



Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-315

Proposal Title: Greenhouse Gas Sampling Approaches for Minnesota Livestock Farms

Project Manager Information

Name: Erin Cortus

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

Office Telephone: (612) 625-8288

Email: ecortus@umn.edu

Project Basic Information

Project Summary: This project will measure and validate greenhouse gas emissions and estimates for the various manure management systems on Minnesota livestock and poultry farms, and help identify feasible mitigation methods.

Funds Requested: \$294,000

Proposed Project Completion: 2023-06-30

LCCMR Funding Category: Air Quality, Climate Change, and Renewable Energy (E)

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.

Manure emissions are a critical piece of agriculture's contribution to greenhouse gas production – both from manure storage and land application of manure nutrients. Concern about manure-related emissions at the community and state level has prompted the Minnesota Pollution Control Agency to estimate greenhouse gas emissions during environmental assessments while determining permit conditions for large concentrated animal feeding operations. Greenhouse gas estimation is also key component to sustainability discussions within the livestock production and food supply chain. Greenhouse gas estimation methods are based on an estimate of the manure excretion by animals, the manure storage method and temperature conditions. This estimation approach does not account for all manure management systems, nor the variability in manure management between farms. Manure sample-based estimates show promise for estimating methane production rates from stored manure, but deserve more extensive testing and comparison to farm-level measurements. Diving into the causes for variability offer opportunity for more realistic and farm-specific greenhouse gas emissions. Improved greenhouse gas measurements or estimates will more accurately predict current greenhouse gas emission levels, identify mitigation techniques, and focus resources where they are needed. This project offers an innovative approach to air quality improvement and strengthens engagement by the livestock sector.

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 to develop a greenhouse gas estimation approach based on a mass balance of volatile solids and nitrogen – precursors to methane and nitrous oxide emissions, respectively. The approach uses manure and other product sampling (e.g., milk), to anchor greenhouse gas emissions to specific farm practices. Ash analyses will confirm that manure (or other) flows are accurate. The mass balance approach will be undertaken in summer and winter conditions on 12 farms that span the range of swine, dairy and turkey production types and manure storage systems for Minnesota. On 4 select farms, the mass balance approach will coincide with continuous aerial emission monitoring of the main greenhouse gas source. The aerial monitoring will demonstrate the temporal variability in emissions, and provide an additional check of the mass balance approach. The mass balance and aerial emission monitoring approaches will be compared to greenhouse gas emission estimation methods currently in practice for Minnesota farms. The hypothesis of this research is that there are farm-based measurements that can supplement and improve our greenhouse gas emissions estimates. In the process, we will identify production practices with potential to mitigate greenhouse gas emissions from manure.

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?

Outcome 1. Trusted sampling and measurement methods improve the accuracy for greenhouse gas emission estimates from the wide variety of manure management systems on Minnesota farms.

Outcome 2. Trusted sampling and measurement methods identify hot spots for mitigating greenhouse gases using current and future manure management methods to reduce emissions.

Activities and Milestones

Activity 1: Mass balance of volatile solids and nitrogen on 12 Minnesota livestock farms

Activity Budget: \$126,174

Activity Description:

The mass of volatile solids, ash and nitrogen entering the farm system (via feed and/or bedding), the mass exiting the system (via manure, milk, meat or other product) or contributing to growth will be measured on a weekly basis. Weekly samples will be collected for feed, manure, milk or other products, and bedding (if applicable), and analyzed on campus for volatile solids, ash and nitrogen concentration. These concentrations will supplement flow measurements collected on farm or via the cooperating producer (i.e. feed intake, ambient and manure storage temperatures, etc.). There will be an unaccounted mass of volatile solids and nitrogen exiting, which we will assume are aerial losses of methane and ammonia/nitrous oxide, respectively. The ash balance provides a check because ash is not lost by volatilization from the system. Ash can also help account for discrepancies in manure production rates (per Keener and Zhao, 2008, BiosysEng). We will collect samples on 4 farms each year, for one month during the summer and one month during the winter (5 weekly sample collections per period per farm). We will also collect samples over two months during summer and winter seasons at two farms per year, overlapping Activity 2.

Activity Milestones:

Description	Completion Date
Summer sampling series at 6 participating farms (2 dairy, 2 swine, 1 poultry, 1 beef)	2021-09-30
Winter sampling series at 6 farms (same as previous summer)	2022-02-28
Summer sampling series at 6 participating farms (2 dairy, 2 swine, 1 poultry, 1 beef)	2022-09-30
Winter sampling series at 6 farms (same as previous summer)	2023-02-28
Volatile solids, ash and nitrogen analysis of samples (will coincide with sampling series)	2023-03-31
Methane gas emissions estimated for farms based on volatile solids balance	2023-06-30

Activity 2: Aerial greenhouse gas emission measurements for 4 manure storage systems in Minnesota

Activity Budget: \$112,074

Activity Description:

Continuous methane and nitrous oxide concentration measurements and coinciding airflow (through fans, wall openings, or over an outdoor manure storage) will be measured on 2 farms per year, for 8 weeks during summer and 8 weeks during winter conditions (4 farms total). The measurements will focus on the main manure storage area of the farm, which may be within the barn; this scenario is expected for swine and poultry wherein the manure is the primary source of methane and nitrous oxide, and stored under roof. The airflow, combined with the concentration difference between exhaust (downwind) and inlet (upwind) air is the emission rate for the barn or manure storage. A mobile trailer will house the gas analysis equipment and data acquisition systems and move between sites, residing temporarily near the measurement site. Supporting environmental and airflow measurement equipment will vary between sites depending on the barns use of mechanical or natural ventilation, and be installed and remote monitored over the year-long period.

Activity Milestones:

Description	Completion Date
Summer sampling series at 2 farms (1 dairy, 1 swine; overlapping with Activity 1)	2021-09-30
Winter sampling series at 2 farms (same as previous summer)	2022-02-28

Summer sampling series at 2 farms (1 poultry, 1 beef)	2022-09-30
Winter sampling series at 2 farms (same as previous summer)	2023-02-28
Greenhouse gas emission rates and patterns generated for measured farms	2023-06-30

Activity 3: Comparison of mass balance and continuous measurements to greenhouse gas estimation methods

Activity Budget: \$55,752

Activity Description:

Measured emissions from the manure storage area based on Activity 1 and 2 for each of the 4 sampled farms will be compared for agreement. The measured emissions from Activity 1 and 2 will also be compared to predicted emissions based on farm-specific input variables using the US EPA State Greenhouse Gas Inventory and Projection Tool. Annual emission estimates from measurements or calculations will consider the manure production rate for the farm, seasonal temperatures, and relevant gas emission rates. The manure and farm characteristics provide checkpoints for model estimates relative to measurements. The measurement (including sampling-related) and random error for measurements will be considered, and reported, in the comparison.

Activity Milestones:

Description	Completion Date
Compare aerial emission measurements of greenhouse gases to estimated values based on calculator	2023-05-31
Compare mass balance estimates of methane and manure nitrogen to estimated values based on calculator	2023-05-31
Compare mass balance and aerial emission measurements of greenhouse gas emissions	2023-06-30

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?

Ongoing funded is not needed. After the desired outcomes are achieved, the data will be available for interpretation and implementation by Minnesota Pollution Control Agency for estimating emissions for proposed feedlots. Through peer-reviewed publications and professional society conferences, the data and comparison results become available for environmental sustainability models that currently use similar estimation methods as MPCA. This ensures that future emission estimates for Minnesota and region farms account for our climate and management systems. Ultimately, the results inform environmental sustainability decisions by producers. An accurate estimate of greenhouse gas emissions adds an important piece to ongoing environmental stewardship.

Project Manager and Organization Qualifications

Project Manager Name: Erin Cortus

Job Title: Assistant Professor and Extension Engineer

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

Erin Cortus joined the Department of Bioproducts and Biosystems Engineering at the University of Minnesota in August 2017. As an Assistant Professor and Extension Engineer, she provides engineering expertise in sustainable animal agriculture systems. She earned her Bachelor of Agricultural and Bioresource Engineering degree and PhD at the University of Saskatchewan. Dr. Cortus also has eight years of experience in a similar Research and Extension role at South Dakota State University. The broad mission of Dr. Cortus' program is to work with producers and communities to understand and continually improve the quality and productivity of livestock environments. Dr. Cortus's past research has focused heavily on emission measurements for multiple livestock species and pollutants. Dr. Cortus was Data Analysis Manager for the National Air Emissions Monitoring Study, and produced emission datasets for swine, dairy, layer and broiler facilities across the US, available through the US EPA and numerous peer-reviewed journal publications. Recently, Dr. Cortus led two USDA NIFA-funded projects (USDA Awards 2010-85112-20510 and 2015-67020-23453) to collect gas flux and supporting environmental and manure conditions for beef cattle systems in the Northern Great Plains. This included measuring gas fluxes from land-application of beef manure. With the exception of lab-scale and land application studies, all projects involved monitoring on producer cooperator farms. The methodologies varied, but the common goal across all studies was to increase understanding of the range of structural, animal and management related factors contributing to emissions, to enhance our ability to estimate emissions for the broader agricultural community.

Organization: U of MN - College of Food, Agriculture and Natural Resource Sciences

Organization Description:

The Bioproducts and Biosystems Engineering Department includes researchers who apply science to understand and develop new processes, systems and solutions for improving the efficiency, performance and environmental sustainability of animal agricultural systems, including the impacts of air quality and climate change. Project personnel are part of the Air Quality and Agricultural Systems group, with laboratory space for manure (and other) sample storage, processing and analysis. The Air Quality group also maintains three trailers for field deployment of air quality monitoring equipment. Project personnel are also University of Minnesota Extension Engineers, contributing to the mission of discovering science-based solutions, delivering practical education, and engaging Minnesotans to build a better future.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Erin Cortus		Project Manager (Primarily Activity 3)			36.5%	0.16		\$29,758
Researcher		Maintain aerial emission monitoring sites and equipment (Activity 1 and 2)			36.5%	1		\$91,338
Graduate Research Assistant		Collect and analyze samples (Activity 1, 2 and 3)			83.2%	1		\$97,973
Undergraduate Research Assistant		Process samples for analysis (Activity 1)			0%	0.5		\$10,666
							Sub Total	\$229,735
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Tools and Supplies	Lab supplies	Sample collection, storage and analysis supplies (\$15/sample*760 samples/yr*2 yr) (Activity 1)					\$22,800
	Tools and Supplies	Lab supplies	Calibration gases and analyzer repair kits (Activity 2)					\$2,200
	Tools and Supplies	Lab supplies	Tubing and cable for monitoring (Activity 2)					\$997
	Tools and Supplies	Lab supplies	PPE for biosecure site visits (\$5/visit*85 visits/yr*2 yr) (Activity 1 and 2)					\$850
	Equipment	Field Equipment	Telescoping towers (\$1000/tower*4 towers) (Activity 2)					\$4,000
	Equipment	Field Equipment	Ventilation monitoring sensors (\$40/fan*10 fans/barn*2 barns/yr*2 yr) (Activity 2)					\$1,600
	Equipment	Field Equipment	Temp/RH sensors for indoor and outdoor conditions at farms					\$2,400

			(\$100/sensor*2 sensors/farm*6 farms/yr*2 yr) (Activity 1)					
	Equipment	Lab Equipment	Datalogger station with antenna for remote connection (Activity 2)					\$1,500
							Sub Total	\$36,347
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Miles/ Meals/ Lodging	Farm visits (85 day trips/yr*2 yr; est 210 miles @ \$0.575/mile + \$23 travel day per diem) = \$143.75)	Visit site for sample collection, sensor installation or cooperator recruitment (Activity 1 and 2)					\$24,438
							Sub Total	\$24,438
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	2 presentations of results at society conference meetings (\$500 registration, \$500 airfare, \$350 hotel, \$150 per diem = \$1500 per person per conference)	Present research results (Activity 1 and 3)	X				\$3,000
							Sub Total	\$3,000
Printing and Publication								
							Sub Total	-
Other Expenses								
		General operating service	Mobile hotspot for remote access of monitoring station (Activity 2)	X				\$480
							Sub Total	\$480

							Grand Total	\$294,000
--	--	--	--	--	--	--	--------------------	------------------

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	2 presentations of results at society conference meetings (\$500 registration, \$500 airfare, \$350 hotel, \$150 per diem = \$1500 per person per conference)	Society meetings are generally held outside of Minnesota, and provide scientific peer review and commentary of research results
Other Expenses		General operating service	Mobile hotspot is dedicated to a project-specific purpose, at monitoring sites, and reduces the amount of travel to check on monitoring system.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	-
Non-State				
			Non State Sub Total	-
			Funds Total	-

Attachments

Required Attachments

Visual Component

File: [918461ee-fbe.pdf](#)

Alternate Text for Visual Component

Example application of monitoring approach applied to a dairy farm and earthen manure storage. There are red stars indicating points for mass balance measurement locations - for concentration and flow of volatile solids, ash and nitrogen at manure transfer points, bedding, feed and milk storage. There are green stars on four towers around the earthen manure storage to indicate aerial gas concentration measurement locations within the gas plume coming from the manure storage; four towers ensure that the plume is measured regardless of wind direction.

Optional Attachments

Support Letter or Other

Title	File
Proposal Submission Authorization	79ae218e-5ec.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

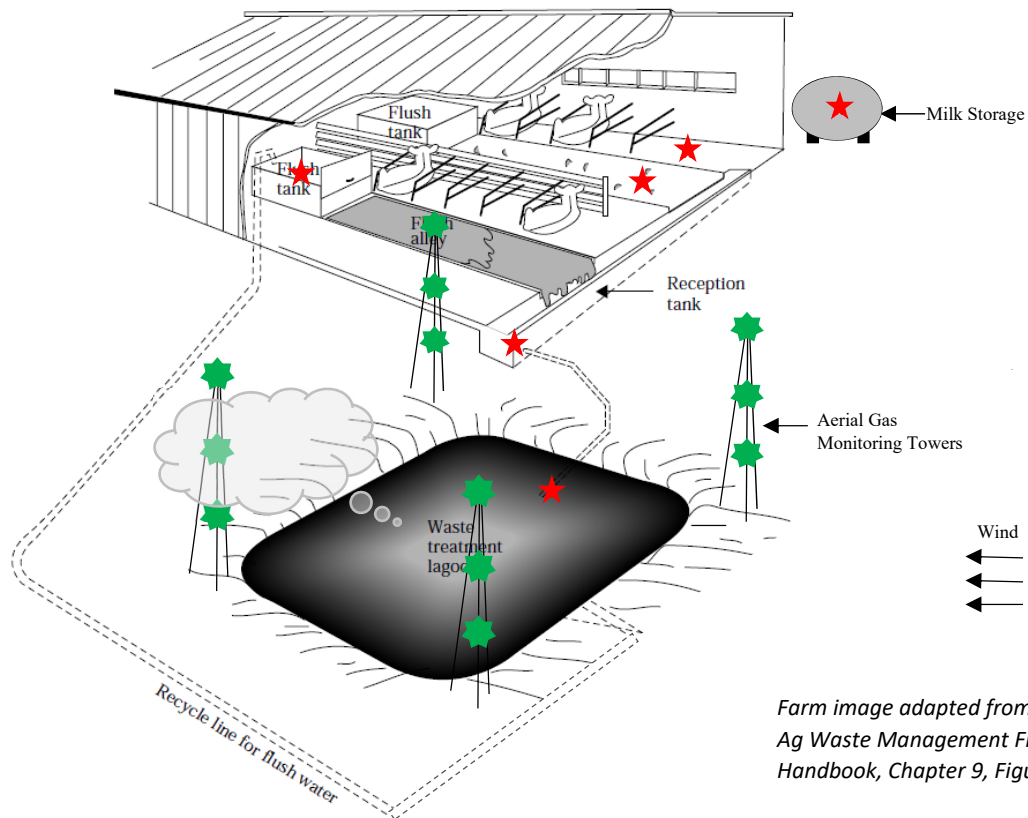
No

Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration



Example application of monitoring approach applied to a dairy farm and earthen manure storage

- ★ Indicate points for mass balance measurements, measuring concentration and flow of volatile solids, ash and nitrogen within the system
- ★ Indicate aerial sampling points around the earthen manure storage, to capture the greenhouse gas plume from the manure storage, regardless of wind direction