Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-052

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

Project Manager Information

Name: John Fieberg

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

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Project Basic Information

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

Funds Requested: $450,000

Proposed Project Completion: 2024-06-30

LCCMR Funding Category: Foundational Natural Resource Data and Information (A)

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.

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 important because they influence herbivore populations, provide recreational harvest and viewing opportunities, occasionally cause human-wildlife conflicts, and may serve as indicators of ecosystem health. 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 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 increasingly challenging to implement, particularly statewide. Based on a recent feasibility study with 100 cameras, 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. Cameras are also applicable to herbivore monitoring. Importantly, this approach also offers exciting opportunities to engage citizen scientists. We will develop necessary infrastructure that can be scaled up for use in a statewide monitoring program.

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.

Our project will leverage data from a MN DNR-UMN pilot study, citizen science expertise at the UMN and recent advances in machine learning to develop infrastructure that can be scaled up for use in a statewide monitoring program that engages citizens while providing better data for wildlife management. Specifically, we will:

1. develop a detailed plan, including protocols and procedures, for involving citizen scientists and educational groups to help with deploying cameras;
2. evaluate available machine learning platforms for processing photo images;
3. develop web-based applications to allow wildlife managers and the general public to visualize animal activity patterns and trends in species distributions and relative abundance.

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?

We will develop infrastructure that can be scaled up for use in a statewide monitoring program that engages citizens while providing better data for wildlife management. We will also develop data visualization tools 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 activity patterns and encounter/co-encounter rates of various carnivore species. These interactive tools will contribute to STEM education, improve wildlife conservation and management decision-making for a large number of species, and facilitate cost-effective collaborations between the MNDNR, UMN, and various stakeholder groups.

Activities and Milestones

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

Activity Budget: $173,819

Activity Description:
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.

Activity Milestones:

Description	Completion Date
Develop protocols to pilot studies with different user groups using remote cameras.	2023-06-30
Pilot plan with 3 or 4 initial user groups.	2023-09-30
Implement plan with an additional 3-4 user groups.	2024-05-31
Develop recommendations for involving citizen scientists in long-term data collection and processing efforts.	2024-06-30

Activity 2: Evaluate and compare available machine learning platforms for processing photo images.

Activity Budget: $112,892

Activity Description:
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 from a list of species known to occur in the area. In addition, the models output a confidence score associated with each classification. Coupling machine learning models with citizen science classification of photos can lead to further efficiencies (Willi et al. 2019). A variety of machine learning platforms and algorithms have been developed recently by Microsoft (Microsoft 2019), Google (https://www.wildlifeinsights.org/home), and other independent research teams (e.g., Norouzzadeh et al. 2018, Tabak et al. 2018, 2019). We will evaluate these different platforms and compare their ability to identify blank photos and to classify individual species using approximately 2.5 million photos collected as part of the pilot study in northern Minnesota between 2016 and 2018.

Activity Milestones:

Description	Completion Date
Compare machine learning algorithms and software for identifying carnivore and herbivore species in photos.	2022-06-30
Develop recommendations regarding the use of machine learning algorithms to identify carnivore and herbivore species.	2023-06-30

Activity 3: Disseminate results to the scientific community and to stakeholders.

Activity Budget: $163,289

Activity Description:

We will develop tools for communicating survey results to wildlife biologists, our citizen-scientists, and the general public. Specifically, we will develop R shiny web-based 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 activity patterns and encounter/co-encounter rates of various carnivore species. R is a free, open-source statistical software language with powerful data visualization tools, and shiny is an R package that makes it easy to develop interactive web apps that take advantage of R's capabilities (see e.g., https://shiny.rstudio.com/gallery/ for examples). Apps will be shared with wildlife agencies and managers to improve conservation and decision-making, with citizen scientists so that they can see their contributions to the project, with teachers and students in STEM courses to facilitate outreach, and with the general public to foster outdoor education and awareness.

Activity Milestones:

Description	Completion Date
Present findings at the 2023 annual meeting of The Wildlife Society	2023-09-30
Present at CitiSci Annual Conference of the Citizen Scientist Association	2024-03-31
Publication of manuscripts describing the monitoring design and summarizing spatial trends in relative abundance.	2024-06-30
Develop R shiny web-based applications for viewing/summarizing spatial-temporal trends and other data summaries.	2024-06-30

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Dr. Lucy Fortson	UMN - School of Physics and Astronomy	She will co-supervise the postdoc and work with her/him to evaluate available machine learning platforms for processing photo images.	Yes
Dr. Robert Blair	UMN - College of Food Ag and Natural Resources	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.	Yes

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?

We will develop and pilot the necessary infrastructure (camera distribution network, machine-learning algorithms, data visualization apps) for implementing a permanent statewide monitoring program for carnivore species using remotely triggered cameras, while also engaging citizens in data collection efforts. Once this infrastructure is in place, we will pursue additional funding to purchase between 5,000 and 10,000 cameras, allowing us to deploy between 2 and 4 cameras per township. This infrastructure will allow expansion of monitoring efforts to non-carnivore species. We plan to recruit additional user groups to help with deploying cameras, including hunters, schools, nature centers, and non-profits.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Minnesota Native Bee Atlas	M.L. 2015, Chp. 76, Sec. 2, Subd. 03g	$790,000

Project Manager and Organization Qualifications

Project Manager Name: John Fieberg

Job Title: Associate Professor

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

Dr. John Fieberg is a McKnight Presidential Fellow and an Associate Professor in the Department of Fisheries, Wildlife, and Conservation Biology at the University of Minnesota. Prior to joining the faculty in 2013, he worked for 10 years as a research statistician with the Minnesota Department of Natural Resources. He has authored or co-authored over 95 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.

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

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.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Dr. John Fieberg, Associate Professor		Will serve as the lead PI 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.			36.5%	0.12		$22,733
Dr. Rob Blair, Professor		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.			36.5%	0.12		$22,241
Dr. Lucy Fortson, Professor		Will co-supervise the postdoc and collaborate on the evaluation of machine learning/artificial intelligence methods for identifying species in camera trap photos.			36.5%	0.12		$34,254
Extension Coordinator		Will develop the plan and implement pilot studies for incorporating citizen scientists into the data collection process (e.g. camera trap set-up, camera trap maintenance, etc.)			31.8%	2		$136,878
Postdoctoral researcher		Will compare machine learning platforms and develop data visualization and analysis tools, including R Shiny Aps to share with teachers and students in STEM courses, wildlife agencies and managers, citizen scientists, and the general public.			25.4%	3		$213,180
							Sub Total	**$429,286**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								

	Equipment	100 remotely triggered cameras (@ $120 each)	For piloting the citizen science component of the project with different user groups.					$12,000
							Sub Total	**$12,000**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	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, mileage, meals)).	Necessary for piloting the citizen science component of the project.					$2,700
							Sub Total	**$2,700**
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	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.	X				$3,414
							Sub Total	**$3,414**
Printing and Publication								

	Publication	Publication costs associated with 2 peer-reviewed journal articles.	Publications are important for sharing findings with the broader scientific community.					$2,600
							Sub Total	**$2,600**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$450,000**

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	Domestic Travel- conference registrations, mileage, airfare, lodging	These presentations will allow us to present the findings of this project, receive feedback from other experts and learn about newest developments in the field.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
In-Kind	120 hrs of time on project implementation from John Erb, MN DNR	John Erb will provide input on tools sought be wildlife managers in the state of Minnesota and also communicate results of this work to stakeholders.	Secured	$4,700
In-Kind	2 million+ classified pictures from 100 trail cameras in northern MN. Dollar amount includes costs associated with pilot camera trap project that resulted in these photos.	We will use the data from this pilot study to develop machine learning algorithms that can be used to identify species in future surveys. The knowledge gained from the pilot camera trap study will also inform how we approach the design of the citizen science component of the project.	Secured	$141,000
			State Sub Total	**$145,700**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**$145,700**

Attachments

Required Attachments

Visual Component

File: 292f9ba6-0d7.pdf

Alternate Text for Visual Component

This project will include 3 activities. We will 1) develop and pilot a plan for involving citizen scientists in statewide monitoring efforts (a picture is included showing citizens deploying a trail camera); 2) evaluate and compare available machine learning platforms for processing photo images (a list of platforms is provided in a second picture); and 3) disseminate results to the scientific community and to stakeholders (several graphs are shown along with a person viewing results on a computer).

Optional Attachments

Support Letter or Other

Title	File
Support Letter from Minnesota Department of Natural Resources	189f813a-c90.pdf
Approval Letter from Sponsored Projects Association	76b6edc8-0f8.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

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

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

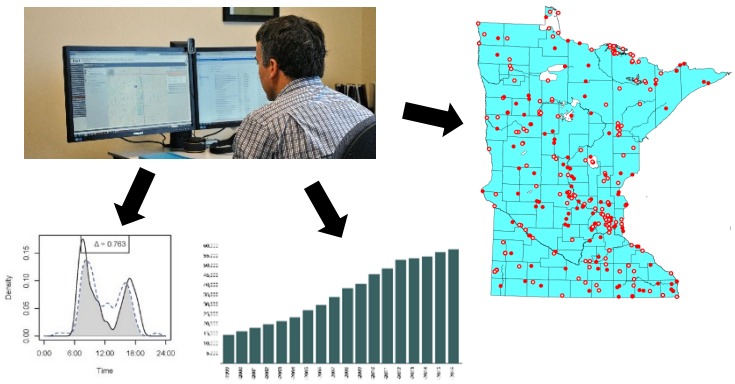
Activity 2: Evaluate and compare available machine learning platforms for processing photo images.

Camera trap systems using ML, *maybe* using ML, or *thinking about* ML

- Wildlife Insights
- Wildlife Protection Solutions
- Microsoft AI for Earth Camera Trap API
- WII CaTRAT
- Project Zamba
- EventFinder
- Where's the Bear?
- AnDeNet (Animal Detection Network)
- Trailcam Data
- BuckTracker
- SnapCat
- ClassifyMe
- Wildlife Observer Network ImageID
- Panthera IDS (Integrated Data System)
- MooseDar

https://agentmorris.github.io/camera-trap-ml-survey/

Activity 3: Disseminate results to the scientific community and to stakeholders.



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