# Environment and Natural Resources Trust Fund
# 2019 Request for Proposals (RFP)

**Project Title:** **ENRTF ID: 018-A**

Next Step in Helping Minnesota's Moose: Understand Brainworm Transmission to Find Solutions

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

**Sub-Category:**

**Total Project Budget: $** 434,186

**Proposed Project Time Period for the Funding Requested:** June 30, 2022 (3 yrs)

**Summary:**

A 2017 workshop determined we don't know enough about brainworm transmission to moose and what mitigation strategies are optimal. We've assembled a multidisciplinary team to tackle the highest research priorities.

**Name:** Tiffany Wolf

**Sponsoring Organization:** U of MN

**Title:** Assistant Professor

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**Location**

**Region:** Northeast

**County Name:** Cook, Lake, St. Louis

**City / Township:**

**Alternate Text for Visual:**

Research into causes of adult moose mortalities from Feb 2013 - Feb 2018 (n=60) demonstrate brainworm to be associated with 25-33% of mortalities.

| | | | |
|---|---|---|---|
| _____ Funding Priorities | _____ Multiple Benefits | _____ Outcomes | _____ Knowledge Base |
| _____ Extent of Impact | _____ Innovation | _____ Scientific/Tech Basis | _____ Urgency |
| _____ Capacity Readiness | _____ Leverage | _____ TOTAL | _____% |
| ____ If under $200,000, waive presentation? | | | |

**PROJECT TITLE:** Next step in helping Minnesota's moose: Understand brainworm transmission to find solutions

**I. PROJECT STATEMENT**

Effective restoration of Minnesota (MN) moose will require continued investment and research to build on the important discoveries that have determined causal factors of moose mortality. Brainworm, *Parelaphostrongylus tenuis,* infection was diagnosed in 25-33% of adult moose mortalities in northeast MN in previous LCCMR funded research. We propose innovative approaches to understand brainworm transmission between white tailed deer and moose to identify vulnerabilities in transmission to enable habitat management practices that benefit moose. We will use landscape analysis to:

- Characterize habitat overlap by deer and moose,
- Prioritize snail/slug species as possible transmission vectors based on ingestion by moose and deer
- Identify patterns of brainworm transmission by mapping the parasite's population genetics.

This project directly addresses the LCCMR priority to develop foundational natural resource data through data acquisition, research, and analysis.

A 2017 workshop of MNDNR, tribal, and university experts determined that we do not know enough about where and how moose are exposed to brainworm within their habitat and what mitigation strategies may be most effective. In response, we have assembled a multidisciplinary team of researchers to tackle the highest research priorities identified in the 2017 workshop. We are building robust datasets of collared moose and deer movements in northeastern MN and are adapting novel metagenomics techniques to noninvasively evaluate snail/slug ingestion by moose and brainworm transmission patterns in deer. Each data set will be linked to the landscape to identify vulnerabilities in brainworm transmission that may be exploited to protect moose.

Brainworm larvae are shed by white tailed deer, the definitive host, and mature in an intermediate host—one of several species of terrestrial snails and slugs—before becoming infectious to ungulates. When a moose ingests an infected snail while browsing, the larvae migrate to meningeal tissue. Rather than remaining there, as in deer, the larvae tunnel through brain and spinal tissue, resulting in neurological disease and often, death. **Few management options have been proposed for controlling this parasite other than controlling deer. We would like to change that.**

**II. PROJECT ACTIVITIES AND OUTCOMES**

**Activity 1:** *Mapping risks of brainworm transmission across moose range to identify options for mitigation.* There is risk of brainworm transmission to moose where deer and moose overlap, but our preliminary data show that deer and moose only overlap in portions of their range. We hypothesize that spatial analysis will reveal landscape and climatic features that are distinct where moose and deer overlap, providing the opportunity to manage for specific habitat types that prevent overlap. Accordingly, our team will 1) quantify spatial overlap by deer and moose across their distributions, 2) characterize landscape and climatic features associated with deer and moose abundance, and 3) create a map of brainworm transmission risk across moose range. We will use deer and moose movement data collected by the Grand Portage Department of Biology and Environment (where high densities of collared moose and deer are studied) to develop the model to predict overlap and transmission risk across the larger northeastern MN region.

**ENRTF BUDGET: $ 186,838**

| Outcome | Completion Date |
|---|---|
| *1. Quantify spatial overlap of deer and moose across different habitat types* | *Dec 2020* |
| *2. Identify landscape and climatic variables most important for deer-moose overlap* | *July 2021* |
| *3. Create a spatial risk map of brainworm transmission based on deer-moose overlap (1) and landscape features (2)* | *July 2021* |

**Activity 2:** *Identify slugs and snails consumed by deer and moose through fecal DNA analysis.* Terrestrial

snails and slugs (gastropods) are known intermediate hosts in brainworm transmission, but which species are most important in transmission remains unclear. To address this gap, we will collect 180 deer and moose pellet samples throughout the transmission season (spring-fall) and use genetic metabarcoding to assess gastropod consumption over habitat types in Grand Portage, where a high density of deer and moose are studied. We hypothesize that if moose and deer are exposed through gastropod consumption, then we can identify key species and habitats for transmission through fecal analysis for gastropod DNA. With this knowledge, management actions such as prescribed burning can be used to reduce gastropod populations in specific habitats.

**ENRTF BUDGET: $127,830**

| Outcome | Completion Date |
|---|---|
| *1. Identify and quantify snail/slug species consumption by deer and moose over space and time through fecal DNA analysis of 180 pellet samples* | *July 2021* |
| *2. Identify which snail/slug species are primary diet components in each habitat type* | *July 2022* |

**Activity 3:** *Identify patterns of brainworm transmission across the landscape by mapping the parasite's population genetics.* We will genotype the larvae transmitted by deer from 150 fecal samples collected across habitats in Grand Portage, where a high density of deer are studied. We hypothesize that the genetic population of brainworm is sufficiently heterogeneous to characterize transmission across the landscape. Ultimately, by mapping the parasite's population genetics, we can describe gene flow of the parasite and identify natural landscape barriers to transmission that might be exploited in future mitigation efforts.

**ENRTF BUDGET: $119,518**

| Outcome | Completion Date |
|---|---|
| *1. Genetic analysis of brainworm larvae from 150 deer pellet samples in northeastern MN* | *July 2021* |
| *2. Identify where natural landscape barriers to transmission might exist through spatial autocorrelation analysis of parasite genetics* | *July 2022* |

**III. PROJECT PARTNERS:**

**Partners receiving ENRTF funding**

| Name | Title | Affiliation | Role |
|---|---|---|---|
| Veterinary Population Medicine; Fisheries, Wildlife and Conservation Biology; UMN Genomics Center | | University of Minnesota | Lead project partner |
| Grand Portage Dept. of Biology and Environment – Seth Moore | Director | Grand Portage Band of Lake Superior Chippewa | Co-leading project partner |
| Luis Escobar | Assistant Professor | Virginia Tech | Collaborating partner |

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

The proposed activities will help fill high priority research gaps in understanding the ecology of brainworm transmission to moose with a primary intent to inform management. The goal of this research is the identification of key areas in transmission that may be effectively targeted by resource management to mitigate moose exposure. We expect additional research will arise from this endeavor, which will further hone management decisions. In particular, we will use the data derived from this project in future proposals to NSF programs (NSF-EEID, https://nsf.gov/funding/pgm_summ.jsp?pims_id=5269 and NSF-NHCS, https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13681).

**V. TIME LINE REQUIREMENTS:**

This will be a 3 year project. Year 1: Data collection, processing and analysis. Year 2: Data collection, spatial model building and statistical analyses. Year 3: Final analyses and interpretation of findings and dissemination.

## 2019 Proposal Budget Spreadsheet

**Project Title:** Next step in helping Minnesota's moose: Understand brainworm transmission to find solutions

**IV. TOTAL ENRTF REQUEST BUDGET** *$434,186 for 3* **years**

| **BUDGET ITEM** (See "Guidance on Allowable Expenses") | **AMOUNT** |
|---|---|
| **Personnel:** | **$ 346,148** |
| UMN Assistant Professor: Tiffany Wolf* - 10% FTE x 3 yrs (salary $33,067 + 33.5% fringe); James Forester (9-month appointment) - 2% FTE x 3yrs (salary $6,960 + 33.5% fringe)<br>*Wolf holds a 12-month contract appointment which stipulates recruitment of 25% of salary and fringe for research effort from externally funded contracts or grants.<br><br>Wolf is the overall project manager, organizing all personnel across activities, as well as directly supervising and mentoring project post-doctoral researchers, graduate research assistant, and VPH resident. Forrester is Co-Investigator and co-lead on Activity 1 research; he will mentor the post-doctoral researcher hired for Activity 1 research. | $ 53,436 |
| Post-doctoral Researcher: TBD - 100% FTE x 2 yr (salary $95,902 + 21.4% fringe); Nick Fountain-Jones - 10% FTE x 2 yrs ( salary $9,782 + 21.4% fringe)<br><br>A full-time post-doctoral researcher in spatial epidemiology will be hired in Year 1 to perform all analyses of Activity 1 under the mentorship of Forrester and Escobar. Fountain-Jones is a community ecologist and post-doctoral researcher who mentor the graduate research assistant and contribtue to analyses of Activity 2 and 3. | $ 128,300 |
| Graduate Research Associate: Tyler Garwood - 50% FTE x 3yrs (salary $79,570 + 72.96%)<br><br>Garwood will participate in all research activities associated with Activities 2 and 3 as part of his thesis research. | $ 136,715 |
| Veterinary Public Health Resident: TBD - 10% FTE x 3yrs (salary $13,466 + 87.86% fringe)<br><br>This position will assist Wolf in project management, data management and outreach. | $ 25,297 |
| Veterinary student labor: TBD - $12/hr x 200 hr | $ 2,400 |
| **Professional/Technical/Service Contracts:** | **$ 57,914** |
| Grand Portage Contract: Biologist: 25% FTE x 2yr (salary $16,800 + 38% fringe); Biology technician: 12% x 2 yrs (salary $8,064 + 38% fringe).<br>GP Biology staff will assist in all aspects of field data collection and management across all project Activities. | $ 34,312 |
| Virgnia Tech Contract: Luis Escobar, Assistant Professor (9-month appointment): 2% FTE x 3 yrs (salary $7,241 + 7.75% fringe). Escobar is a biogreographer with specialized expertise in spatial and ecological niche modeling. He joined this research team 2 years ago when he held a post-doctoral position at University of Minnesota and will continue as Co-Investigator on this project in his new faculty position at Virginia Tech, given his expertise and input in the development of the project goals and design. He will have a leading role in Activity 1. | $ 7,802 |
| UMGC metagenomics and molecular services for Activities 2 and 3 (Metabarcoding (180 samples x$35/sample + $1969) = $8,269; RadSeq (150 = $6,701); qPCR ($3.06 x 90 samples x 3 replicates) = $830) | $ 15,800 |
| **Equipment/Tools/Supplies:** sampling supplies, preservation, and transportation, dissecting microscope, computer software, micropipettes, disposables) | **$ 6,000** |
| **Acquisition (Fee Title or Permanent Easements):** N/A | $ - |
| **Travel:** 8 twelve-day trips to Grand Portage from St. Paul by grad RA to collect field data for Activities 2 and 3 ($15,824), 1 6-week trip to Blacksburg, VA by post-doctoral RA to work under direction of Escobar in year 1 for Activity 1 ($6,140 to cover round trip travel and lodging during project work), 1 three-day trip/year by Co-I (Escobar) from Blacksburg, VA to St. Paul for annual in-person project meetings ($2160) | **$ 24,124** |
| **Additional Budget Items:** N/A | $ - |
| **TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =** | **$ 434,186** |

**V. OTHER FUNDS** *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

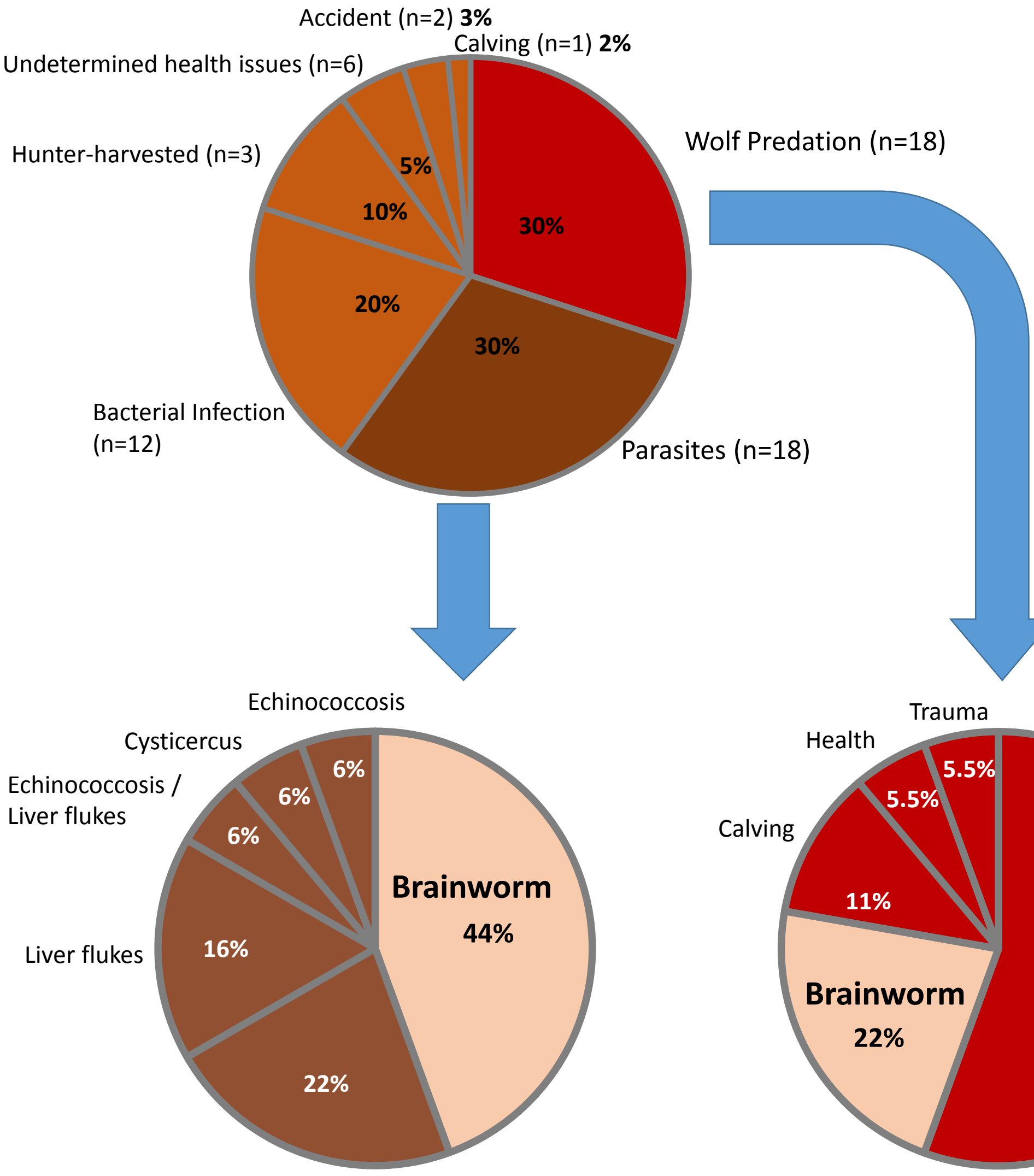
| **SOURCE OF FUNDS** | **AMOUNT** | **Status** |
|---|---|---|
| **Other Non-State $ To Be Applied To Project During Project Period:**<br>College of Veterinary Medicine's Population Systems Signature Program Grant, Project Title: Untangling Parelaphostrongylus tenuis transmission in a declining moose population, Project Manager: Tiffany Wolf | $64,098 | *In progress* |
| **Other State $ To Be Applied To Project During Project Period:** N/A | $ - | |
| **In-kind Services To Be Applied To Project During Project Period:**<br>In Kind from University of Minnesota (Personnel time (including additional 12% FTE of Tiffany Wolf as Primary Investigator and 1% FTE of Meggan Craft as Co-Investigator), veterinary supplies, equipment, and travel costs): $54,505<br><br>In Kind Services from Grand Portage Band of Chippewa (Grand Portage NRM will provide in-kind support for the three-year project in a total amount of $259,210.00 which includes salary from personnel time (including Seth Moore at 5% FTE) with corresponding 13.06% fringe, in-kind support of collaring moose and deer, equipment (GPS, computer, printer, digital camera). Not included in calculations are vehicle use, fuel costs, travel costs, and miscellaneous supplies and equipment required to conduct operations over the two-year period.): $259,210;<br><br>In Kind from Virginia Tech (Computer software for Activity 1 spatial analyses): $20,000 | $ 303,715 | *Committed* |
| **Past and Current ENRTF Appropriation:**<br>ENRTF 2017, Project Title: Evaluation of anthropogenic micro pollutants in subsistence species used by the Grand Portage Band of Lake Superior Chippewa, Project manager: Seth Moore; MITPPC 2018, Project Title: Understanding the benefits and limitations of using goats for invasive plant control, Project manager: Tiffany Wolf | $ 845,533 | *In progress* |
| **Other Funding History:** N/A | $ - | |

Next step in helping Minnesota's moose:

**Understand brainworm transmission to find solutions**

## Causes of Adult Moose Mortalities

Feb 2013 - Feb 2018 (*n=60)*




Data provided by Michelle Carstensen, Wildlife Health Program, Minnesota Department of Natural Resources

## PROJECT MANAGER QUALIFICATIONS AND ORGANIZATION DESCRIPTION

**Tiffany Wolf, Project Manager,** is an Assistant Professor in the Department of Veterinary Population Medicine at the University of Minnesota College of Veterinary Medicine. She is also an Associate Fellow of the UMN Institute on the Environment. She earned a Ph.D. in Comparative and Molecular Biosciences (University of Minnesota) and a D.V.M. (Louisiana State University). With a background in wildlife epidemiology and ecosystem health, her research focuses on understanding diseases of wildlife populations at the interface of humans, animals, and the environment. She is particularly interested in the dynamics of infectious diseases in multi-host pathogen systems and optimizing epidemiological, ecological, and molecular approaches to assess changes in health and mitigate disease impacts on populations. Current projects include understanding the role of health in a declining moose population, *Parelaphostrongylus tenuis* and *Mycobacterium tuberculosis* Complex transmission in multihost systems, human-primate disease transmission, wildlife disease surveillance, and contaminants of emerging concern in aquatic ecosystems. Dr. Wolf recently organized a workshop of state, tribal, and university natural resource managers and researchers to assess the state of knowledge of *P. tenuis* transmission and prioritize research gaps.

The collective experience and organizational support of the project team members will ensure successful completion of the proposed project goals.

## ORGANIZATIONAL DESCRIPTION

The diverse and multidisciplinary team assembled to identify vulnerabilities in the *P. tenuis* transmission system in an effort to mitigate risks to moose is comprised of two colleges at the University of Minnesota, the UMN Genomics Center, the Grand Portage Band of Lake Superior Chippewa, and Virginia Tech. Drs. Tiffany Wolf and Meggan Craft are faculty members and Nicholas Fountain-Jones a post-doctoral researcher of the Department of Veterinary Population Medicine in the College of Veterinary Medicine. The Department of VPM merges clinical and population research with veterinary diagnostic medicine to create opportunities to address today's most pressing issues in animal health and sustainability. Dr. James Forester is a faculty member of the Department of Fisheries, Wildlife and Conservation Biology in the College of Food, Agriculture, and Natural Resources Sciences. The Department of FWCB studies the biology and ecology of some of the most interesting and diverse organisms and ecosystems in the world. Their goal is to respond to societal needs for information and education pertaining to the conservation of our natural resources and to ensure excellent teaching, research, and outreach programs. Dr. Daryl Gohl is the R&D Lead of the University of Minnesota Genomics Center. The UMGC provides genomic technologies and services to researchers and clinicians at the University of Minnesota, and to external academic and industry scientists throughout the United States and internationally, advancing the use of advanced genomics in research. Dr. Seth Moore is Director of the Grand Portage Department of Biology and Environment, which has been studying causes of moose decline and habitat use on the Grand Portage Reservation since 2010 and deer habitat use since 2015. The Department of Biology and Environment is responsible for protecting ecological health by restoring ecosystems and addressing threats to natural resources. Lastly, Dr. Luis Escobar is faculty in the Department of Fish and Wildlife Conservation at Virginia Tech, where he uses biogeographic approaches to understand the ecology of biodiversity (including parasites and invasive species) under diverse land use and climate change conditions.