Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-128

Proposal Title: Resilience and Increased Intense Rain in Minnesota Watersheds

Project Manager Information

Name: Jason Ulrich

Organization: Science Museum of Minnesota - St. Croix Watershed Research Station

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Project Basic Information

Project Summary: Landscape resilience to flooding due to increases in intense rain events and landscape alteration will be evaluated for Southern Minnesota's major rural watersheds.

Funds Requested: $189,000

Proposed Project Completion: 2023-06-30

LCCMR Funding Category: Small Projects (H)

Secondary Category: Water Resources (B)

Project Location

What is the best scale for describing where your work will take place?

Region(s): SW, SE,

What is the best scale to describe the area impacted by your work?

Region(s): SE, SW,

When will the work impact occur?

In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

There has been much discussion about observed and predicted increases in intense rain events (IRE's) and their connection to flooding. Flooding can cause loss of productive cropland, damage to rural and municipal infrastructure, and degradation of river water quality.

In conjunction with these discussions are continued debates--even among scientists--about the role that landscape alterations related to agriculture and urbanization play in flooding.

As a result, important questions remain unanswered:
--Foremost, what is the "resilience" of our watersheds to intense rain events? In other words, what magnitude of IRE will overwhelm a watershed's landscape factors, as they relate to storing runoff or at least slowing it down, resulting in flooding?--Two inches of rain in 24 hours? Four inches?

--And how do agricultural and urban landscape alterations affect watershed resilience? How will increases in the number of IRE's affect it?

--Finally, what magnitudes of IRE's will likely result in impactful flooding no matter the watershed's landscape factors (including possible future conservation efforts)?

Answering these types of questions is critical for adding missing context to the debates around climate, landscape alteration and flooding, and will help foster more science-based, economically-practical policies and watershed management strategies to mitigate future flood impacts.

What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.

We propose quantifying resilience to increases in IRE's as it pertains to flooding in ten major (USGS HUC-8) rural watersheds in Southern Minnesota (most will be located in the Minnesota River Basin). This region has experienced substantial landscape alteration and is seeing some of the largest increases in IRE's. The Cottonwood watershed, because of its substantial increases in IRE's, will be researched in detail, and the findings applied to the rest of the project watersheds.

For each watershed, we will create a "scorecard" that quantifies:
-- resilience in terms of the volume and duration of flood flows resulting from IRE's under current and predicted climate conditions,

-- how resilience has been affected by landscape alteration from 1948-2019,

-- the proportional roles that different climate and landscape factors play in determining current and future resilience to IRE's,

-- how different levels of conservation investment might improve (or not improve) resilience.

Thus, the major takeaway from this project will be disentangling the effects climate and landscape factors each have on flooding resilience to IRE's, and the extent to which interventions to improve resilience might be economically practical.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

The outcomes will provide first-of-its-kind information for helping State to local agencies create more cost-effective conservation strategies as they relate to flooding-- such as MPCA WRAPS, BWSR One-Watershed/One-Plan and local watershed management plans.

Outcomes will also help farmers, farm managers and crop consultants understand realities of future flooding as they may pertain to productivity of cropland and potential land retirement.

The overarching outcome will be providing necessary -- and thus far, missing -- context and solid science to policy-makers as well as the general public regarding the interplay between increasing rainfall (including IRE's), agricultural/urban intensification, and flooding.

Activities and Milestones

Activity 1: Conduct detailed analysis and modeling of Cottonwood Watershed to quantify resilience to intense rain events.

Activity Budget: $104,000

Activity Description:
Research has shown that the degree of increases in IRE's since 1948 are varied and unevenly distributed across and within Southern Minnesota's major watersheds; however, the Cottonwood watershed (near New Ulm) is unique in that significant IRE increases have occurred in a nearly uniform manner throughout the watershed. A reasonable assumption is that the Cottonwood's increases in IRE's are a likely representation of what could occur across the project area in the coming decades. Therefore, our approach entails first intensively modeling the Cottonwood and then extending these results to the rest of project watersheds using a statistical framework (Activity 2). The model will promote a detailed understanding of Cottonwood's resilience to flooding, and the most important climate and landscape factors influencing it.

The Cottonwood will be modeled using the agro-hydrological model SWAT. The model will be developed to explicitly incorporate the most important hydrologic response variables including extent of row-crop and urban landuse, extent of drain tile, seasonal crop growth, local farming practices, and wetland and lake storage. The model will be calibrated and validated using USGS flow gauging data at New Ulm from 1948-2019.

Activity Milestones:

Description	Completion Date
Gather necessary climate and watershed data (soils, LiDAR, landuse, drain tile extent, wetlands storage, etc.).	2022-01-31
Construct and calibrate SWAT using observed USGS flow data.	2022-04-30
Analyze SWAT model results to identify important resilience factors related to IRE's.	2022-06-30

Activity 2: Quantify resilience to IRE's in project watersheds by extending results of Cottonwood watershed analysis and modeling.

Activity Budget: $85,000

Activity Description:
Activity 2 entails extending results from Activity 1 to the other nine project watersheds where models were not created. First, each watershed's precipitation record will be modified to reflect the Cottonwood's proportional increases in IRE's; then, this record will be linked to landscape factors found to influence the Cottonwood's modeled resilience (e.g., GIS-derived variables such as watershed slope, drainage density, soil type, available wetland storage, etc.) using a statistical framework to estimate resilience to IRE's in the other nine project watersheds. These results will be used to develop the resilience scorecards (See Proposed Problem Solution section above).

Much of the activity will be concerned with outreach and communicating the results of the project. We propose writing a full summary report featuring the set of watershed resilience scorecards as well as methodologies, posting the report, scorecards, and illustrative GIS data on Science Museum websites, composing social media posts summarizing and promoting the results, presenting the results at least twice at water resource and farm group conferences, and at State Agencies. A peer-reviewed journal manuscript focused on the project will also be drafted.

Activity Milestones:

Description	Completion Date
Develop statistical framework to extend SWAT model results to project area watersheds.	2022-09-30
Synthesize results and create resilience scorecards.	2023-01-31
Draft manuscript for submittal to peer-reviewed journal.	2023-06-30
Construct final report, GIS datasets, social media content, and present results at conferences/agencies.	2023-06-30

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Jim Almendinger	Science Museum Of Minnesota - St. Croix Watershed Research Station	Partner who will assist and advise in all phases on the project.	Yes

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this be funded?

Results will be implemented through creation of a significant set of deliverables designed for outreach, aiming for communicating the project findings to diverse audiences such as environmental and water professionals, scientists, farmers, policy-makers, and the general public (as further detailed in Activity 2). No funding will be required after the project completion date. However, similar work could be undertaken in the future to analyze resilience in regions of the State not included within the project area.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Mapping Unprofitable Cropland for Water and Wildlife	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04n	$100,000
Develop Market-Based Alternatives for Perennial Crops to Benefit Water Quality and Wildlife	M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 08c	$150,000

Project Manager and Organization Qualifications

Project Manager Name: Jason Ulrich

Job Title: Assistant Scientist

Provide description of the project manager's qualifications to manage the proposed project.

As a watershed modeler and hydrologist, my scientific studies focus on understanding and quantifying the effects of factors such as landuse, climate and agricultural practices on hydrology and water quality. My two principal areas of expertise are: 1) modeling the behavior of agricultural watersheds using the state-of-the-art models such as SWAT and HSPF, and 2) GIS analysis for better understanding of small-scale hydrologic and sediment processes using LiDAR elevation data. My experience combines modeling, GIS, and statistical analyses with economics to better predict the cost-effectiveness of proposed agricultural best-management-practices (BMP) strategies, and to understand the effects of climate change and agricultural on trends in river hydrology and water quality. I am currently project manager for the LCCMR-funded "Mapping Unprofitable Cropland for Water and Wildlife" project.

Affiliations:
2016-present: Assistant Scientist, St. Croix Watershed Research Station, Science Museum of Minnesota.
2013-present: Ph.D. Candidate, Water Resources Science. University of Minnesota.

Education:

2006. M.S., Water Resources Science. University of Minnesota.

2000. B.S., Natural Resources and Environmental Studies, University of Minnesota.

Selected Publications:

Almendinger, J.E. and J.S. Ulrich. 2017. Use of SWAT to Estimate Spatial Scaling of Phosphorus Export Coefficients and Load Reductions Due to Agricultural BMPs. Journal of the American Water Resources Association.

Ulrich, J.S. and P. Conrad. 2015. Cost-Effective Agricultural BMP Planning Using Precision Conservation Principles and Advanced GIS Tools: A Case Study in the Squaw Creek Watershed, Iowa. Presented at 2015 MN Water Resources Conference.

Schottler S. P., Ulrich, J.S., Engstrom, D.E. 2016. Comment on climate and agricultural landuse change impacts on streamflow in the upper Midwestern U.S. Water Resources Research.

Schottler S.P., Ulrich, J.S., Belmont, P., Moore, R., Lauer, J.W., Engstrom, D.E., Almendinger, J.E. 2013. Twentieth century agricultural drainage creates more erosive rivers. Hydrological Processes.

Organization: Science Museum of Minnesota - St. Croix Watershed Research Station

Organization Description:

The Science Museum of Minnesota (SMM) is a private, non-profit 501(c)3 institution dedicated to encouraging public understanding of science through research and education. The St. Croix Watershed Research Station the environmental research center of the SMM with the mission to foster, through research and outreach, “a better understanding of the ecological systems of the St. Croix River basin and watersheds worldwide.” The SCWRS supports an active year-round program in environmental research and graduate-student training, guided by a dedicated in-house research staff with direct ties to area universities and colleges. It collaborates closely with federal, state, and local agencies with responsibility for managing the St. Croix and upper Mississippi rivers and is a full partner with the National Park Service for resource management in parks of the western Great Lakes region. Its research has played a central role in setting management policy for the St. Croix and Mississippi rivers, for establishing water-quality standards for Minnesota lakes and for developing long-term monitoring plans for the National Park Service.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Assistant Scientist		Project manager, primary modeler, analyst, developer of communication deliverables			30%	1.5		$123,411
Senior Scientist		Assist with modeling, analysis, development of communication deliverables			30%	0.5		$61,757
							Sub Total	**$185,168**
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Tools and Supplies	1 license for modeling, GIS or statistical analysis software	Used for advanced analysis; modification of model and analytical source codes					$1,000
							Sub Total	**$1,000**
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Miles/ Meals/ Lodging	3 round-trips to Cottonwood watershed area - cities of New Ulm or Marshall	Meetings with local environmental professionals during model development					$1,132
	Conference Registration	Travel to 2 out-state conferences	Presenting project results to environmental, farm group or Agency audiences					$1,200

	Miles/ Meals/ Lodging							
							Sub Total	**$2,332**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Printing	Printing costs	Producing multiple copies of bound final reports; printing presentation posters					$500
							Sub Total	**$500**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$189,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	Science Museum of Minnesota	Support services from Science Museum of Minnesota 40.83% of direct costs	Secured	$77,168
			Non State Sub Total	**$77,168**
			Funds Total	**$77,168**

Attachments

Required Attachments

Visual Component

File: bbfa17f9-26c.pdf

Alternate Text for Visual Component

The graphic first summarizes the need for research into the effects of increasing intense rain events on watershed flood resilience, defined as the amount of rain that a watershed can handle before flooding results.

It then shows a map of many of the major watersheds in Southern Minnesota, and introduces the approach of using the Cottonwood watershed, which is the epicenter of increasing intense rain in the last 70 years, as a kind of case study to quantify flood resilience and the key factors influencing it.

Last, it is shown how the Cottonwood's results will be applied to nine other Southern Minnesota watersheds, and results for each watershed reported in a "Watershed Resilience Scorecard", in which the current extent of flooding attributed to intense rains, key climate and landscape flood factors, and economical practicality of mitigation investments will all be identified.

Optional Attachments

Support Letter or Other

Title	File
SMM_IRSform_990	b8c6b270-5ef.pdf
SMM_Letter_of_Support	8a9c688b-3f0.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have patent, royalties, or revenue potential?

No

Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

No

Environment and Natural Resources Trust Fund (ENRTF)

Project Title: Resilience and Increasing Intense Rain in Minnesota Watersheds

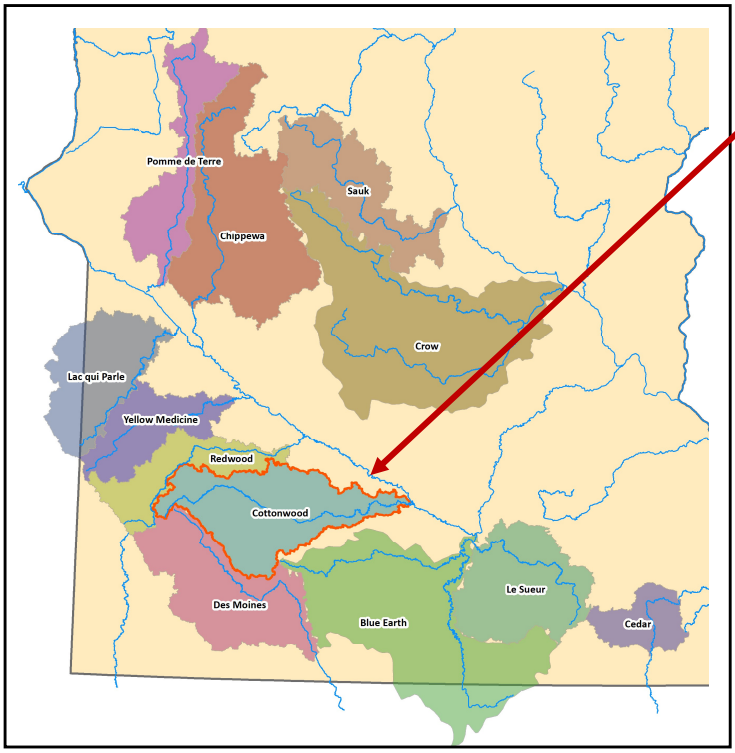
Resilience: *The depth of rain a watershed can handle before flooding results.*

We need to know:

-- How are increasing numbers of intense rain events affecting flooding resilience in our rural, agricultural watersheds?

-- What climate and landscape factors are most important?

-- What solutions are (and are not) economically-practical?

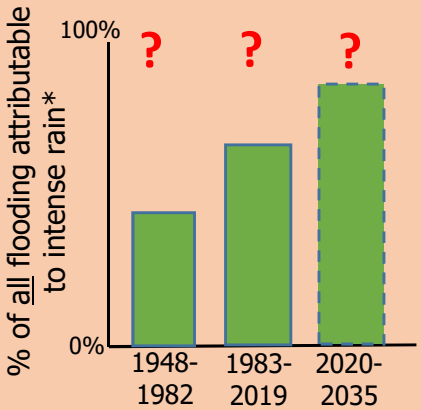


The Cottonwood River watershed has been at the epicenter of increasing intense rain over the last 70 years.

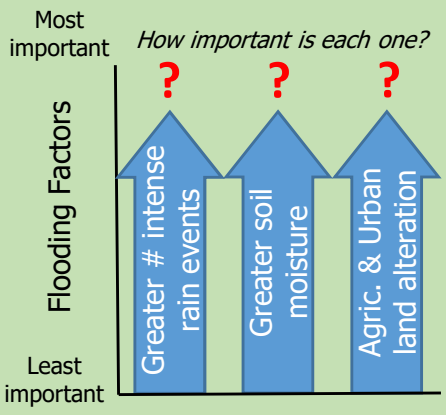
1) We'll analyze the Cottonwood's resilience to intense rains, 2) Apply those lessons to at least nine other rural watersheds in Southern MN.

Watershed Resilience Scorecard (conceptual) : **Redwood River**

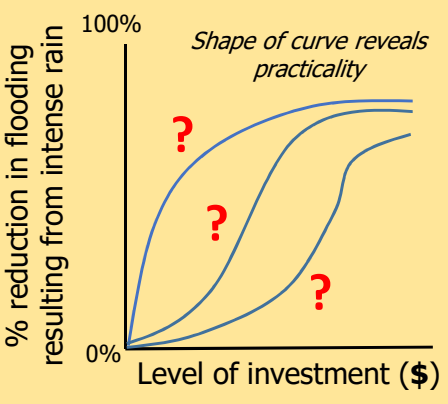
Identify the extent of intense rain flooding.



Identify the key flooding factors.



Identify most economically practical mitigations.



* Flooding can also be caused by non-intense rain and snowmelt.