**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**

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| **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. |  |  |  |

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| **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* |
| **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 (*[www.zooniverse.org/lab](http://www.zooniverse.org/lab)*) 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.