

**Environment and Natural Resources Trust Fund  
2020 Request for Proposals (RFP)**

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**Project Title:**

**ENRTF ID: 029-A**

Monitoring Carnivores Statewide: A Citizen-Science Trail-Cam Project

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**Category:** A. Foundational Natural Resource Data and Information

**Sub-Category:**

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**Total Project Budget: \$** 789,988

**Proposed Project Time Period for the Funding Requested:** June 30, 2023 (3 yrs)

**Summary:**

This project will develop and deploy the infrastructure needed to implement a statewide monitoring program for carnivores using remotely triggered cameras and citizen scientists.

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**Name:** John Fieberg

**Sponsoring Organization:** U of MN

**Job Title:** Dr.

**Department:** Fisheries, Wildlife, and Conservation Biology

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**Location:**

**Region:** Statewide

**County Name:** Statewide

**City / Township:** St. Paul

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**Alternate Text for Visual:**

Visualization of project activities, including data collection with camera traps, image classification using machine learning, and data analysis and web-based visualizations.

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



**PROJECT TITLE: Monitoring Carnivores Statewide: A citizen-science trail-cam project**

**I. PROJECT STATEMENT**

Minnesota is known for its wildlife, including iconic carnivores such as bears, lynx and wolves. Apart from the emotional impact these animals have on our public, they are also important because they influence herbivore populations (e.g., moose, deer), provide recreational harvest and viewing opportunities, occasionally cause human-wildlife conflicts, and may serve as indicator species for inferring the health of ecosystems. Knowing where these species are and what they are doing is the first step in their conservation. Management concerns have increased for several key carnivore species in Minnesota including fishers, martens, bears, lynx, and wolves. Understanding distribution and trends in relative abundance is critical for making informed wildlife management decisions and for understanding the effects of land use/land cover change and environmental variability on population dynamics. The MN DNR currently monitors trends in carnivore species using track surveys, but these are costly and increasingly challenging to implement, particularly statewide. Based on a feasibility study with 100 cameras started in 2015, the MN DNR and partners at UMN have determined that the use of remotely triggered cameras is the most efficient mechanism to monitor simultaneously multiple species of carnivores across their entire range in Minnesota. Importantly, this approach also offers exciting opportunities to engage citizen scientists in data collection and processing efforts.

*Our project will leverage data from the above MN DNR-UMN pilot study, citizen science expertise at the UMN Center for Citizen Science, and recent advances in machine learning to develop a statewide monitoring program that engages citizens while providing better data for wildlife management. Specifically, we will develop:*

1. A detailed plan, including protocols and procedures, for involving citizen scientists and educational groups to help with deploying cameras and identifying species in photos;
2. a framework for processing photo images that combines machine learning algorithms and species identifications from citizen scientists;
3. web-based applications to allow wildlife managers and the general public to visualize trends in species distributions and relative abundance.

**II. PROJECT ACTIVITIES AND OUTCOMES**

**Activity 1:** *Develop and pilot a plan for involving citizen scientists in statewide monitoring efforts*

**ENRTF BUDGET: \$154,569**

Opportunities exist for involving citizen scientists and educational groups, both in the deployment of cameras and to aid with processing photos, but doing so requires careful attention to recruitment, training, and retention processes to ensure adequate availability of well-trained volunteers. We will begin by reviewing similar large-scale monitoring programs, including Snapshot Wisconsin and eMammal, and then develop a plan, including protocols and procedures, for involving citizen scientists in long-term data collection efforts. We will initially pilot this plan with 3 or 4 user groups such as University of Minnesota Crookston, Leech Lake Tribal College, Central Lakes and Vermillion Community Colleges, Three Rivers Park District, and several high school classrooms that currently conduct track surveys for the MN DNR. Longer-term, we also plan to recruit citizen scientists from other successful LCCMR projects including — the MN Breeding Bird Survey, the MN Native Bee Atlas, and MN Master Naturalist — as well as recruit new volunteers from across the state.

Outcome	Completion Date
1. Develop protocols, design and Implement pilot studies with different user groups for incorporating citizen scientists into the data collection process.	Dec 2022
2. Develop recommendations for involving citizen scientists in long-term data collection and processing efforts.	June 2023



**Environment and Natural Resources Trust Fund (ENRTF)**  
**2020 Main Proposal Template**

**Activity 2 Title:** *Develop infrastructure for processing, analyzing, and summarizing camera trap data*  
**ENRTF BUDGET:** \$635, 419

A statewide monitoring program will generate a large number of images that need to be stored and processed (e.g., Snapshot Wisconsin has generated 22 million images since 2016). Machine learning algorithms offer one possibility for processing photos efficiently. This approach works by using photos with known species identifications to train models so that they can classify future images as either “empty” (no animal in the photo) or as a photo containing one of a list of species known to occur in the area. In addition, the models output a level of uncertainty associated with each classification. Although recent applications to camera trap data have demonstrated that machine learning algorithms can achieve high levels of accuracy (e.g., > 90%), algorithms can sometimes have a difficult time identifying similar species (e.g., fisher-marten). Success rates can be improved by combining machine-learning algorithms with classifications made by trained volunteers, especially when volunteers focus their efforts on photos that have high levels of uncertainty.

We will use approximately 2.5 million photos collected as part of the pilot study in northern Minnesota between 2016 and 2018 to train machine-learning algorithms for classifying carnivore species found in Minnesota. In addition, we will use the well-established Zooniverse online citizen science platform, developing further infrastructure and protocols for validating these classifications using the thousands of volunteers typically attracted to a Zooniverse project. This hybrid approach to species classifications will allow for efficient processing of photos, wider volunteer reach and more meaningful engagement with volunteers since many of the empty pictures will be eliminated before viewing. Lastly, we will develop web applications that allow users to visualize spatial and temporal trends for species of interest, determine a list of all species detected within spatial regions, and visualize patterns of occurrence and co-occurrence of various carnivore species.

Outcome	Completion Date
1. Develop and deploy an online platform for uploading and storing images	July 2021
2. Develop a machine learning algorithm for identifying species specific to Minnesota	July 2022
3. Develop and deploy an online Zooniverse project ( <a href="http://www.zooniverse.org/lab">www.zooniverse.org/lab</a> ) for integrating machine learning and citizen science classifications	June 2023
4. Develop statistical models and web-based applications for viewing/summarizing spatial-temporal trends and other data summaries.	June 2023

**III. PROJECT PARTNERS AND COLLABORATORS:**

Funds received from this Environmental and Natural Resources Trust Fund (ENRTF) request will be through an agreement with the University of MN with Drs. Fieberg, Fortson, and Blair as co-Principal Investigators. Drs. Fortson and Blair are co-directors of the UMN’s Center for Citizen Science, bringing decades of experience in project implementation and technical expertise in citizen science. Partners will include John Erb, Research Scientist with the Forest Wildlife Populations and Research Group of the MN DNR, and Zooniverse@UMN.

**IV. LONG-TERM IMPLEMENTATION AND FUNDING:**

This project will develop and pilot the necessary infrastructure (camera distribution network, web-based data ingestion-to-data summaries pipeline, machine-learning algorithms) for implementing a permanent statewide monitoring program for carnivore species using remotely triggered cameras, while also engaging citizens in data collection and species identification efforts. Once this infrastructure is in place, we will pursue additional funding for long-term data storage and processing and to purchase between 5,000 and 10,000 cameras, allowing us to deploy between 2 and 4 cameras per township. Future efforts will likely allow expansion of monitoring efforts to non-carnivore species (e.g., turkey, deer, moose). We also plan to recruit additional user groups to help with deploying cameras and processing the data, including hunters, schools, nature centers, and non-profits.



**Legal Citation:**

**Project Manager:** John Fieberg

**Project Title:** Monitoring Carnivores Statewide: A citizen-science trail-cam project

**Organization:** University of Minnesota

**Project Budget:** \$789,988

**Project Length and Completion Date:** June 31, 2023

**Today's Date:** March 15, 2019

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
<b>BUDGET ITEM</b>			
<b>Personnel (Wages and Benefits)</b>	\$ 769,880	\$ -	\$ 769,880
John Fieberg, Principal investigator, Associate Professor (AP), FWCB. (0.5 summer month in 2020, 2021, 2022; \$22,176, Fringe rate = 36.0% of salary)			
Lucy Fortson, Co-investigator, Professor (P), SPA. (0.5 summer month in 2020, 2021, 2022; \$23,719, Fringe rate = 36.0% of salary)			
Rob Blair, Co-investigator, Professor (P), FWCB (0.5 summer month in 2020, 2021, 2022; \$22,008, Fringe rate = 36.0% of salary)			
Extension coordinator: will develop plan for and implement pilot studies for incorporating citizen scientists into the data collection process; will help manage Zooniverse projects; will develop protocols and guidelines for using data ingestion system, camera trap set-up, camera trap maintenance, etc. (100% time during last 2 years of the project; \$124,508, Fringe = 29.5% of salary)			
Postdoc in Fortson's data science group to develop and train the model(s), build the infrastructure (SQL) to ingest and store the data, assist with data intensive aspects of visualizations, etc (100% time, first 2 years of the project; \$141,900, Fringe = 24.3% of salary)			
Web developer in Fortson's data science group to develop any new and maintain needed Zooniverse infrastructure, and additional UIs for data ingestion and visualization (100% time in all 3 years, \$278,682, Fringe = 36.0% of salary)			
Postdoc researcher in Fieberg's lab to develop data statistical models for distribution/trends and associated visualization tools. Will also interface between the different project team members (MN DNR, Zooniverse staff implementing ML algorithms, web developer). 100% time during first 2.4 years of study; \$156,887, Fringe = 24.3% of salary.			
<b>Professional/Technical/Service Contracts</b>			
Zooniverse (well-established online citizen science platform that reaches thousands of volunteers typically attracted to participating in this kind of project), hosting costs	\$ 3,000	\$ -	\$ 3,000
Minnesota Supercomputing Institute (in-house service for picture storage), hosting costs	\$ 3,000	\$ -	\$ 3,000
<b>Equipment/Tools/Supplies</b>			
Office & General Supplies- postage, paper, pens, toner, etc.	\$ 500	\$ -	\$ 500
<b>Capital Expenditures Over \$5,000</b>			
	\$ -	\$ -	\$ -
<b>Fee Title Acquisition</b>			
	\$ -	\$ -	\$ -
<b>Easement Acquisition</b>			
	\$ -	\$ -	\$ -
<b>Professional Services for Acquisition</b>			
	\$ -	\$ -	\$ -
<b>Printing</b>			
	\$ -	\$ -	\$ -
<b>Travel expenses in Minnesota</b>			
Travel to work with citizen science collaborators (3 locations/groups in year 2 and 6 locations/groups in year 3, each involving 2 nights lodging, gas, food).	\$ 2,700	\$ -	\$ 2,700
Domestic Travel- conference registrations, mileage, airfare, lodging (1 presentation each of 2 years by a PI or postdoc). Specifically, we plan to give presentations at annual meetings of The Wildlife Society and the Citizen Science Association. These presentations will allow us to present the findings of this project, get feedback from other experts and learn about newest developments in the field.	\$ 8,808	\$ -	\$ 8,808
<b>Other</b>			
General services- publishing costs	\$ 2,100	\$ -	\$ 2,100

<b>COLUMN TOTAL</b>	\$ 789,988	\$ -	\$ 789,988
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SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
<b>Non-State:</b>		\$ -	\$ -	\$ -
<b>State:</b> Funding of pilot camera trap project in northern MN resulting in 2 million+ pictures from 100 cameras	secured	\$ 141,000	\$ 141,000	\$ -
<b>State:</b> 100 remotely triggered cameras for piloting with citizen scientist groups	secured	\$ 12,000	\$ 12,000	\$ -
<b>State In kind:</b> 120 hrs of time on project implementation from John Erb, MN DNR	secured	\$ 4,700	\$ -	\$ 4,700
<b>Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS</b>	Amount legally obligated but not yet spent	Budget	Spent	Balance
Aquatic Invasive Species Research Center Sub-Project #14: Cost-effective monitoring of lakes newly infested with zebra mussels M.L. 2013, Chp. 52, Sec. 2, Subd. 06a		\$ 266,500	\$ 203,277	\$ 63,223
Sandhill Cranes Population and Management in Minnesota M.L. 2014, Chp. 226, Sec. 2, Subd. 05h		\$ 250,000	\$ 249,679	\$ 321
Minnesota Native Bee Atlas M.L. 2015, Chap. 76, Sec. 2, Subd. 03g		\$ 790,000	\$ 474,562	\$ 315,438

## Monitoring Carnivores Statewide: A citizen-science trail-cam project

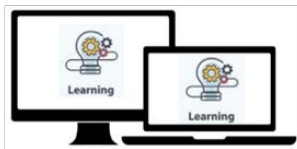
### Activity 1: DATA COLLECTION



*Develop protocols, design and implement pilot studies with different user groups for incorporating citizen scientists into the data collection process.*

### Activity 2: PROCESSING, ANALYZING, AND SUMMARIZING CAMERA TRAP DATA

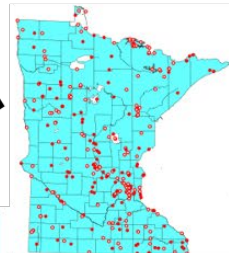
*Develop and deploy an online platform for uploading and storing images*



*Develop a machine learning algorithm for identifying species specific to Minnesota*



*Develop and deploy an online Zooniverse project for integrating machine learning and citizen science classifications*



*Develop statistical models and web-based applications for viewing/summarizing spatial-temporal trends and other data summaries.*

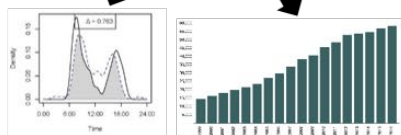


Image references from top to bottom, left to right:

<http://yourwildlife.org/2017/11/students-discover-update/>

<https://www.africanimpact.com/volunteer-projects/field-research-wildlife-internship-south-africa/>



## Environment and Natural Resources Trust Fund (ENRTF) 2020 Main Proposal Template

### Monitoring Carnivores Statewide: A citizen-science trail-cam project

#### Project Manager Qualifications:

**Dr. John Fieberg** is a McKnight Presidential Fellow and has been an Associate Professor in the Department of Fisheries, Wildlife, and Conservation Biology at the University of Minnesota since 2013. Prior to that, he worked for 10 years as a research statistician with the Minnesota Department of Natural Resources. He has authored or co-authored close to 90 scientific publications and has considerable expertise in the application of statistical and mathematical models to natural resource problems. Dr. Fieberg and his PhD student, Fabiola Iannarilli, have been collaborating with the Minnesota Department of Natural Resources to design and implement a camera-based monitoring program for large carnivores. He will be responsible for overall project coordination, and will supervise a postdoctoral researcher responsible for developing statistical models for estimating distribution/trends and associated data visualization tools.

**Dr. Rob Blair** is a Professor of Fisheries, Wildlife, and Conservation Biology at the University of Minnesota. Currently, he is the principal investigator of a National Science Foundation-funded project that is examining how citizen-science projects can be used as a springboard to authentic scientific inquiry by secondary students. He will hire and oversee a full-time Extension Coordinator who will be responsible for developing, planning, and implementing pilot studies to involve citizen scientists in the data collection process. Together, they will also develop specific recommendations for involving citizen scientists in long-term data collection and processing efforts.

**Dr. Lucy Fortson** is a Professor in the School of Physics and Astronomy at the University of Minnesota. She is the co-founder of the Zooniverse online citizen science platform enabling over 1.6 million volunteers to participate in over 120 research projects from astrophysics to zoology. Dr. Fortson holds two current National Science Foundation grants for development of Zooniverse infrastructure focusing on providing data science tools for research teams to fully exploit their data classified by the volunteers. Dr. Fortson collaborates nationally and internationally with leaders in citizen science and was recently instrumental in bringing the 2017 Citizen Science Association conference to Minnesota and chaired the local organizing committee. She will supervise a data scientist responsible for developing and training machine learning algorithms, and a web developer responsible for building the infrastructure (SQL) to ingest and store data and for creating web-based visualizations. Her team will also maintain the project's Zooniverse infrastructure. Zooniverse currently hosts the Snapshot Wisconsin and eMammal photo processing projects.

#### Organization Description

The University of Minnesota is Minnesota's flagship, land grant university. It has a strong tradition of excellence in education, research, and outreach.