Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-155

Proposal Title: Rural-Urban Partnerships to Advance Conservation Farming with Technology

Project Manager Information

Name: Eric Chapman

Organization: University of St. Thomas

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Project Basic Information

Project Summary: We seek to broaden participation in conservation agriculture statewide by applying high-tech assessment tools, building farmer-scientist-student collaborations across rural and urban communities, and expanding farmer-farmer knowledge exchange networks.

Funds Requested: $548,000

Proposed Project Completion: 2024-08-31

LCCMR Funding Category: Methods to Protect, Restore, and Enhance Land, Water, and Habitat (F)

Project Location

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

Statewide

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

Statewide

When will the work impact occur?

During the Project and In the Future

Narrative

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

Conservation agriculture (CA) involves land management that increases the long-term health of agricultural and adjacent ecosystems. No-till farming, cover crops, and crop rotation represent three core CA practices that decrease soil loss, conserve soil nutrients, protect water and air quality, and increase soil carbon capture. These practices not only have broad environmental benefits by reducing greenhouse gas levels, but they also increase drought resiliency of individual farms. In 2017, only 4% of total acreage of MN farmland across 5800 farms used no-till practices. Additionally, 5302 farms utilized cover crops, representing only 7.7% of farms and 2% of total MN farmland acreage. Farmers often hesitate to implement CA because they think CA reduces yields and farm profitability. However, savings (from lower fuel and fertilizer use) mean that many farmers will likely benefit economically by adopting CA practices. This proposal aims to broaden participation in CA farming by: 1) Using advanced technology to tackle issues identified by farmers as obstacles to CA implementation, 2) Creating a statewide learning network of farmers interested in implementing CA that leverages farmer-farmer relationships, and 3) Building infrastructure/capacity for long-term collaboration and knowledge exchange within and between rural and urban communities invested in advancing CA.

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.

The extent to which conservation agriculture decreases soil loss, conserves soil nutrients, and protects water and air quality is well known. Increasingly, there is broader acknowledgment of the long-term economic benefits of implementing CA practices as well, however, many challenges to broader adoption remain. To increase participation in CA, we seek funding to build long-lasting, collaborative relationships between growers, academics, soil and water conservationists, and high school and undergraduate students. We aim to leverage the rural field-based experience and intimate real-world traditional knowledge of farmers with the urban institutional resources (access to technology, classroom and research opportunities, and undergraduate students) of the University of St. Thomas (UST). Through interdisciplinary methods between biologists and engineers, using cutting-edge technologies (including unmanned aerial vehicles, robotics, artificial intelligence, and machine learning), and farmer surveys described below, we will identify statewide farmer obstacles to adopting CA practices and develop science, technology and enhanced relationships to address the identified obstacles. The generation of a farmer-farmer knowledge network, co-production of knowledge between farmers and scientists, county soil and water conservationists, and broader public engagement activities will enable us to build mutually beneficial relationships between rural and urban communities and increase the long-term capacity to increase CA implementation.

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?

Increasing the acreage of farmland incorporating CA practices represents an opportunity to protect and restore soil, water and air quality, build community capacity by creating a network of farmers committed to incorporating CA principles, and increase agricultural resiliency to climate change. Our project will build capacity for and participation in CA farming by: 1) documenting and highlighting advantages of CA for farmers with cutting edge science and technology; and 2) fostering a long-term statewide network of farmers interested in implementing CA that leverages farmer-farmer, farmer-scientist, and farmer-community relationships across rural and urban regions.

Activities and Milestones

Activity 1: Identify conservation agriculture implementation obstacles and develop science and technology to address them

Activity Budget: $263,000

Activity Description:
We will design and implement surveys to assess statewide barriers and opportunities for farmers to incorporate CA practices (Milestone 1). Our efforts will initially focus on surveying farmers with whom we have had long-term collaborative relationships. To expand the scale of our survey, we will work with existing government and non-government organizations to expand farmer-farmer networks. We will include all farmers that express interest in CA in Activity 2.

Simultaneously, we will evaluate the impact of CA practices on indicators of ecological health and crop success, including chemical (nutrients), physical (soil stability, aquatic habitat relations) and biological (yield, plant vigor/health) measures. We will use cutting-edge technology (remote sensing techniques; unmanned aerial vehicles (UAVs, otherwise known as drones) outfitted with relevant cameras and sensors, normalized difference vegetation index (NDVI), and artificial intelligence (AI) to remotely quantify indicators listed above on a model farm (Milestone 2). Drone and remote sensing techniques will be complemented with traditional field-based assessments of the same parameters on a subset of participating farms (Milestone 3). To implement the above, we will build a broad coalition of growers, academics, soil and water conservationists, students, and citizen scientists.

Activity Milestones:

Description	Completion Date
Characterize obstacles via surveys and interviews	2022-03-31
Identify priority areas and develop/test technology to address them on model farm	2022-06-30
Optimize technology and conduct experiments across multiple farms	2024-06-30

Activity 2: Create a statewide network of farmers interested in implementing CA

Activity Budget: $155,000

Activity Description:
We will use results from farmer surveys and our drone- and field-based methodologies from Activity 1 to facilitate the creation of a Farmer Circle – a statewide network of farmers interested in implementing CA practices that regularly meet within their communities (Milestone 1). To build the network, we will: 1) leverage ongoing projects and networks including the Morrison County Soil and Water Conservation District; 2) rely on farmer-farmer relationships; 3) recruit farmers using various outreach activities.

We will quantify the impact of CA practices on farmer social parameters across farms and communities statewide. We will also assess to what extent participating in a network influences farmers' sense of belonging and willingness to implement CA practices (Milestone 2). We will also interview a subset of farmers across the state to better understand how their involvement in this project influences their perceptions of CA. This activity will culminate in regional focus-group workshops where participating farmers will hear from farmers within their region and beyond about their experience with CA. By coupling various measures of ecological data with farmer survey and interview data we hope to generate a holistic understanding of the potential of CA practices to improve social and ecological health in MN.

Activity Milestones:

Description	Completion Date
Establishment of a farmer-farmer knowledge sharing network (Farmer Circle)	2023-06-30
Characterize social benefits and CA adoption drivers via surveys and focus groups	2024-06-30

Activity 3: Building infrastructure/capacity for long term collaboration and communication within and between rural and urban communities

Activity Budget: $130,000

Activity Description:
To ensure our collaborative efforts are long-lasting and build stronger connections between rural and urban communities, we will use a broad and diverse approach to build infrastructure and capacity for long-term farmer-scientist-student partnerships. First, we propose embedding the outlined activities to enhance undergraduate course and research experiences at the University of St. Thomas. We will develop urban agriculture field sites to prototype and field test tech-based assessments of CA practices (Milestone 1). Second, we will enlist urban high school and undergraduate students to visit and collaborate with partner farms statewide, where students will have the opportunity to live in and authentically experience rural community life, and assist farmers with operations (Milestone 2). Third, we will share our progress and results from Activities 1-3 above with Minnesota State Fair goers, where we can showcase rural-urban linkages (Milestone 3). Fourth, we will invite participating farmers to attend a symposium hosted in the Twin Cities, where growers, scientists, and students can share their experiences participating in this project (Milestone 4). The combination of these four milestones will increase urban and rural community connections, capacity for implementing CA practices, and infrastructure and institutional support for long-term collaboration.

Activity Milestones:

Description	Completion Date
Rural site visits for high school and undergraduates (Farmer Ridge Exchange)	2023-06-30
Embedding science support activities in courses and current urban farming practices	2023-06-30
Annual State Fair project progress debrief with the public (every August during grant period)	2023-08-31
Urban Symposium with scientists, students, and rural partner farmers	2024-08-31

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Hassan Salamy	University of St. Thomas	Dr. Salamy will develop and implement our technology related activities with the rest of our School of Engineering collaborators using sensor data from drones. They will use data collected from drones and field surveys and machine learning to predict crop yield from partner farms.	Yes
Cheol-Hong Min	University of St. Thomas	Dr. Min will develop and implement our technology related activities with the rest of our School of Engineering collaborators using sensor data from drones. They will use data collected from drones and field surveys and machine learning to predict crop yield from partner farms.	Yes
Chih Lai	University of St. Thomas	Dr. Lai will develop and implement our technology related activities with the rest of our School of Engineering collaborators using sensor data from drones. They will use data collected from drones and field surveys and machine learning to predict crop yield from partner farms.	Yes
Adam Kay	University of St. Thomas	As an agroecologist Dr. Kay will provide his experience working with undergraduate students in urban communities and provide opportunities for students through the classroom to collaborate with partnering farmers.	Yes
Dalma Martinovic	University of St. Thomas	Dr. Dalma Martinovic will provide expertise with environmental data analysis and interpretation from partner farms, help expand the farmer-farmer knowledge sharing network, and the assist with the farmer symposium planning.	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?

As outlined above, we will incorporate various approaches to ensure long-term success. Most of the activities highlighted in the proposal will be maintained through integration with courses at UST. For example, students will have the opportunity to assist farmers in grant application preparation through classroom service efforts. By tying these efforts to the classroom, UST can provide students and resources to assist farmers. Furthermore, we envision farmers co-developing scholarly work with scientists as integral participants on peer-reviewed publications. To expand this work, we will also pursue additional funding through the National Science Foundation, USDA, and potentially other state funded opportunities.

Project Manager and Organization Qualifications

Project Manager Name: Eric Chapman

Job Title: Visiting Assistant Professor

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

Eric Chapman is a Visiting Assistant Professor of Biology at the University of St. Thomas in St. Paul, MN. His teaching and research focus on sustainable food systems, regional sustainability, and improving linkages between urban and rural communities through collaborative community partnerships.

He received his Ph.D. from Arizona State University in 2015 in Environmental Life Sciences. He served as a National Science Foundation (NSF) Science, Engineering and Education for Sustainability (SEES) Postdoctoral Fellow from 2015-2017. As a SEES Fellow, he worked with fishers and suppliers, economists, and social scientists to forecast the potential of mudflat and estuarine system restoration to support bivalve fishery enhancement. Since 2017, he has taught multiple courses at UST with community partners exploring the role of biology in the food system. Through these senior capstone courses, he has brought over 50 urban undergraduate students to nearby rural farms, providing authentic and genuine

research experiences in the classroom while thoughtfully collaborating and partnering with local farmers.

In 2017, he also co-founded Shed Initiative (shedinitiative.org), an interdisciplinary non-profit organization focused on collaborating with rural landowners and land managers, existing organizations, and local governments to develop and implement watershed-scale initiatives focused long-term management solutions that lead to productive fields, lower groundwater contamination and surface water runoff, and higher carbon and soil retention.

From 2013-2014, he served as a NSF Sustainability Science for Sustainable Schools Fellow where he worked with high schools in Phoenix, Arizona implementing sustainability projects at the curricular, campus, and community level. He has published 7 first author peer-reviewed papers, has received multiple grants, and presented at over 2 dozen scientific conferences.

Organization: University of St. Thomas

Organization Description:
The University of St. Thomas (UST) was founded in 1885 and emphasizes values-based education and career preparation, it helps solve community problems through education and service-learning programs. 56% of UST students receive need-based scholarship or grant aid. The largest private university in Minnesota (11,000 students, 461 full-time faculty), it offers bachelor's degrees in 85 major fields of study and 45 graduate degree programs, and is ranked as a National University. UST's Biology Department views -faculty research as essential - over the past 10 years, the faculty in Biology Department have received research grants from the NSF, NIH, USDA, USEPA, USGS, and multiple MN agencies (DNR, MPCA). Currently, the UST's Science Division has ca $5.7 million of capital equipment, nearly half of which is owned/ maintained by Biology.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Dr. Eric Chapman		Project Manager			33%	1.89		$188,000
Dr. Adam Kay		Urban Sustainable Agriculture Expert			8%	0.16		$20,000
Dr. Cheol-Hong Min		Electrical/Computer Engineer			8%	0.16		$22,588
Dr. Chih Lai		Computer Scientist			8%	0.16		$27,480
Dr. Hassan Salamy		Electrical/Computer Engineer			8%	0.16		$22,000
Dr. Dalma Martinovic-Weigelt		Environmental Scientist			8%	0.16		$22,800
2 Graduate Academic Year Research Assistants		Research Assistants			0%	0.63		$43,200
2 undergraduate Summer Research Assistants		Research Assistants			0%	0.51		$31,104
							Sub Total	**$377,172**
Contracts and Services								
Doug Wille	Professional or Technical Service Contract	Mr. Wille is a third generation farmer from Randolph, MN. Mr Wille's farm will serve as a model farm for CA; we will expand ongoing efforts to measure effects of conservation agriculture outlined in Activity 1. Mr. Wille will consult on farming practices and building the farmer-farmer network (Farmer Circle).				0.24		$10,958
Farmer-farmer conservation agriculture network	Professional or Technical Service Contract	This budget item represents 20 contracts of $3000 to create of the farmer-farmer knowledge share network (Farmer Circle) and to support farmers statewide in their efforts to implement conservation				0.24		$60,000

participant support for 20 individuals (TBD)		agriculture practices on their farms. We will recruit farmers using a variety of methods described in Activity 1 and 2.						
Morrison County Soil and Water Conservation District	Sub award	We will use Morrison County SWCD's respected presence in the community to help recruit farmers, build rapport within the community, and consult on implementing conservation agriculture practices. Their long-term approaches have significantly improved water and soil resources in rural MN and we seek to strengthen rural-urban collaboration.				0.24		$25,000
							Sub Total	**$95,958**
Equipment, Tools, and Supplies								
	Equipment	Drone (3 units)	Drones for multiple location survey that we will use to characterize various parameters outlined in Activity 1					$14,985
	Equipment	Tetracam MCAW Multi-spectral Camera (2 units)	Plant chlorophyll react at different spectral frequencies, in broadband analysis specific energy reflections are muted, a multispectral camera is thereby required to use narrowband filters to identify the energy reflected by a specific crop					$8,985
	Equipment	Raspberry Pi RGB Camera (6 units)	Cameras to take RGB pictures of the crops					$300
	Equipment	GPU Nvidia Titan RTX (2 units)	GPU to improve performance for the data analytics and image / video processing					$5,000
	Equipment	Soil Sensor - soil saturation H2O (20 units)	Provides a means of measuring how much water is available in the soil so that permanent plant wilt can be avoided					$4,500
	Equipment	Soil Sensor - soil compaction (3 units)	Provides a means of measuring the soil compaction so root penetration can be predicted					$1,800

	Equipment	Light Sensor - PAR (10 units)	Provides a means of measuring in-band available energy (light) is available for the crop					$2,400
	Equipment	Fertilizer sensor - pH (10 units)	Provides a means of determining fertilizer concentration					$1,500
	Equipment	Soil Sensor -Temperature at depth (10 units)	Provides a means of measuring temperature thereby predicting nutrient absorption by roots					$900
	Equipment	Weather Station (3 units)	To collect outdoor weather using weather station					$1,500
	Tools and Supplies	Biological field supplies to support field collected data (PVC piping, measuring devices, sample bottles for collection)	Biological field supplies to support field collected data					$1,000
							Sub Total	**$42,870**
Capital Expenditures								
		Servers for Computing (2 units)	High end performance servers capable of supporting machine learning to process, analyze, and visualize data.					$20,000
		Matlab license for research (2 licenses)	The Matlab toolkit for image analysis is required to be run on multiple machines within the PA cluster. Each machine in the cluster requires its own license					$11,000
							Sub Total	**$31,000**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging		Travel to model farm and partner farms near the Twin Cities Metro					$1,000
							Sub Total	**$1,000**
Travel Outside Minnesota								

							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$548,000**

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	The Biology Department at the University of St. Thomas	The Biology Department at the University of St. Thomas will provide the following in-kind contributions: In direct cost 41%; conference space for the symposium hosted by UST ($1000); conference lunch ($25 x 50 participants); a one day booth rental at the Minnesota State Fair for outreach each year of the project ($1000); and publication and printing costs ($2,000).	Potential	$30,000
			Non State Sub Total	**$30,000**
			Funds Total	**$30,000**

Attachments

Required Attachments

Visual Component

File: 30247acb-a2c.docx

Alternate Text for Visual Component

Figure 1. Clockwise from upper left: students visit turkey farm near Cannon Falls highlighting educational opportunities between urban and rural communities; Doug Wille's farm in Randolph, MN; students hear from Kurt Kimber, a farmer in Farmington, MN in his equipment barn; Mr. Wille combining corn in the late summer.

Figure 2. Map of potential project counties (left pane) and location of Wille Model Farm (right pane). We propose engaging with farmers statewide and these counties represent potential project sites throughout the state. Mr. Wille's farm will serve as the project model farm and assessing impacts of conservation agriculture practices.

Figure 3. Clockwise from upper left: drones can carry infrared and RGB cameras to survey farm fields; ground rover can inspect details in the areas identified by drone; we tested our equipment framework in a simulated field in the university greenhouse; a moving camera robot that monitors plants from above in greenhouse to simulate year-round of flying drones.

Figure 4. Clockwise from upper left: Plants' photosynthetic volume and health status can be monitored by the NDVI (Normalized Difference Vegetation Index) map calculated from the infrared images; each line represents the NDVI values collected from one plant area in the left image over time, which can train A.I. models to predict future plant health and yields; images can also train A.I. models in detecting invasive species / weeds.

Financial Capacity

File: e98d6359-c70.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

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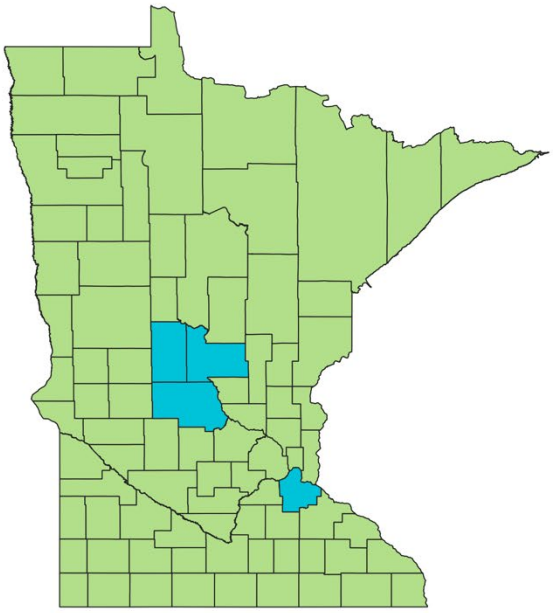

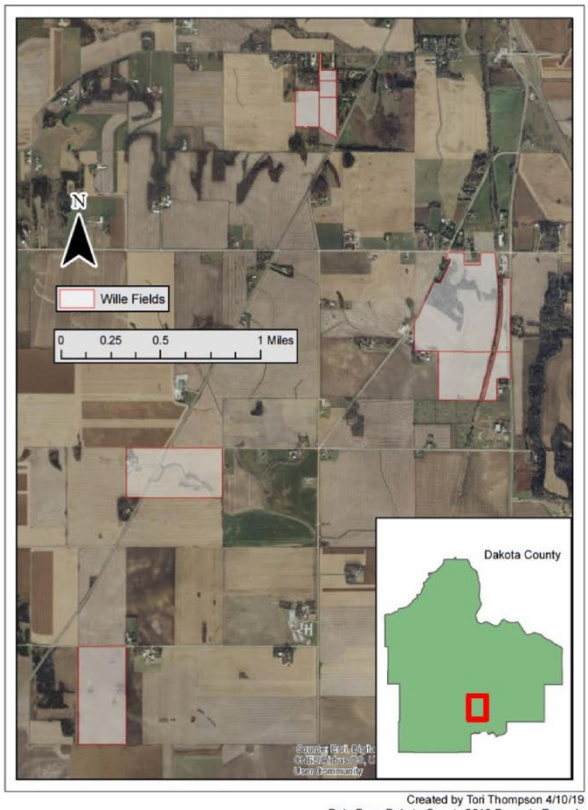

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