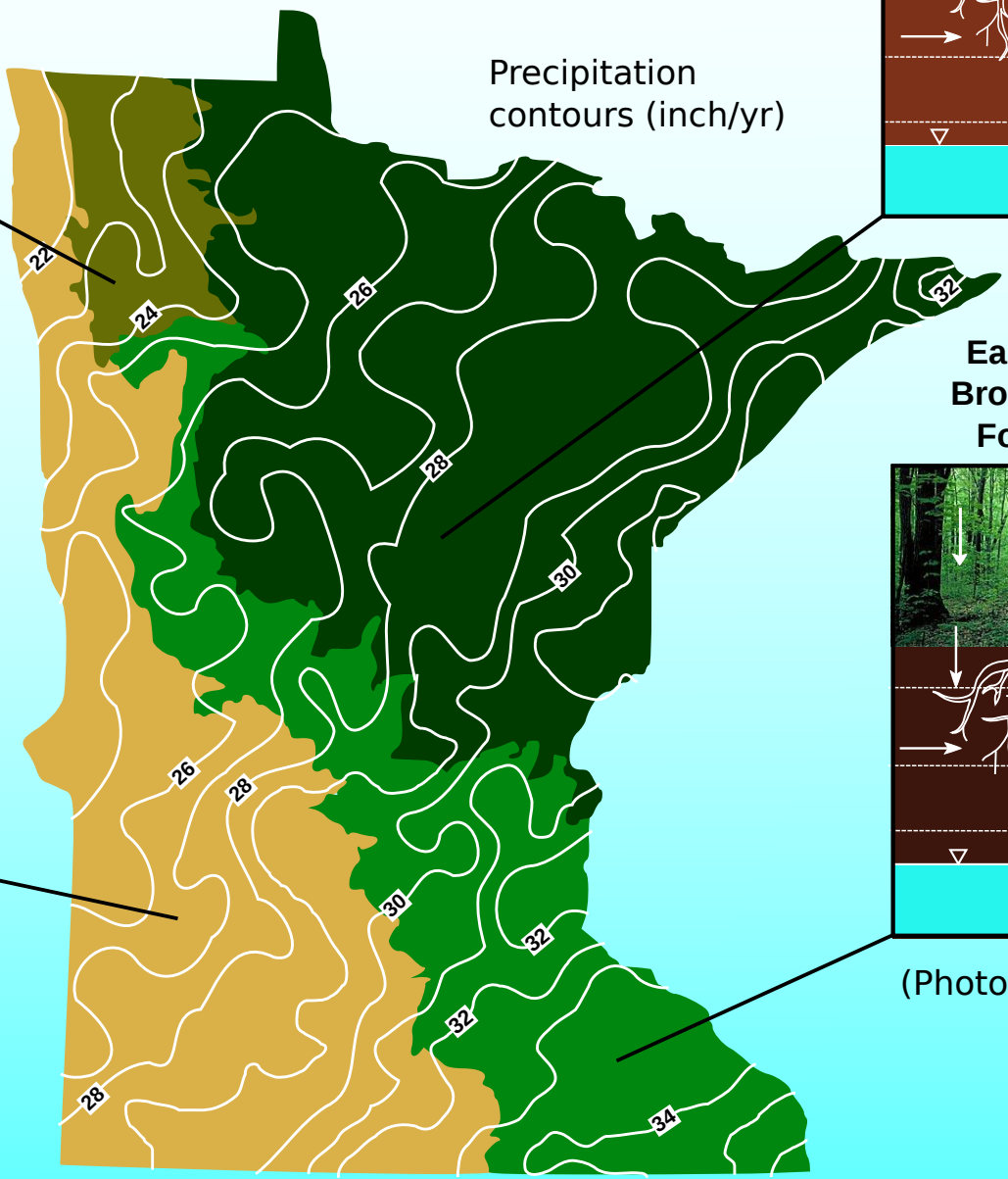
Tallgrass Aspen Parkland



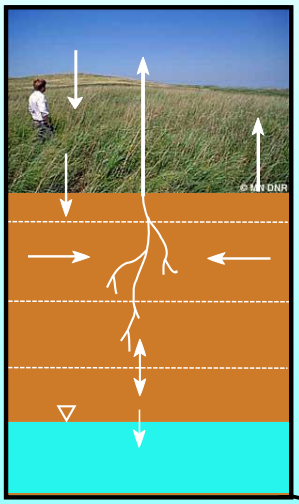
Laurentian Mixed Forest



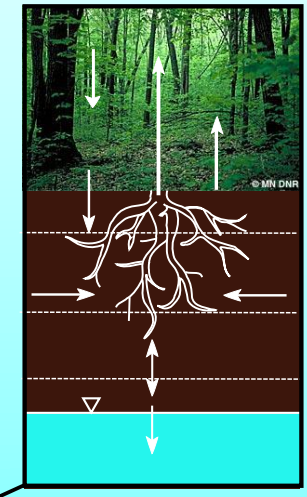
Precipitation contours (inch/yr)



Prairie Parkland

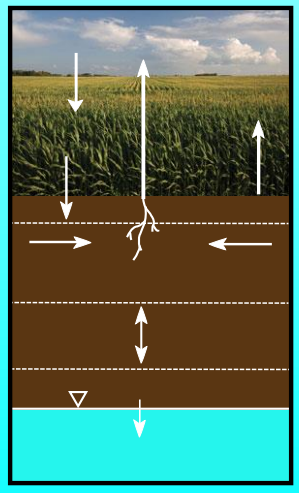


Eastern Broadleaf Forest



(Photos by DNR)

Farmland



Vegetation controls groundwater recharge across Minnesota's diverse eco-regions, hydrogeological provinces, and sharp precipitation gradient.

Our proposed assessment tool will provide statewide maps of plant growth and groundwater recharge estimates to help prepare for impacts when climate and land-cover change.

Project Manager Qualifications & Organizational Description

Project Title: Assessing Vegetation's Control on Minnesota's Groundwater

Gene-Hua (Crystal) Ng
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Professor Ng joined the Department of Earth Sciences at the University of Minnesota in April 2014 following a position as a Research Hydrologist at the US Geological Survey (USGS) in Menlo Park, CA. She is also a graduate advisor in the Water Resources Sciences program at the University of Minnesota. Her research focuses on integrating computational models and field data to understand interactions among climate, vegetation, biogeochemical processes, and groundwater systems.

In past work, she designed a probabilistic framework for evaluating groundwater recharge under historical and future climate change scenarios in the southern High Plains following grassland conversion to crops. In the Mojave Desert, she implemented the "Community Land Model," the model intended for the proposed project, to represent feedbacks between soil moisture and shrub growth and identified multi-year rainfall patterns that drive plant productivity. Her work has also included development of statistical calibration procedures for merging diverse data and models. In contaminant-affected systems, she has employed reactive-transport models to assess long-term groundwater impacts from an oil spill near Bemidji, MN and from a former wastewater disposal facility on Cape Cod, MA. Professor Ng's newest project at the University of Minnesota is to investigate the impact of groundwater-surface water interactions on wild rice in northeastern Minnesota.

Ng was a Mendenhall postdoctoral fellow at the USGS in Menlo Park, CA (2010-2011) after working as a postdoctoral research associate at MIT (2009). She received her PhD in Environmental Engineering from the MIT (2009) and her BA in Applied Mathematics from Harvard University (2003).

Department of Earth Sciences, University of Minnesota - Twin Cities

The Department is part of the Newton Horace Winchell School of Earth Sciences and belongs to the College of Science and Engineering at the University of Minnesota. It includes about 25 full faculty members and it awards bachelors, masters, and doctorate level degrees in Earth Sciences and various sub-disciplines, including hydrogeology. A number of on-going research projects in the department focus on Minnesota water resources issues, including in the karst region of southeast Minnesota and in watersheds and surface waters with high sulfate and mercury.