Environment and Natural Resources Trust Fund
2012-2013 Request for Proposals (RFP)

Project Title: **ENRTF ID:** **054-C2**

Innovative Techniques for Monitoring Movements of Invasive Species

Topic Area: C2. Invasive Species - Terrestrial

Total Project Budget: $ 244,000

Proposed Project Time Period for the Funding Requested: 2 yrs, July 2013 - June 2015

Other Non-State Funds: $ 0

Summary:

Commercially available pilotless GPS-guided small-scale drone aircraft will be adapted to automatically locate movements of invasive species through photographic spectral imaging in selected terrestrial and aquatic systems.

Name: Clarence Lehman

Sponsoring Organization: U of MN

Address: 1987 Upper Buford Cir
St. Paul MN 55108

Telephone Number: (612) 625-1839

Email lehman@umn.edu

Web Address www.umn.edu

Location

Region: Statewide

County Name: Statewide

City / Township:

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

PROJECT TITLE: Innovative techniques for monitoring movements of invasive species

I. PROJECT STATEMENT

Why. The timing is finally right. Starting in the 1870s, Alvin Wilcox, pioneer surveyor of Becker County, tracked the movement of Canada Thistle across the northern regions of Minnesota. He provided some of the earliest notifications of invasive species, but at that time little could be done. Using traditional methods, armies of field workers combing the landscape would be required to follow each movement and determine where control efforts should be focused, for a variety of species. By the turn of the 21st century, little had changed in our reliance on limited survey data. Rapid detection of invasive species remained one of the most difficult tasks. But now, quite recently, remarkable miniaturization and cost reduction in remote sensing allows lightweight, high-resolution, multi-spectral cameras to be combined with self-piloting, small-scale, GPS-guided drone aircraft which can exceed the efforts of hundreds of individual field workers. This requires no new inventions. It is commercial technology, currently used in large-scale agriculture, now ready for testing, demonstration, and deployment in natural environmental settings.

Goals. We propose to develop the use of remote aerial drone-vehicle technology for tracking invasive species across Minnesota's Wildlife Management Areas, State Parks, Scientific and Natural Areas, and other important locations such as the University's Itasca and Cedar Creek field sites. Goals are (1) to develop techniques that can identify the entrance of unwanted species into new areas while they are still sparse enough to be controlled; (2) to apply those techniques over uplands and along the shores of our lakes, rivers, ponds, and streams; (3) to experiment over open water to detect aquatic plants, and generally examine the limits of this new technology; (4) to examine possibilities for infrared and aerial radio-tracking of animals, and (5) to increase public awareness of invasive species and related topics concerning natural resources.

How. We will conduct ground-truthing of temporal-spectral patterns—"fingerprints" of exotic and native species—combined with low-altitude, high-resolution drone aircraft images of local landscapes. We will apply existing image software and develop special software as necessary to identify individual plants of various species and detect spatial gradients that indicate directions of invasion and movement. We will organize public demonstrations of the technology and hold discussion sessions at selected field sites. We will create a permanent project website available to site managers and the public alike, showing videos, images, and data from the project. Results of our project will provide the basis for detailed information on a scale never before possible. It will help place our state at the forefront of monitoring and control efforts in the country, and provide information to feed forward to many other state, local, and federal efforts.

II. DESCRIPTION OF PROJECT ACTIVITIES

Activity 1: *Spectral testing and calibration* **Budget:** $141,000

Description: The first field season and subsequent winter season will be for laboratory and field testing, calibration, and initial analysis.

Outcome	Completion Date
1. Order and obtain final equipment and conduct training	*August 2013*
2. Assemble and test under controlled laboratory and field conditions	*August 2013*
3. Select initial survey sites and fingerprint specific exotic and native species	*September 2013*
4. Identification and development as necessary of image processing software	*February 2014*
5. Calibrated field tests	*October 2013*

Activity 2: *Application and surveys* **Budget:** $103,000

Description: The second field season will be for surveys of selected sites, based on the calibration and testing of the first season, and for demonstrations. The second winter season will be for analysis, reporting, and publication, which will continue beyond the two years of the project.

Outcome	Completion Date
1. Actual surveys of selected sites	*September 2014*
2. Public demonstration sessions ideas, methods, and results	*September 2014*
3. Publicly accessible website with close-fly images	*December 2014*
4. Field guide to spectral characteristics of invasive species	*March 2016*
5. Occurrence lists of invasive species in selected sites	*October 2015*
6. Final reports and publications	*December 2015*

III. PROJECT STRATEGY

A. Project Team/Partners

All named team members are affiliated with the University of Minnesota. (1) Clarence Lehman has engineering and management experience in industry and academia, and will contribute that experience to managing the project. He will also contribute long experience from industry with computer methods and also knowledge on upland ecology. (2) John Rotenberry will be organizing field sites for the College of Biological Sciences, including coordination with state, local, and federal sites. He has published materials on photogrammetric engineering and remote sensing, and his current role will be valuable to this project. (3) James Cotner will contribute expertise to the wetland components of the project, and also knowledge on the effects of humans on ecosystems. (4) Craig Bantz directs the information technology department for the College of Biological Sciences and will oversee technology for the project. (5) Michael Nelson studies the establishment and spread of invasive species in Minnesota and has experience with low-altitude aerial photography for biological surveys, and will contribute efforts related to that. (6) Stergios Roumeliotis works with vision-aided navigation of aerial autonomous vehicles, and he will be consulted for topics in navigation and image analysis. (7) We will employ graduate and undergraduate-level workers to carry out the day-to-day operation, collect data, organize the results, help prepare reports and publications, assist with public presentation, and other duties. Trust fund allocations will cover time spent by these graduate and undergraduate workers, as well as time spent for project management by C. Lehman and technological support by C. Banz and staff. (8) We will also work with the Department of Natural Resources and other relevant agencies to coordinate information on this emerging technology and to enhance knowledge of Minnesota's habitats and natural resources.

B. Timeline Requirements

This project requires two field seasons, one for testing and calibrations, the other for actual field surveys. We will primarily fly the pilotless drones for surveying during the growing season, but will also test how the technology operates during winter. The growing season will be dedicated to gathering data, testing, and demonstrating, while the off season will be used for activities related to organizing and analyzing results.

C. Long-Term Strategy and Future Funding Needs

This is a stand alone project that should not need future support. It will establish the efficacy of these new automated techniques for monitoring species and results will be communicated to other agencies. It could, however, generate much interest and consequences could be far-reaching. Many agencies—state, federal, and local—are experiencing budget pressures and difficulties managing their natural areas. This technology could help them by saving funds for equivalent amounts of information returned, or expand information returned for the same amount of funds allocated.

2012-2013 Detailed Project Budget

IV. TOTAL ENRTF REQUEST BUDGET - 2 years

BUDGET ITEM	AMOUNT
Personnel: **PI** (8% of full-time appt.; 74% salary, 26% fringe) - for project management, analysis, report writing, and other academic tasks **Post Doc** (100% of full-time appt.; 81% salary, 19% fringe) - for planning, analysis, field coordination, and other tasks as required **Field Assistant** (40% of full-time appt.; 91% salary, 9% fringe) - for seasonal employees to assist the student/graduate researchers in field aspects of the project **IT Personnel** (12% of full-time appt., 71% salary, 29% fringe) - for technology assessment and support	$ 194,000
Contracts:	$ -
Equipment/Tools/Supplies: Equipment covers two MicroPilot MP-Vision electric unmanned aerial vehicles or equivalent (small-scale drone air), with spare parts and high-resolution cameras. Fully automatic GPS flight plan, altitude 400-2,200 feet, speed 60 km/h average, duration 50 minutes under load, or equivalent. This technology will develop further by the time the project starts, and the best equipment will be chosen at that time.	$ 38,000
Acquisition (Fee Title or Permanent Easements):	$ -
Travel: Travel and lodging covers travel to field sampling sites and to the public demonstrations and discussions supported by the project.	$ 10,000
Additional Budget Items: Publication Costs: Publication costs cover potential fees for open-access publication of results of the project.	$ 2,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 244,000

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ Being Applied to Project During Project Period:	$ -	*Indicate: Secured or Pending*
Other State $ Being Applied to Project During Project Period:	$ -	*Indicate: Secured or Pending*
In-kind Services During Project Period:	$ -	
Remaining $ from Current ENRTF Appropriation (if applicable):	$ -	*Indicate: Unspent? Not Legally Obligated? Other?*
Funding History:	$ -	

Project Manager Qualifications
Clarence Lehman

Clarence Lehman has experience in engineering, science, and management, both in industry and academia. He serves as Associate Dean for Research and Graduate Education in the University's College of Biological Sciences, as Adjunct Faculty in the Department of Ecology, and as a Fellow of the University's Institute on the Environment. For six years he also served as Associate Director of Cedar Creek Ecosystem Science Reserve.

His academic degrees are all three from the University of Minnesota. Clarence Lehman's work covers theoretical, experimental, and computational ecology, renewable energy, biodiversity and its ecosystem properties, connections between ecology and economics, and restoration of natural habitats. He has restored and maintains several areas of native prairies, savannas, and wetlands in northwestern Minnesota and maintains them through specialized experiments for adaptive management.

Clarence Lehman has experience designing and managing projects and experiments, including three LCCMR projects—one on grassland energy and water purification, another on grassland management and wildlife conservation. The latter is ongoing in its second phase. He handled the computerized aspects of the design and layout of Cedar Creek's long-term biodiversity experiment and its long-term carbon dioxide enrichment experiment. He also has designed and managed three practical prairie experiments located in northwestern Minnesota to determine best establishment practices, seeding times, and burning frequencies for restored native prairies.

Scientific papers authored and coauthored cover topics such as biodiversity and the functioning of ecosystems, habitat destruction and extinction, competition among species, environmental change, long-term carbon cycling, stability of ecological systems, and ecological economics. Scientific software development covers new methods for computer simulation of natural systems, including those involving the spread of human and wildlife disease, a computer system to select native prairie plants suited to specified geographic locations in Minnesota under specified soil, moisture, and sunlight conditions, and web-based keys for plant species identification,