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

Project Title: **ENRTF ID:**   013-A

Landslide Hazards and Impacts on Minnesota's Natural Environment

Category: A. Foundational Natural Resource Data and Information

Total Project Budget: $ 672,408

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

Summary:

We will create landslide susceptibility maps using a landslide inventory and quantitative analysis of LiDAR to provide tools and data for land managers to make sound mitigation and restoration decisions.

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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:

Five of the major regions in Minnesota have slopes prone to landslides that can cause damage to infrastructure and excess sediment loading to rivers. Examples of slides from each region are shown to demonstrate the need for better prediction and mitigation strategies: Red River, Minnesota River, Lake Superior, Upper Mississippi, and Lower Mississippi including SE Minnesota.

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

I. PROJECT STATEMENT

The state of Minnesota faces threats to environmental sustainability due to excessive sediment that **negatively affects water quality, riparian ecosystems, trout and other fisheries and recreational facilities.** Recent research by members of this proposal team identified that **the majority of sediment delivered to many watersheds comes from bluff erosion and landslides adjacent to stream channels**. Furthermore, landslides have caused considerable damage to infrastructure and even loss of life in Minnesota. Eroding, hazardous slopes present an acute natural resource management challenge, yet the state lacks a landslide hazards map and mitigation strategy. Our proposed research will provide information on the distribution, failure mechanisms, and frequency of landslides in order to make sound mitigation decisions. We will address this challenge through the following actions:

- **Inventory the locations of recent landslides in Minnesota**
- **Evaluate the types of landslides, their geologic and topographic settings and their causes**
- **Analyze precipitation records to anticipate how extreme weather is related to landslides**
- **Use high-resolution data (LiDAR) to map of landslide susceptibility quantitatively**
- **Provide tools for land managers to make informed decisions about mitigation and restoration.**

In June 2014, widespread landslides occurred in south-central Minnesota; a similarly rainy period in 2012 caused two deaths. In June 2012, a two-day rain event in Duluth generated hundreds of landslides, extensively damaging Jay Cooke State Park and limiting access to Thomson Dam, which was in jeopardy of failing. In August 2007, a year's worth of rain fell in 36 hours in southeastern Minnesota causing extensive landsliding. Weak clay soils in the Red River valley frequently fail, undermining homes and roads. These events defined our study areas:

- **Mississippi river in southeast Minnesota**
- **Minnesota River valley from New Ulm to Chaska**
- **Lake Superior watershed**
- **Red River Valley**
- **7-county metropolitan are**a.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Landslide inventory and precipitation data collection*   **Budget: $ 141,983**

Conduct historical research; perform LiDAR and air photo analyses to identify slide locations; collect and interpret antecedent precipitation data.

Outcome	Completion Date
1. Completed historical records search for the 5 landslide regions	January 2018
2. Compiled digital database of landslide locations to guide follow up work	May 2018
3. Collect precipitation data for well-documented landslides	March 2019

Activity 2: *Preliminary landslide susceptibility map*   **Budget: $ 235,232**

Identify relationships among landslide process, local topography, geography, geology, and hydrology.

Outcome	Completion Date
1. Field work to check historical records and GIS analyses	Oct. 2018
2. Identification of geology and topography at landslide sites	Oct. 2019
3. Interpretation of landslide process and domain	May 2020

Activity 3: *Statewide LiDAR difference maps; hazard map, dissemination.*   **Budget: $ 295,193**

Process repeat airborne LiDAR data, compare to terrestrial LiDAR, create digital database of findings

Outcome	Completion Date
1. Analyze repeat airborne LiDAR in the Duluth area	May 2018
2. Use ongoing terrestrial LiDAR scans in each region for comparison with airborne LiDAR	May 2020
3. Develop best management practices for using LiDAR for meaningful change detection	June 2020

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4. Analyze precipitation data to determine slope-failure thresholds	June 2020
5. Create preliminary landslide hazard map based on LiDAR topographic analyses, underlying geology, and empirical evidence from landslide inventory	June 2020

III. PROJECT STRATEGY

A. Project Team/Partners

The team was assembled because of their scientific and technical competence and their experience in each of the five study areas. Most received degrees from the U of M. The National Weather Service will help with data collection. The USGS Landslide Hazard Program's limited budget is focused on the Mountain West. One of their experts (DeLong) is based in Mounds View, Minn. and has joined this team. The USGS is a trusted source of geologic information and they will increase the quality and impact of our work including dissemination through USGS publications. All project partners listed here would be funded with ENRTF funds, with additional in-kind support being provided from the University of Minnesota, MNSU, and the USGS.

1. Karen Gran, Earth & Environmental Sciences, UMD: coordinate work; supervise students mapping and doing historical research; advise grad-level process domain work; terrestrial LiDAR scan bluffs (ongoing for the past 5 years); Lake Superior basin.
2. Carrie Jennings, Earth Sciences, Adjunct Graduate Faculty, UM Twin Cities: coordinate work, reports and budget; field characterization; result dissemination. Supervise undergrads in metro and SE Minn.
3. Andrew Wickert, Earth Sciences, UM Twin Cities: advise graduate students manipulating statewide LiDAR datasets and developing a precipitation threshold model. Supervise undergrads in SE MN.
4. Stephen DeLong, USGS Hazards Mission Area: fix issues with 2011-2012 Duluth LiDAR; do spatial analyses on statewide LiDAR; align efforts with USGS Landslide Hazard Program; mentor students
5. Stephanie Day, (recent U of M PhD) Geology, NDSU: supervise students mapping and doing historical research; advise grad-level project in terrestrial LiDAR in Red River valley and Le Sueur basin (her PhD area).
6. Phil Larson and Dr. Forrest Wilkerson, Geography and Earth Science Programs, MSU, Mankato: Supervise student mapping, hazard assessment and historical work; cover area between New Ulm and St. Peter.
7. Laura Triplett, Geology, Gustavus Adolphus College: supervise students mapping and doing historical research; cover area from St. Peter to Chaska.
8. Andy Breckenridge, Adjunct, Earth & Environmental Sciences, UMD Geology, UW Superior: create metadata for prior work in lower St. Louis watershed; evaluate LiDAR difference map to be created for this area.
9. Jeni McDermott, University of St. Thomas: supervise undergraduates to inventory slope modifications and repairs in the metro area; field area metro to Red Wing.

B. Project Impact and Long-Term Strategy

This work acquires, analyzes, and distributes new data on landslides across the state of Minnesota. We propose to produce a USGS Fact-Sheet on landslides in Minn., a USGS Digital Database detailing the distribution of landslide hazard and journal articles detailing our scientific methods, observations, and conclusions. This work will include the development and application of innovative LiDAR processing techniques, making use of the state's investment in LiDAR data acquisition. Publication of landslide hazard assessments will provide science-based information to support decision-making to help:

- MPCA implement targeted sediment-reduction strategies
- DNR manage critical river corridors and avoid home buyouts
- communities manage land uses in vulnerable areas
- plan for emergency response

C. Timeline Requirement:
Three years (7/1/17 – 6/30/20) to allow two full field seasons and three academic years.

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2017 Detailed Project Budget

Project Title: Landslides hazards and impacts on Minnesota's natural environment

IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel:	
Karen Gran, UMD, Co-PI, (75% salary+25% benefits, 4% FTE) (summer): Supervise student mapping and historical research, graduate student synthesis & terrestrial lidar scanning, Superior Basin.	$17,476
Carrie Jennings, U of M, Project Manager, Co-PI, (75% salary+25% benefits, 8% FTE) (summer): Coordinate work, reports and budget; field characterization; result dissemination. Metro/SE MN	$32,895
Andrew Wickert, U of M, Geologist, (75% salary+25% benefits, 4%FTE) (summer): Supervise statewide LiDAR analyses and development of a precipitation threshold model. SE MN.	$16,372
Graduate research assistants (2), UMD and U of M, (51% salary+49% fringe, 50%FTE) (12 mo/yr, 9/1/17-6/30/20). 1) Assist with synthesis of 5 regional maps; develop process domain model to aid with hazards delineation and prediction. 2) Statewide lidar and repeat lidar analyses.	$200,015
Undergraduate research assistants (2), U of M and UMD, (100% salary, 25% FTE) (summer). Conduct historical research, field mapping & verification; terrestrial lidar collection.	$20,073
Professional/Technical/Service Contracts:	
U.S. Geological Survey: Stephen DeLong (GS-13), Mounds View, MN, Landslide Hazards Program,20% FTE; GIS Specialist (GS-7), 50% FTE: Properly align 2011-2012 repeat Duluth LiDAR; spatial analyses on statewide LiDAR; align efforts with USGS Landslide Hazard Program; mentor students; assist with QA/QC and data publication and dissemination.	$200,471
Minnesota State University, Mankato, Phil Larson and Forrest Wilkerson 4% FTE per year; undergraduate assistants (25% FTE, 2 yrs); graduate assistant (50% FTE, 1 yr); Mapping, hazard assessment and historical work between New Ulm and St. Peter.	$54,929
North Dakota State University, Stephanie Day 4% FTE; Undergraduate assistant (25% FTE, 2 yr), Graduate assistant (50% FTE, 2 yr); Terrestrial Lidar rental: Mapping, hazard assessment and historical research in Red River; repeat terrestrial LiDAR analyses in Red River and Le Sueur.	$67,875
Gustavus Adolphus College, Laura Triplett 4% FTE per year; undergraduate assistants 25% FTE per year (2 yrs). Mapping and historical research in area from St. Peter to Chaska.	$24,148
University of St. Thomas, Jeni McDermott 4% FTE per year; undergraduate assistants (25% FTE, 2 yrs): Mapping and historical research in Twin Cities.	$22,686
UW Superior, Andy Breckenridge: 2% FTE per year. Create metadata for prior work in lower St. Louis watershed; evaluate LiDAR difference map to be created for this area.	$6,674
Equipment/Tools/Supplies: Field books, shovels, TLS storage cards, sample bags, Munsell charts	$1,500
Additional budget items: Terrestrial LiDAR scanner use, $200/day for 12 days	$2,400
Travel: Quarterly meetings (1280 mi/yr); Field work (1000 mi/yr); NC GSA meeting registration	$4,894
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$672,408

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:		
Other State $ To Be Applied To Project During Project Period: *Coastal Zone grant*	$ 2,400	*Pending*
In-Kind Services To Be Applied To Project During Project Period: UMN *Indirect cost recovery (52%)*	$ 106,471	*secured*
In-kind Services To Be Applied To Project During Project Period: *USGS Geologist salary/fringe.*	$ 10,000	*secured*
In-kind Services To Be Applied To Project During Project Period: *MSU : TA support 2016/17*	$ 17,000	*secured*
Funding History:	NA	
Remaining $ From Current ENRTF Appropriation:	NA	

The cost of landslides in Minnesota

mapio

Landslides in Crookston has led to compromised house foundations.

Stephanie

Slow mass wasting between 2012 and 2015 in Moorhead damaged this new fishing pier that was later removed.

Red River

Lake Superior

Upper Mississippi

Minnesota River

Lower Mississippi

Ben Garvin
City of St. Paul

A landslide in the spring of 2013 made news when two elementary students were killed during a class field trip.

USGS

Flooding in the Summer of 2012 caused landslides leading to significant infrastructure damage in Duluth.

Kent Kirkby
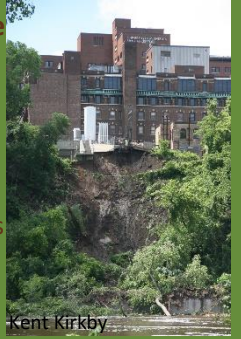
A landslide in June 2014 caused the West River parkway in Minneapolis to be closed and 20 people at The Fairview Hospital to be temporarily evacuated. The hospital was declared safe, but the hospital steam site sits just 10 feet from the cliff edge.

Girish Uprety
Girish Uprety

A massive failure in the summer of 2014 didn't damage any infrastructure, but contributed to high sediment loads in the Minnesota River watershed.


05/07/2016
Kristina Krklec

June 2014 in Henderson several landslides occurred on a ravine. One of these landslides destroyed a home causing well over $100,000 in damage.

Toby Dogweiler

Landslides in southeastern Minnesota damage agricultural fields.

ENRTF ID: 013-A

Project Manager Qualifications and Organization Description:

Dr. Karen Gran, Co-PI, is an Associate Professor in the Department of Earth & Environmental Sciences at the University of Minnesota Duluth where she has been since 2007. She teaches undergraduate and graduate courses in geology, geomorphology, and stream restoration. In the past 5 years, she has advised 15 graduate students at the M.S. and Ph.D. level, with 12 of them doing environmental research in the state of Minnesota. Since 2007, Dr. Gran has been working extensively in the Minnesota River basin, first developing an integrated sediment budget in the Le Sueur River basin and later expanding that project into the Greater Blue Earth River basin. She is currently involved in a project to develop appropriate mitigation strategies for sediment source reduction in the Greater Blue Earth River basin (MDA, MPCA, MAWRC -funded), as well as a large interdisciplinary effort on understanding how the Minnesota River responds to land use and climate change funded by the Water Sustainability and Climate initiative at the National Science Foundation. In the Duluth area, she has worked for 5 years measuring erosion rates and sediment volumes associated with river bluff failures, including research on the effectiveness of expensive bank stabilization projects in Amity Creek and the Knife River. Some of the work proposed here is an extension of that effort. In the past ten years, Dr. Gran has managed over $1.8 million of research grant funding, including large collaborative projects in Minnesota with investigators at 5 different institutions. Her role on this project will be to ensure synthesis of all of the data collection efforts by collaborators throughout the state in addition to leading the data collection effort in the Lake Superior basin. She will be working closely with the USGS and Dr. Jennings at the U of M on this effort to ensure seamless transition of data from our many collaborators. She will also be advising a graduate student who will be analyzing subsurface geology, hydrogeology, relief, soils, and land use to start developing a hazards map for landslides throughout the state of Minnesota, and collecting and analyzing terrestrial lidar data on bluffs in the Duluth area.

Dr. Carrie Jennings, Co-PI and Project Manager, has held an Adjunct Graduate appointment at the Department of Earth Sciences, University of Minnesota since 1996. She teaches undergraduate and graduate level course, advises and participates in research. She conducted a pilot landslide project for Hennepin County with U of M students and faculty using county and FEMA funds. She worked for 22 years at the Minnesota Geological Survey in the County Atlas Program mapping surficial deposits. She has collaborated on projects similar to the one being proposed when she partnered with Co-PI Karen Gran with the National Center for Earth Surface Dynamics at the U of M on the Integrated Sediment Budget for the Le Sueur River basin, Minnesota that was funded with Clean Water Legacy funds through the MPCA ($484,000). She has also successfully collaborated on similar multi-PI projects with Dan Engstrom and Shawn Schottler of the St. Croix Watershed Research Station. Those projects also involved sediment loading to streams. She is currently a geologist at the Department of Natural Resources, EcoWaters Division, where the pilot project for Hennepin County was facilitated. She is submitting this proposal with her U of M affiliation but the Land Use group at the DNR support this work. Her role in this project will be to direct and coordinate the data collection of the subcontractors; oversee student work in southeastern Minnesota; coordinate regular meetings; participate in fieldwork; write reports and help disseminate information.