Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-182

Proposal Title: Minnesota Center for Agricultural Spray Drift Reduction

Project Manager Information

Name: Christopher Hogan

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: The University of Minnesota will establish a center devoted to developing and implementing protocols and technologies to mitigate the impacts of pesticide spray drift on water and land habitats.

Funds Requested: $1,049,000

Proposed Project Completion: 2024-06-30

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.

Agricultural spray drift occurs when pesticides are transported beyond their target field to the surrounding environment. Spray drift has significant detrimental effects on land and water habitats. Pesticide sprays consist not only of the active chemical ingredient, but also surfactants designed to promote leaf wettability. Pesticides present on natural lands contribute to the proliferation of invasive, pesticide resistant weed species. Exposure to pesticides and surfactants places an unwanted evolutionary pressure and potential loss of habitat for both natural plant species and pollinators. Increased surfactant concentrations in lake and rivers contribute to a loss of habitat for fish species, as surfactants are often moderately toxic to fish.

A scientifically-driven effort is needed to reduce spray drift. Drift occurs when the droplets spayed are too small to gravitationally deposit before being entrained by prevailing winds, which leads to their transport hundreds of feet or more away for the target application site. Drift is therefore a problem of spray physics and droplet physics, and a physics-driven approach will result in safe, implementable guidelines for MN growers to use when spraying agrochemicals, accounting for equipment utilized in spraying, agrochemical tank mixture, and local weather conditions.

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.

At the University of Minnesota, we have previously developed new measurement techniques to better describe droplet formation in sprays and droplet transport using a unqiue wind tunnel, designed specifically for spray analysis. The techniques, utilizing digital-inline holography as well as elutriators, are the state-of-the-art. We have capabilities in laboratory scale spray measurement and direct field measurements of spray drift. We now intend to establish a center devoted to spray drift reduction, translating laboratory developments into state-wide impact. Our proposed solution to spray drift is multi-tiered. Through a spray drift reduction center, we intend to (1) improve predictions of spray drift via more rigorous droplet size measurements, (2) bring state-of-the-art spray size distribution measurements to the field, allowing MN growers to see first-hand if their current practices lead to spray drift, (3) provide MN growers with accurate spray drift predictions accounting for local weather conditions via a web-based, free application, (4) provide education through free annual short courses on spray drift and mitigation strategies, and (5) aid MN companies in developing spray drift reduction technologies via rigorous quantitative measurements needed to demonstrate the efficacy of new spray drift reduction nozzles and agrochemical tank mix additives.

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 first key outcome will be the establishment of simple-to-follow yet scientifically rigorous practices that MN growers can use to apply agrochemicals safely, reducing drift and reducing its impact on MN land, air, and water, as well as native plants and pollinators. A web-based application accounting for local weather will allow for such practices to be followed. Second, in the event of high levels of spray drift (detected by visible damage), we will develop a set of practices to determine the extent of drift and at specific field sites.

Activities and Milestones

Activity 1: Development of improved measurement methods to quantify agricultural spray droplet sizes.

Activity Budget: $419,600

Activity Description:
Current practices in approving pesticide tank mixtures require measurement of the size distributions of droplets using laser diffraction. Our previous work has demonstrated this is a flawed approach, and drift reduction measures need more rigorous, better engineered, measurement techniques. Our first objective is hence to develop and optimize a single droplet, imaging based technique, called digital-inline holography (DIH) to become the gold standard measurement approach to quantify spray droplet size distributions. DIH is a recently developed imaging based technique that enables individual droplet size, shape, and speed analysis. Professor Jiarong Hong, the co-Director of the Minnesota Center for Agricultural Spray Drift Reduction, is one of the world's leading experts in DIH. First, we will adapt machine-learning based data analysis algorithms, simplifying the measurement for spray droplet size analysis in DIH. This will set DIH as the gold standard in DIH analysis. Second, we will develop turn-key, portable DIH systems, which can be used not only in laboratory measurements, but for droplet size distribution measurements during actual field applications on sprayers and on drones. Third, we will apply DIH measurements in a series of field trials using approved tank mixes to assess the true driftable content in field settings.

Activity Milestones:

Description	Completion Date
Machine Learning Algorithm Completion	2022-01-31
Development of portable DIH system for field deployment	2022-06-30
Report on true driftable content measurements in field trials	2024-06-30

Activity 2: Development of improved models of spray drift, accounting for local weather conditions, which are made available to MN farmers

Activity Budget: $262,250

Activity Description:
A major challenge in reducing spray drift to natural land and water habitats is that not only are certain nozzle and agrochemical tank mixtures required to avoid small droplet formation and long range transport, but also, the potential for spray drift is strong dependent on local weather conditions. This includes relative humidity, chance of rain, and most importantly, wind speed, as both too high a speed and too low a speed can promote spray drift. MN growers must therefore balance agrochemical treatment needs with daily, and in some cases hourly, variations of local weather. We intend to great simplify this process by first developing improved models of droplet transport (which are presently dependent on the program AGDisp). Second, traditional modeling will be coupled with machine learning based models of droplet size distributions resulting from DIH measurements in laboratory settings, providing a large data set of nozzles and agrochemical tank mixtures. Incorporating these two measurements, we will then develop a web based application that allows MN growers to input crop, nozzle type, and tank mixture, and which outputs days wherein spraying can be carried out safely, and how spraying should be carried out (nozzle pressure, wind speed needed).

Activity Milestones:

Description	Completion Date
Improved Droplet Transport and Dispersion Model	2023-06-30
Completion of initial machine-learning model of droplet size distributions	2023-08-31

Initial roll-out of web based app	2023-12-31
Semi-Annual Town Hall meetings to understand MN grower needs towards spray drift	2024-06-30

Activity 3: Establishment of a testing and education center for technologies devoted to agricultural spray drift reduction in Minnesota

Activity Budget: $367,150

Activity Description:
An additional hindrance to spray drift reduction is that the approval process for new technologies, including new nozzle types and new agrochemical tank mix additives designed to reduce spray drift is arduous. Only a finite number of laboratories (<5) in the United States have been traditionally set up to make the size distribution measurements needed for product registration, and none of these laboratories are in Minnesota. MN has a chance to be the leading state in the nation both in spray drift reduction practices and in spray drift reduction technologies. What is needed now for the latter is a streamlined measurement process from a reliable third party laboratory locally. We have rectified that issue by establishing a Good-Laboratory-Practice (GLP) protocol for measurements of spray size distributions, for the tank mix product registration process. Our third goal in establishing a center for spray drift reduction is now to establish UMN as a third party testing center, providing streamlined testing of spray drift reduction technologies, and to develop an educational short course for growers, engineers, and the public. The short course would be offered annually with instructors from industry, academia, and government.

Activity Milestones:

Description	Completion Date
Deliver first annual spray drift short course and symposium	2022-06-30
Incorporated of DIH measurements into Good-Laboratory-Practice Protocol	2022-06-30
Continuous submission of spray drift reduction technology performance reports	2024-06-30

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?

Drift reduction measures will be implemented by developing a web application which allows MN growers to input nozzle type, agrochemical tank mixture, and location, and which outputs appropriate nozzle operating conditions and time of day or days (in a given week) when agrochemicals can be sprayed in a safe manner. Findings will be presented in peer-reviewed scientific journals and in an annual report presented at UMN symposium. Ongoing efforts beyond the project will be supported via registration fees for 2-3 day short courses provided annually, and by providing testing services for companies developing adjuvants and nozzles towards spray drift reduction.

Project Manager and Organization Qualifications

Project Manager Name: Christopher Hogan

Job Title: Professor

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

Professor Chris Hogan has been a faculty member at the University of Minnesota since 2009. Since that time, he has been Principal Investigator or Co-Principal Investigator on external grants and contracts totally over $5.5M (this includes current funds, but only funds devoted to his laboratory group and not to co-investigators). Sponsors include the Department of Defense, the National Science Foundation, the Department of Energy, the Advanced Research Projects Agency for Energy, the Center for Disease Control, BASF, Winfield United, Boston Scientific, Honeywell, and numerous other local and international companies. 9 PhD students, 5 Master Students, and 7 post-doctoral associates have completed their studies performing research under his supervision, and currently his laboratory group consists of a full-time staff researcher, a laboratory manager, 7 PhD students, and 2 MS students. He has published more than 100 peer-reviewed scientific publications, his work has results in 3 patents (including one commercial measurement instrument), and he is the Editor-in-Chief of the Journal of Aerosol Science. With Professor Jiarong Hong and Dr. Bernard Olson (UMN staff scientist), he oversaw the donation, and installation of a unique low speed spray analysis wind tunnel, laser diffraction, and PDPA system (from Winfield United with a >$500K valuation), as well as the development of a digital inline holography system at the University of Minnesota. This facility is the only one of its type in a United States University Mechanical Engineering Department.

Organization: U of MN - College of Science and Engineering

Organization Description:

The University of Minnesota-Twin Cities campus, spanning the East Bank campus, West Bank campus, and Saint Paul Campus, is the flagship campus of the University of Minnesota system, with nearly 48,000 students and ~3,800 academic staff. Its educational and research programs in science and engineering consistently rank in the top 25 in nearly all disciplines, and in 2019 its research expenditures were $982 million. This project in particular will be housed within the department of Mechanical Engineering. Founded in 1889, the department has 44 active faculty, 56 staff members, 311 graduate students, 74 postdoctoral associates, research associates and visitors, and about 560 undergraduate students. Aerosol and Particle Technology measurement techniques, leveraged heavily in this project, were originally developed in the University of Minnesota Mechanical Engineering Department in the 1950s, and leadership in aerosol and fluid mechanics measurement continues in the department to this day.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Professor Chris Hogan		Center co-Director and Project Manager			37%	0.51		$123,106
Professor Jiarong Hong		Center co-Director			37%	0.51		$108,686
Postdoctoral Associates		Research Engineers			25%	6		$403,103
Graduate Research Assistant		Measurement and Program Development			72%	3		$322,444
							Sub Total	**$957,339**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Tools and Supplies	Laboratory Supplies	The spray wind tunnel facility at the University of Minnesota is installed and operation. $20,054 per year is needed for the purchase of laboratory supplies for tunnel operation					$60,161
							Sub Total	**$60,161**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**

Travel In Minnesota								
	Miles/ Meals/ Lodging	Meals and lodging for site visit and short course	These funds will be used to support project personnel lodging during site visits and instructors visiting the University of Minnesota for the short course					$15,000
							Sub Total	**$15,000**
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	Center Personnel will attend 2-3 conferences per year	Center Personnel will present platform talks as well as posters to disseminate results on improved spray drift reduction techniques					$15,000
							Sub Total	**$15,000**
Printing and Publication								
	Publication	Publication fees	$500 are requested per year to be used towards color printing fees in peer-reviewed, technical publications					$1,500
							Sub Total	**$1,500**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$1,049,000**

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				
			Non State Sub Total	**-**
			Funds Total	**-**

Attachments

Required Attachments

Visual Component

File: e5e4491d-a79.pdf

Alternate Text for Visual Component

Page 1:
Image (a): Palmer Pigweed spreading in Minnesota (https://agfaxweedsolutions.com/2019/04/03/minnesota-palmer-pigweed-continues-to-spread-what-you-should-know/)
Image (b): Wild rice in Minnesota (https://statesymbolsusa.org/symbol-official-item/minnesota/state-food-agriculture-symbol/wild-rice)
Image (c): Minnesota native plants (http://mnnps.org/)
Image (d): Pollinators endangered by pesticides (https://www.mda.state.mn.us/pesticide-fertilizer/best-management-practices-pollinators-their-habitat)
Image (e): Pesticides implicated in fish deaths in Minnesota
https://beyondpesticides.org/dailynewsblog/2012/07/pesticides-blamed-for-fish-kill-on-canadian-coast/)

Page 2:
Clockwise, from bottom left: Depictions of the UMN spray drift wind tunnel facility, field application of agrochemicals from a spray book, depictions of a holography carrying drone and holography 3D droplet size and position output (blue: driftable contect, red: large droplets), representation of web-based application, and shadowgraph of a flat-fan agrochemical spray nozzle.

Optional Attachments

Support Letter or Other

Title	File
WinField United LOS	03fe5bc1-356.pdf
SPA Approval	d935cd5c-2e7.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

Yes,

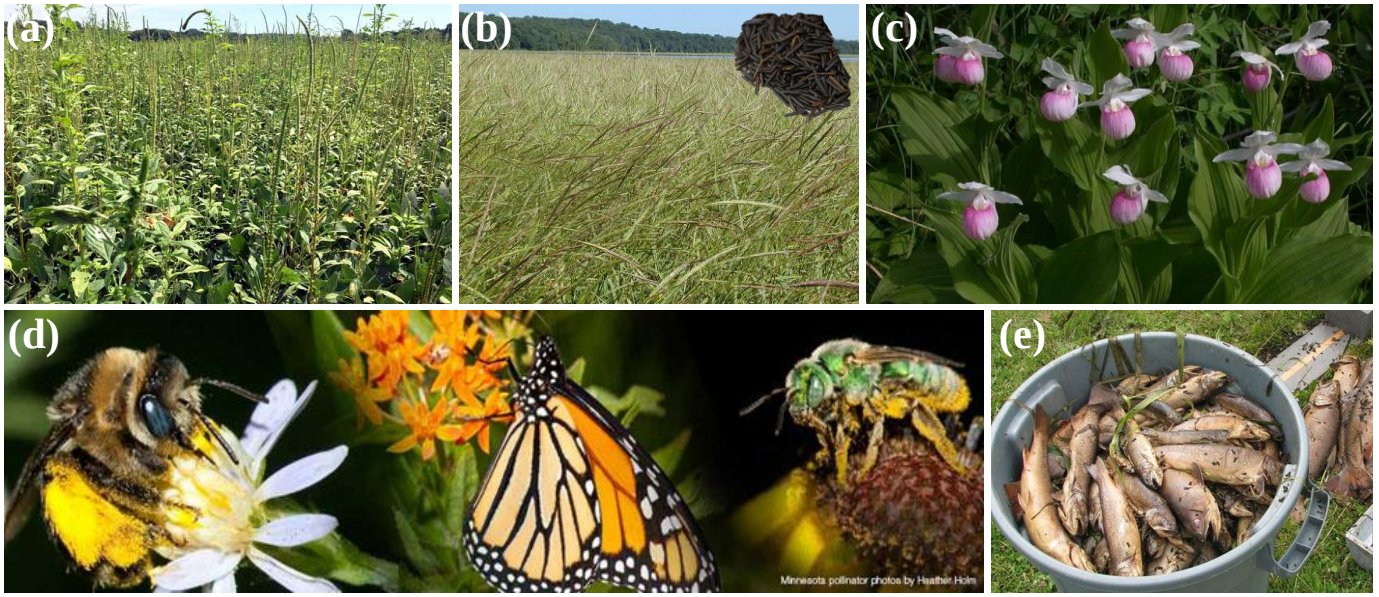
- Patent, Copyright, or Royalty Potential
- Potential revenue generated or net income from the sale of products or assets developed or acquired with ENRTF funding

Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration


(a)
(b)
(c)
(d)
Minnesota pollinator photos by Heather Holm
(e)

From Lab to Field