



# Environment and Natural Resources Trust Fund (ENRTF) M.L. 2019 ENRTF Work Plan (Main Document)

---

**Today's Date:** 3/19/2019

**Date of Next Status Update Report:** 3/1/2020

**Date of Work Plan Approval:**

**Project Completion Date:** June 30, 2022

**Does this submission include an amendment request?** no

---

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

**Project Manager:** Tiffany Wolf

**Organization:** University of Minnesota

**College/Department/Division:** Veterinary Population Medicine Department

**Mailing Address:** 495 Animal Science/Veterinary Medicine, 1988 Fitch Ave.

**City/State/Zip Code:** St. Paul, MN 55108

**Telephone Number:** 612-625-0492

**Email Address:** wolfx305@umn.edu

**Web Address:**

---

**Location:** Northeastern Minnesota, specifically Cook, Lake and St. Louis counties.

---

**Total Project Budget:** \$400,000

**Amount Spent:** \$0

**Balance:** \$400,000

---

**Legal Citation:** M.L. 2019, Chp. xx, Sec. xx, Subd. xx

**Appropriation Language:**

**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. OVERALL PROJECT STATUS UPDATES:**

**First Update March 1, 2020**

**Second Update September 1, 2021**

**Third Update March 1, 2021**

**Fourth Update September 1, 2022**

**Fifth Update March 1, 2022**

**Final Report between project end (June 30) and August 15, 2022**

**III. 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: \$ 155,267**

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

**First Update March 1, 2020**

**Second Update September 1, 2021**

**Third Update March 1, 2021**

**Fourth Update September 1, 2022**

**Fifth Update March 1, 2022**

**Final Report between project end (June 30) and August 15, 2022**

**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: \$123,566**

<b>Outcome</b>	<b>Completion Date</b>
<i>1. Identify and characterize the frequency of snail/slug species consumption by deer and moose overtime through fecal DNA analysis of pellet samples</i>	<i>July 2021</i>
<i>2. Identify which snail/slug species are primary diet components across seasons</i>	<i>July 2022</i>

**First Update March 1, 2020**

**Second Update September 1, 2021**

**Third Update March 1, 2021**

**Fourth Update September 1, 2022**

**Fifth Update March 1, 2022**

**Final Report between project end (June 30) and August 15, 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: \$121,167**

<b>Outcome</b>	<b>Completion Date</b>
<i>1. Genetic analysis of brainworm larvae from deer pellet samples in northeastern MN for a goal of 150 deer samples</i>	<i>July 2021</i>
<i>2. Identify where natural landscape barriers to transmission might exist through spatial autocorrelation analysis of parasite genetics</i>	<i>July 2022</i>

**First Update March 1, 2020**

**Second Update September 1, 2021**

**Third Update March 1, 2021**

**Fourth Update September 1, 2022**

**Fifth Update March 1, 2022**

**Final Report between project end (June 30) and August 15, 2022**

**IV. DISSEMINATION:**

**Description:** The core intent of this project is to provide science-based information for assessing and managing risks associated with brainworm transmission between deer and moose. Our goal is also to communicate our findings in both policy and scientific arenas. In order to reach a broad range of stakeholders, we anticipate the following public and scientific communications.

1) Tribal and regional audiences:

- local public radio program will provide updates on study results
- results and recommendations will be made to the Grand Portage Tribal Council, where a large portion of the study will be conducted
- we intend to engage Minnesota’s media community to deliver updates and results of this study through the popular press

2) Minnesota Department of Natural Resources:

- this project stems partly from the findings of the LCCMR-funded moose mortality study, thus we will regularly share findings from this study to colleagues in the Wildlife Health Program.

3) Scientific Audience

- we intend the submission of at least three scientific articles submitted to peer reviewed journals. These publications will communicate scientific results, as well as sampling methods, diagnostic methodologies and system-based analyses.

- we will submit scientific abstracts to the International and North American Moose meetings, among other scientific meetings, to share findings through oral presentations.

4) Education/Extension programs

- this project will be used as a platform to deliver STEM education through experiential learning to tribal students in Grand Portage.

- Drs. Wolf and Forester have appointments in the UMN Colleges of Veterinary Medicine (ecosystem health) and Food, Agricultural, and Natural Resource Sciences. They teach courses to undergraduate, graduate and professional students, as well as in the Grand Challenge Curriculum. These findings will be incorporated into already developed case studies in all of the above.

- a website is currently under construction to showcase and disseminate information about ongoing ecosystem health research projects conducted by Dr. Wolf and other faculty in the College of Veterinary Medicine. This project is planned for inclusion in the earliest version of the new website (yet to be officially named and launched).

The Minnesota Environment and Natural Resources Trust Fund (ENRTF) will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications per the [ENRTF Acknowledgement Guidelines](#).

**First Update March 1, 2020**

**Second Update September 1, 2021**

**Third Update March 1, 2021**

**Fourth Update September 1, 2022**

**Fifth Update March 1, 2022**

**Final Report between project end (June 30) and August 15, 2022**

**V. ADDITIONAL BUDGET INFORMATION:**

**A. Personnel and Capital Expenditures**

**Explanation of Capital Expenditures Greater Than \$5,000:** N/A

**Explanation of Use of Classified Staff:** N/A

**Total Number of Full-time Equivalent (FTE) Directly Funded with this ENRTF Appropriation:**

Enter Total Estimated Personnel Hours for entire duration of project: 8,413.6	Divide total personnel hours by 2,080 hours in 1 yr = TOTAL FTE: 4.05
---	---

**Total Number of Full-time Equivalent (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:**

Enter Total Estimated Contract Personnel Hours for entire duration of project: 1,632.8	Divide total contract hours by 2,080 hours in 1 yr = TOTAL FTE: 0.79
--	--

**VI. PROJECT PARTNERS:**

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

**A. Partners outside of project manager’s organization receiving ENRTF funding**

Biologist (TBD), Grand Portage Department of Biology and Environment, Grand Portage Band of Lake Superior Chippewa, data acquisition and management in Grand Portage

Biological technician (TBD), Grand Portage Department of Biology and Environment, Grand Portage Band of Lake Superior Chippewa, field logistics and data acquisition

Luis Escobar, PhD, Assistant Professor, Department of Fish and Wildlife Conservation, Virginia Tech, Co-Lead on Activity 1.

**B. Partners outside of project manager’s organization NOT receiving ENRTF funding**

Seth Moore, PhD, Director of Biology and Environment, Grand Portage Band of Chippewa, Project Lead for Grand Portage

**VII. 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](https://nsf.gov/funding/pgm_summ.jsp?pims_id=5269) and NSF-NHCS, [https://www.nsf.gov/funding/pgm\\_summ.jsp?pims\\_id=13681](https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13681)).

**VIII. REPORTING REQUIREMENTS:**

- Project status update reports will be submitted March 1 and September 1 each year of the project
- A final report and associated products will be submitted between June 30 and August 15, 2022

**IX. SEE ADDITIONAL WORK PLAN COMPONENTS:**

- A. Budget Spreadsheet**
- B. Visual Component or Map**
- C. Parcel List Spreadsheet**
- D. Acquisition, Easements, and Restoration Requirements**
- E. Research Addendum**

**Attachment A:**  
**Environment and Natural Resources Trust Fund**  
**M.L. 2019 Budget Spreadsheet**



**Legal Citation:**

**Project Manager: Tiffany Wolf**

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

**Organization: University of Minnesota**

**Project Budget: \$400,000**

**Project Length and Completion Date:** 3 years, July 2022

**Today's Date: 3/17/19**

<b>ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET</b>	<b>Budget</b>	<b>Amount Spent</b>	<b>Balance</b>
<b>BUDGET ITEM</b>			
<b>Personnel (Wages and Benefits)</b>	\$ -	\$ -	\$ -
UMN Assistant Professor: Tiffany Wolf* - \$42,987 (9.5% salary, 34.2% fringe) 9.5% FTE x 3 yrs; James Forrester (9-month appointment) - \$9,217 (2% salary, 34.2% fringe) 2% FTE x 3yrs *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.  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. Forrester is Co-Investigator and co-lead on Activity 1 research; he will mentor the post-doctoral researcher hired for Activity 1 research.	\$ 52,204	\$ -	\$ 52,204
Graduate Research Associate: Tyler Garwood - \$140,220 (50% salary + 77.4% benefits) 50% FTE x 3yrs  Garwood will participate in all research activities associated with Activities 2 and 3 as part of his thesis research.	\$ 140,220	\$ -	\$ 140,220
Post-doctoral Researcher: TBD - \$120,319 (100% salary + 23.0% fringe) 100% FTE x 2 yr; Nick Fountain-Jones - \$12,311 (10% salary + 23.0% fringe) 10% FTE x 2 yrs  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 contribute to analyses of Activity 2 and 3.	\$ 132,630	\$ -	\$ 132,630
<b>Professional/Technical/Service Contracts</b>		\$ -	\$ -
Grand Portage Contract: Biologist: \$23,184 (25% salary + 38% fringe) 25% FTE x 2yr ; Biology technician: \$11,128 (salary 12% + 38% benefits) 12% FTE x 2 yrs. GP Biology staff will assist in all aspects of field data collection and management across all project Activities.	\$ 34,312	\$ -	\$ 34,312
Virginia Tech Contract: Luis Escobar, Assistant Professor (9-month appointment): \$7,241 (2% salary + 7.75% fringe) 2% FTE x 3 yrs. Escobar is a biogeographer 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	\$ -	\$ 7,802
UMGC metagenomics and molecular services for Activities 2 and 3 (Metabarcoding (180 samples x\$35/sample + \$1969) = \$8,269; RadSeq (150 = \$6,702); qPCR (\$3.07 x 90 samples x 3 replicates) = \$829)	\$ 15,800	\$ -	\$ 15,800
<b>Equipment/Tools/Supplies</b>			
Disposable supplies: sample collection and preservation, laboratory processing	\$ 4,500	\$ -	\$ 4,500
Computer software for data analysis	\$ 1,000	\$ -	\$ 1,000
<b>Travel expenses in Minnesota</b>			
2 twelve-week trips to Grand Portage (GP) from St. Paul by grad RA to collect field data for Activities 2 and 3 (\$7,932), 4 1-week trips to GP by various project personnel to accomplish project activities, 1 three-day trip/year by Co-Investigator (Escobar) from Blacksburg, VA to St. Paul for annual in-person project meetings and activities (\$2,500). Round trip travel to GP includes mileage (\$350/round trip), lodging for student (\$64/week) or faculty (\$60/night), and a weekly meal budget (\$80/week). Travel for Co-I Escobar includes airfare (\$500/trip) and lodging in St. Paul (\$120/night).	\$ 10,432	\$ -	\$ 10,432
<b>Other</b>			

Out of state travel: This funding supports travel to VA and/or lodging in VA for the 4-week duration of mentorship, while the RA will be responsible for maintaining their permanent residence in MN during this temporary time away. 1 4-week trip to Blacksburg, VA by post-doctoral RA to work under direction of Escobar in year 1 for Activity 1 (\$1,100 to cover either round trip travel and/or lodging during project work - additional funds will be obtained from other funding sources). Having the RA work directly under the mentorship and unique expertise of Co-Investigator Escobar over several weeks is the most efficient approach to accomplishing objectives under Activity 1; Or travel to 1-2 scientific conferences to present project findings (e.g. International or North American Moose Conference, Wildlife Disease Association, Native American Fish and Wildlife conference): airfare (\$500) and conference registration or lodging (\$322). Note: most of these conferences meet outside of MN, but presentation of findings at these large conferences will facilitate broad dissemination of findings, and position MN as a leader in moose and brainworm research.	\$ 1,100	\$ -	\$ 1,100
<b>COLUMN TOTAL</b>	\$ 400,000	\$ -	\$ 400,000

<b>OTHER FUNDS CONTRIBUTED TO THE PROJECT</b>	<b>Status (secured or pending)</b>	<b>Budget</b>	<b>Spent</b>	<b>Balance</b>
<b>Non-State:</b> 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	secured	\$ 64,098	\$ 23,804	\$ 40,294
<b>Non-State:</b> College of Veterinary Medicine's contract with Grand Portage for moose research, covers an additional 12% personnel for Tiffany Wolf on project, supplies, and travel between St. Paul and Grand Portage.	pending	\$ 25,000	\$ -	
<b>In kind:</b> In Kind from Virginia Tech (covers approximately 5% additional personnel time for Luis Escobar's contribution to the project)	secured	\$ 20,000	\$ 20,000	\$ -
<b>In kind:</b> 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;	secured	\$ 259,210	\$ -	\$ 259,210
<b>PAST AND CURRENT ENRTF APPROPRIATIONS</b>	<b>Amount legally obligated but not yet spent</b>	<b>Budget</b>	<b>Spent</b>	<b>Balance</b>
<b>Current appropriation:</b> M.L. 2017, Chp. 96, Sec. 2, Subd. 04g, Project Title: Evaluation of anthropogenic micro pollutants in subsistence species used by the Grand Portage Band of Lake Superior Chippewa, Project manager: Seth Moore	\$ 208,306	\$ 400,000	\$ 191,694	\$ 208,306
<b>Current appropriation:</b> ML 2016, Ch 186, Sec 2, Subd 6a, Project Title: Understanding the benefits and limitations of using goats for invasive plant control, Project manager: Tiffany Wolf	\$ 410,442	\$ 445,533	\$ 35,091	\$ 410,442
<b>Past appropriations:</b>		\$ -	\$ -	\$ -



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

Proposal: 018-A

Project Manager: Tiffany Wolf



**Causes of Adult Moose Mortalities**

Feb 2013 - Feb 2018 (n=60)



