Penn
University of Pennsylvania

Office of Research Services

February 26, 2025

RE: Application Entitled **"Use of Conservation K9s for Aquatic Invasive Species Detection"**
PI: Dr. Lisa Murphy

To Whom It May Concern:

We are pleased to have the opportunity to submit the application entitled "Use of Conservation K9s for Aquatic Invasive Species Detection" under the direction of Dr. Lisa Murphy. We are requesting award dates of 10/01/2025 -09/30/2026, with a total requested amount of $18,882.00.

If you have any questions or require additional information, please feel free to contact me at telephone at 215-898-8898 or via email at giaboe@upenn.edu.

Gia Boersema

Thank You!
Gia Boersema, CRA, M.S
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Use of Conservation K9s for Aquatic Invasive Species Detection

Project Summary

Our project will assess the feasibility of using working dogs for early detection of invasive New Zealand mud snails (NZMS). NZMS are a small invasive species that impact the ecological structure of waterways by displacing native species and decreasing fish health due to their indigestibility. Early detection of NZMS within hatcheries can reduce the risk of NZMS introduction to waterways from state fish hatcheries, thereby preserving local fish population health.

We propose to achieve this by teaching a working conservation detection dog to indicate the presence of NZMS in fish hatchery sediment and bio boxes. Our methodology includes a multi-stage training plan wherein the dog learns to associate the scent of NZMS with a reward in increasingly more realistic search scenarios. At each stage, the dog will be assessed for detection precision and sensitivity. We anticipate that the dog's excellent sense of smell and high-speed search skills will allow for more efficient hatchery inspections and earlier detection of NZMS invasions.

Project Narrative

Project Description

Project Objectives

- To assess the feasibility of working dogs as an innovative early detection tool for control of aquatic invasive species (AIS)
- To associate the appeal of dogs with the promotion of AIS issues in outreach and education materials using our existing reporting channels
- To create repeatable protocols for use in future AIS conservation dog projects by maintaining video and training logs

New Zealand mud snails (NZMS) are an aquatic invasive species that are typically less than 6 mm long, making them difficult to visually locate, especially when present in lower densities (Geist et al., 2022; Hartzell & Macelko, 2022). Fish hatcheries are particularly vulnerable to colonization by invasive species due to their ideal temperatures and nutrient availability, and they have the potential to spread invasives to outside waterways (Stockton, 2011). Staff at fish hatcheries find and control these tiny snails in their systems by inspecting bio boxes and sediment found in the headboxes of raceways, among other methods (Pennsylvania Fish and Boat Commission, 2025; B. Niewinski, personal communication, February 25 2025). This is time-consuming but critical to prevent the accidental introduction of NZMS to Pennsylvania waterways, where they can cause nutritional decline in wild fish populations, disrupt the food chain, and displace native species (Hall et al., 2001, 2006; Krist & Charles, 2012; Larson & Black, 2015; and Vinson & Baker, 2008).

The Wildlife Futures Program (WFP) is a partnership between the University of Pennsylvania's School of Veterinary Medicine and the Pennsylvania Game Commission aimed at strengthening the health and resilience of Pennsylvania wildlife. Our Conservation K9 Team was developed to aid in statewide wildlife health and conservation efforts through the use of trained detection dogs. In a literature review of detection dog performance compared to other detection methods, dogs were found to be more effective in almost 90% of studies (Grimm-Seyfarth et al., 2021). Because of this, private, state, and federal agencies (e.g. New Jersey Conservation Foundation, USDA) are utilizing dogs in their regular surveillance efforts. Dogs are especially efficient at locating small or cryptic species that may be difficult for human searchers to locate or perceive (Karp, 2020). Conservation dogs have specifically detected invasive mollusks (such as Zebra and Quagga mussels) and participated in community outreach to educate the public on aquatic invasive species (DeShon et al., 2015, 2016; Richards, 2018, pp.119-166).

For these reasons, we propose that detection dogs could complement current NZMS surveillance practices in the mid-Atlantic region. We will train a WFP canine-handler team to detect NZMS presence in fish hatchery sediment and bio boxes as a proof of concept to assist with NZMS surveillance at fish hatcheries in central Pennsylvania.

Methods

Stage One: Introducing NZMS Odor

- Acquire Scientific Collectors Permit
- Collect NZMS from State Fish Hatcheries in Centre or Clinton Counties
- Develop protocol for dog decontamination to use throughout all project stages
- Set up NZMS in housing tanks for training
- Teach working dog to indicate presence of NZMS

Stage Two: Detection in Sediment

- Collect sediment from hatchery where NZMS is absent as a control
- Collect sediment from hatchery where NZMS is present
- Set up separate tanks for holding different sediments
- Teach working dog to indicate presence of NZMS in sediment
- Begin familiarizing working dog with State Fish Hatchery environment

Stage Three: Detection on Bio Boxes

- Visit State Fish Hatchery to evaluate bio boxes for a mockup
- Construct a mock bio box for use in training
- Teach working dog to indicate presence of NZMS on bio box
- Continue familiarizing working dog with State Fish Hatchery environment

Stage Four: Detection at Fish Hatchery

- Perform searches on sediment and bio boxes from raceways with known NZMS status
- Perform searches on sediment and bio boxes from raceways with unknown NZMS status

Throughout All Stages: Information Sharing

- Document project progression and training details in each stage through video and written training logs
- Write up periodic progress reports for submission to MAPAIS
- Develop a repeatable dog training protocol and NZMS surveillance procedure that can be used by future AIS detection dog teams
- Share news about the project per the Outreach Plan

Results Expected

- Achieve 75%+ detection accuracy as measured in training
- Dog can detect NZMS in sediment and bio boxes at fish hatcheries
- Dog-handler team will assist with monthly hatchery inspections
- Produce written protocol of dog training methods
- Complete protocol for dog decontamination to prevent transport of AIS
- Submit two progress reports to MAPAIS during project timeframe
- Present project results at MAPAIS meeting and at least one other regional conference

Outreach Plan

Our training protocols and methods will be made available for anyone interested in future AIS projects. Project results will be shared in the following ways:

By attending and presenting at conferences and other scientific gatherings, which could include:

- Northeast Association of Fish and Wildlife Agencies (NEAFWA) conference
- MAPAIS biannual meeting
- PA Invasive Species Council meetings
- North American Invasive Species Management Association (NAISMA) webinars

By using the Wildlife Futures Program's various reporting methods, which could include:

- Annual report directed to influential stakeholders like UPenn leadership, legislators, funding and research partners, etc.
- Monthly, quarterly, and annual reports distributed to the Pennsylvania Game Commission or other vested stakeholders (such as the Pennsylvania Fish and Boat Commission)
- Quarterly newsletter to the public
- Penn Vet's social media, including Facebook, Instagram, and YouTube
- Outreach events like PA Farm Show, Great American Outdoor Show, Working Animal Appreciation Day, etc.

Having a dog associated with sometimes-unglamorous conservation tasks immediately draws the public's interest and attracts a wide audience of people from outside of fish and wildlife fields. This gives us a unique opportunity, in any report we publish, to provide education on how the public can avoid becoming a vector for NZMS or other aquatic invasives. Additionally, a conservation detection dog seen out and about can help start productive conversations about AIS.

We have seen evidence of this throughout our work with the Wildlife Futures Program, where we have had multiple social media and news articles published about our program, chatted with state representatives, and attended outreach events where our dogs provided demonstrations that impressed onlookers and prompted curious questions (Kratz, 2023; Pritchett & Montag, 2023; University of Pennsylvania School of Veterinary Medicine, 2023, 2024).

Project Timeline

October-December

- Acquire collections permit
- Collect snails once permit is received
- Develop decontamination protocol

January-February

- Methods Stage 1
- MAPAIS Progress Report 1
- Disseminate project information via WFP reporting channels

March-May

- Methods Stage 2
- Methods Stage 3
- MAPAIS Progress Report 2
- Disseminate project information via WFP reporting channels

June-September

- Methods Stage 4
- Disseminate project information via WFP reporting channels

September

- Complete written protocol
- Create presentation for MAPAIS and conference
- Disseminate project information via WFP reporting channels

Budget Table

Personnel					
Name	Role	Effort	Salary	Benefits	Total
Lisa Murphy	PI	0.12 Calendar Months	$1,660	$523	$2,182
Brenna Aizen	Supervisor	0.12 Calendar Months	$755	$238	$993
Robyn Strong	Dog Handler	1.0 Calendar Month	$4,642	$1,462	$6,104
Travel					$840
Supplies					
Dog Training Supplies					$700
Dog Decontamination Supplies					$300
Home Aquarium					$500
Total Direct Costs					$11,620
Indirect Costs (62.5%)					$7,262
Total Costs					$18,882

Budget Justification

Personnel

Lisa Murphy, VMD, DABT (PI, 0.12 Calendar Months Effort). Lisa is a Co-Director of the University of Pennsylvania Wildlife Futures Program and will provide guidance and oversight of this project.

Brenna Aizen (Supervisor, 0.12 Calendar Months Effort). Brenna is the Supervisor for the University of Pennsylvania Wildlife Futures Program Conservation K9 Team. Brenna will provide guidance and oversight of this project.

Robyn Strong (Dog Handler, 1.0 Calendar Month Effort). Robyn is a current dog handler with the University of Pennsylvania Wildlife Futures Program. Robyn's role in this project will be to train and handle K9 Victoria for the detection of New Zealand mud snails at a designated Pennsylvania Fish & Boat Commission Hatchery.

*The University full-time benefit rate of 31.5% is applied to all salary charges.

Travel

Travel to and from local hatcheries is requested at the federal mileage reimbursement rate, currently $0.70/mile. We anticipate making approximately 20 total hatchery trips averaging approximately 60 roundtrip miles each.

Supplies

Funds are requested for two 25-gallon home aquariums and associated supplies to house target species and control. Dog training supplies and decontamination supplies are also requested.

Indirect Costs

University of Pennsylvania's current federal indirect cost rate is 62.5%. The agreement is attached to this application.

References

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Aquatic Invasive Species Control Plan: New Zealand Mudsnail. (2025, January). Pennsylvania Fish and Boat Commission, Division of Environmental Services. https://www.pa.gov/content/dam/copapwp-pagov/en/fishandboat/documents/conservation/ais/ais-control-plan-nzm.pdf

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DeShon, D., Wong, W. H., Farmer, D., & Jensen, A. (2016). The ability of scent detection canines to detect the presence of quagga mussel (Dreissena rostriformis bugensis) veligers. *Management of Biological Invasions*, *7*(4), 419–428. https://doi.org/10.3391/mbi.2016.7.4.11

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Geist, J. A., Mancuso, J. L., Morin, M. M., Bommarito, K. P., Bovee, E. N., Wendell, D., Burroughs, B., Luttenton, M. R., Strayer, D. L., & Tiegs, S. D. (2022). The New Zealand mud snail (Potamopyrgus antipodarum): autecology and management of a global invader. *Biological Invasions*, *24*(4), 905–938. https://doi.org/10.1007/s10530-021-02681-7

Grimm-Seyfarth, A., Harms, W., Berger, A. (2021). Detection dogs in nature conservation: A database on their world-wide deployment with a review on breeds used and their performance compared to other methods. *Methods in Ecology and Evolution,* 12, 568–579. https://doi.org/10.1111/2041-210X.13560

Hall, R., Jr, Tank, J., & Dybdahl, M. (2001). Exotic snails dominate nitrogen and carbon cycling in a highly productive stream. *The UW National Parks Service Research Station Annual Reports*, *25*, 72–77. https://doi.org/10.13001/uwnpsrc.2001.3457

Hall, R. O., Dybdahl, M. F., & VanderLoop, M. C. (2006). Extremely high secondary production of introduced snails in rivers. *Ecological Applications*, *16*(3), 1121–1131. https://doi.org/10.1890/1051-0761(2006)016

Hartzell, S. M., & Macelko, N. (2022). Range Expansion of the Invasive New Zealand Mudsnail (Potamopyrgus antipodarum) in the Susquehanna and Delaware River Basins of Pennsylvania. *Journal of the Pennsylvania Academy of Science*, *96*(1), 36–45. https://doi.org/10.5325/jpennacadscie.96.1.0036

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Kratz, A. (2023, February 24). Dogs could prove helpful in fight against chronic wasting diseases. *fox43.com*. https://www.fox43.com/article/life/animals/dogs-detect-chronic-wasting-disease-wildlife-futures-deer-animals-game-commission/521-c8c77335-b22a-4231-accc-3c7f0137ba79

Krist, A. C., & Charles, C. C. (2012). The invasive New Zealand mudsnail, Potamopyrgus antipodarum, is an effective grazer of algae and altered the assemblage of diatoms more than native grazers. *Hydrobiologia*, *694*(1), 143–151. https://doi.org/10.1007/s10750-012-1138-5

Larson, M. D., & Black, A. R. (2015). Assessing interactions among native snails and the invasive New Zealand mud snail, *Potamopyrgus antipodarum,* using grazing experiments and stable isotope analysis. *Hydrobiologia*, *763*(1), 147–159. https://doi.org/10.1007/s10750-015-2369-z

Pritchett, V., & Montag, M. (2023, May 22). Dogs trained to sniff out chronic wasting disease in Pennsylvania. *Abc27 News*. https://www.abc27.com/news/top-stories/dogs-trained-to-sniff-out-chronic-wasting-disease-in-pennsylvania/

Richards, N. L. (2018). Using detection dogs to monitor aquatic ecosystem health and protect aquatic resources. In *Springer eBooks* (pp.119-166). https://doi.org/10.1007/978-3-319-77356-8

Stockton, K. (2011). Methods to Assess, Control, and Manage Risks for Two Invasive Mollusks in Fish Hatcheries. [M.S thesis, University of Idaho]. https://usgs-cru-individual-data.s3.amazonaws.com/cmoffitt/thesis_dissert/Kelly%20Stockton%20thesis-1.pdf

University of Pennsylvania School of Veterinary Medicine. (2023, February 9). *A proof-of-concept study led by #PennVet suggests detection dogs could assist in managing chronic wasting disease (CWD) affecting members of* [thumbnail link] [Facebook post]. Facebook. https://www.facebook.com/PennVetSchool/posts/10158810408166573/

University of Pennsylvania School of Veterinary Medicine. (2024, August 1). *#TBT to Working Animal Appreciation Day! Earlier this summer, Penn Vet's Wildlife Futures Program Conservation K9 handlers Elle and Robyn* [image] [Facebook post]. Facebook. https://www.facebook.com/PennVetSchool/posts/1021569442753452/

Vinson, M. R., & Baker, M. A. (2008). Poor Growth of Rainbow Trout Fed New Zealand Mud Snails Potamopyrgus antipodarum. *North American Journal of Fisheries Management*, *28*(3), 701–709. https://doi.org/10.1577/m06-039.1

UNIVERSITY OF PENNSYLVANIA – SCHOOL OF VETERINARY MEDICINE

CURRICULUM VITAE

Lisa A. Murphy, VMD, DABT

Education

1988-1992	B.S.	Stanford University (Biological Sciences)
1993-1997	V.M.D.	University of Pennsylvania School of Veterinary Medicine

Faculty Appointments

2004-2006	Adjunct Clinical Instructor, Department of Environmental and Population Health, Tufts University School of Veterinary Medicine – *provided core toxicology lectures for Tufts veterinary students*
2005-2015	Assistant Professor of Toxicology – Clinician Educator, Department of Pathobiology, University of Pennsylvania School of Veterinary Medicine
2015-2022	Associate Professor of Toxicology – Clinician Educator, Department of Pathobiology, University of Pennsylvania School of Veterinary Medicine
2022-present	Associate Professor of Toxicology – Clinician Educator, Department of Pathobiology, University of Pennsylvania School of Veterinary Medicine

Selected Peer-Reviewed Publications

1. Murphy LA, Lewbart GA, Meerdink GL, Bargren GL. Whole blood and plasma cholinesterase levels in normal koi (*Cyprinus carpio*). JVDI 17:74-75, 2004.
2. Sleeman J, Magura K, Howell J, Rohm J, Murphy L. Hepatic mineral values of white-tailed deer (*Odocoileus virginianus*) from Virginia. Journal of Wildlife Diseases 46(2):525-531, 2010.
3. Vudathala D, Cummings M, Murphy L. Analysis of multiple anticoagulant rodenticides in animal blood and liver using principles of QuEChERS method. Journal of Analytical Toxicology 34(5):273-279, 2010.
4. Stout JD, Brinker DF, Driscoll CP, Davison S, Murphy LA. Serum biochemistry values, plasma mineral levels, and whole blood heavy metal measurements in wild northern goshawks *(Accipiter gentilis*). Journal of Zoo and Wildlife Medicine 41(4):649-655, 2010.
5. Stansley W, Murphy LA. Liver lead concentrations in raptors in New Jersey, U.S.A., 2008-2010. Bulletin of Environmental Contamination and Toxicology. 87(2):171-174, 2011.
6. Vudathala D, Murphy L. Rapid method for the simultaneous analysis of six ionophores in feed by liquid chromatography-mass spectrometry. Journal of AOAC International 95(4), 2012.
7. Stansley W, Cummings M, Vudathala D, Murphy LA. Anticoagulant rodenticides in red-tailed hawks, *Buteo jamaicensis*, and great horned owls, *Bubo virginianus*, from New Jersey, USA, 2008-2010. Bulletin of Environmental Contamination and Toxicology 92:6-9, 2014.
8. Horak K, Chipman R, Murphy L, Johnston J. Environmental contaminant concentrations in Canada geese (*Branta canadensis*) muscle: probabilistic risk assessment for human consumers. Journal of Food Protection 77(9):1634-1641, 2014.
9. Istvan SA, Marks SL, Murphy LA, Dorman DC. Evaluation of a point-of-care anticoagulant rodenticide test for dogs. Journal of Veterinary Emergency and Critical Care 24(2):168-173, 2014.

10. Vudathala D, Cummings C, Murphy L. A multi-residue screen for the analysis of toxins in bovine rumen contents. Journal of Veterinary Diagnostic Investigation. 26(4):531-537, 2014.
11. Miller EA, Driscoll CP, Davison S, Murphy L, Bronson E, Wack A, Rivas A, Brown J. Snowy owl (*Bubo scandiacus*) morbidity and mortality investigation in the DOS region in the winters of 2013-2014 and 2014-2015. Delmarva Ornithologist 44:4-12, 2015.
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13. Vudathala D, Smith S, Khoo L, Kuhn DD, Mainous ME, Steadman J, Murphy L. Analysis of microcystin-LR and nodularin using triple quad liquid chromatography-tandem mass spectrometry and histopathology in experimental fish. Toxicon 138:82-88, 2017.
14. Eleftheriou A, Murphy L, Welte S. Evaluation of lead and mercury prevalence in bald eagles (*Haliaeetus leucocephalus*) from the mid-Atlantic USA. Journal of Zoo and Wildlife Medicine 48(3):910-914, 2017.
15. Vudathala D, Klobut J, Cummings M, Tkachenko A, Reimschuessel R, Murphy L. Multilaboratory evaluation of a lateral flow method for aflatoxin B1 analysis in dry dog food. Journal of AOAC International 103(2):480-488, 2020.
16. Vudathala D, Cummings M, Tkachenko A, Guag J, Reimschuessel R, Murphy L. A lateral flow method for aflatoxin B_1 in dry dog food: an inter-laboratory trial. Journal of AOAC International 104(3):555-561, 2021.
17. Anis E, Turner G, Ellis J, Di Salvo A, Barnard A, Carroll S, Murphy L. Evaluation of real time RT-PCR panel for detection of SARS-CoV-2 in bat guano. Journal of Veterinary Diagnostic Investigation 33(2):331-335, 2021.
18. Mallikarjun A, Swartz B, Kane SA, Gibison M, Wilson I, Collins A, Moore MB, Charendoff I, Ellis J, Murphy LA, Nichols T, Otto CM. Canine detection of chronic wasting disease (CWD) in laboratory and field settings. Prion 17(1):16-28, 2023.
19. Xu X, Murphy LA. Simultaneous determination of pyrethrins, pyrethroids, and piperonyl butoxide in animal feeds by liquid chromatography-tandem mass spectrometry. Toxins 15(6):401-412, 2023.
20. Xu X, Murphy LA. Simple and fast quantification of cannabinoids in animal feeds by liquid chromatography-tandem mass spectrometry. Journal of Veterinary Diagnostic Investigation 35(4):425-429, 2023.
21. Xu X, Murphy LA. Fast and sensitive LC-MS/MS method for quantification of cannabinoids and their metabolites in plasma of cattle fed hemp. Journal of Separation Science. 30 October 2023. https://doi.org/10.1002/jssc.202300630
22. Facka A, Frair J, Keller T, Miller E, Murphy L, Ellis JC. Spatial patterns of anticoagulant rodenticides in three species of medium-sized carnivores in Pennsylvania. Canadian Journal of Zoology. 29 November 2023 https://doi.org/10.1139/cjz-2023-01
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University of Pennsylvania - Wildlife Futures Program
Curriculum Vitae
Brenna Aizen

EDUCATION

Bachelor of Science in Animal Science
Penn State University, State College, PA (2015-2018)

WORKING DOG EXPERIENCE

Conservation K9 Supervisor – 2021-Present
University of Pennsylvania's Wildlife Futures Program, PA, USA

Contract, Explosives Detection Dog Team Development – 2021
Resorts World Las Vegas, NV, USA

Contract, Spotted Lanternfly Detection Dog Team Development – 2020
Pennsylvania Department of Agriculture, PA, USA

Contract, Single Purpose Detection Dog Development – 2021
MK9 Solutions, Alabama, USA

Law Enforcement K9 Trainer – 2018-2020
Penn Vet Working Dog Center, PA, USA

Training Intern – 2017
Penn Vet Working Dog Center, PA, USA

Training Assistant – 2015-2018
Main Line Deputy Dog, PA, USA

Training Assistant – 2014
Partnerhunde Österrich, Nußdorf am Haunsberg, Austria

PRESENTATIONS

Vara's Job: Lessons from a Conservation Dog. Wildlife Disease Association Conference, Canberra, Australia. 2024.

Potential Application of Detection Dogs in Chronic Wasting Disease Management. Chronic Wasting Disease (CWD) Symposium, CO, USA. 2023.

Potential Application of Detection Dogs in Chronic Wasting Disease Management. Northeast Association of Fish and Wildlife Agencies (NEAFWA) Conference, PA, USA. 2023.

PROFESSIONAL QUALIFICATIONS AND MEMBERSHIPS

Certified Professional Dog Trainer-Knowledge Assessed, 2018.

The Wildlife Society Conservation Detection Dog Working Group, 2024.

University of Pennsylvania - Wildlife Futures Program
Curriculum Vitae
Robyn Strong

EDUCATION

Bachelor of Science (*Summa cum laude*) in Zoology
Humboldt State University, Arcata, CA (2012-2015)

ANIMAL TRAINING EXPERIENCE

Conservation K9 Handler – Jan 2022-present
Wildlife Futures Program, University of Pennsylvania; Kennett Square, PA, USA

Training Team Member – May 2020-Dec 2021
Santa Fe Animal Shelter and Humane Society; Santa Fe, NM, USA

Dog and Horse Trainer – Dec 2019-Nov 2021
Strong Animal Training; Santa Fe, NM, USA

Assistant Trainer – Sep 2018-Nov 2019
Terra Nova Equine Training Center; Lamy, NM, USA

RESEARCH EXPERIENCE

Research and Education Intern – Jan-Mar 2018
Golden Triangle Asian Elephant Foundation, Anantara Golden Triangle Resort, Thailand

Research Assistant – Feb-May 2017
Advisor: Lily Johnson-Ulrich, PhD – University of Zurich, Switzerland
Mekelle University Urban Hyena Project; Mekelle, Ethiopia

Research Assistant – Nov 2015-Oct 2016
Advisor: Dr. Kay Holekamp – Michigan State University Mara Hyena Project
Maasai Mara National Reserve, Kenya

Field Technician – Summer 2015
Advisor: Angela Darnell – University of Louisiana at Lafayette
Chiricahuas, AZ, USA

PEER-REVIEWED PUBLICATIONS

Lily Johnson-Ulrich, Gidey Yirga, Robyn Strong, Kay E Holekamp. The effect of urbanization on innovation in spotted hyenas. Animal Cognition 24(5), 2021.

Tracy M Montgomery, Julia R Greenberg, Jessica L Gunson, Kecil John, Zachary M Laubach, Emily Nonnamaker, Erin S Person, Heidi Rogers, Emily M Ronis, Laura Smale, Katherine R Steinfield, Robyn Strong, Kay E Holekamp, Jacinta C Beehner. Measuring salivary cortisol in wild carnivores. Hormones and Behavior 137(43):105082, 2022.

PRESENTATIONS/OUTREACH

Spotted Hyenas: Behavior and Demographics. Serena Lodge, Maasai Mara National Reserve, Kenya. 2015-2016.

Wolf Communication. Wolf Park, Battle Ground, IN. 2014.

Investigation into variation of cranial morphology in Canids. Humboldt State University, Arcata, CA. 2014.

Evolution of sociality in lions (*Panthera leo*). Humboldt State University, Arcata, CA. 2014.

PROFESSIONAL QUALIFICATIONS

Certified Professional Dog Trainer-Knowledge Assessed – 2021

American Kennel Club Canine Good Citizen Evaluator – 2021

Force Free Shelter Professional – 2020

TAGTeach Level 1 Certification – 2019

HONORS

Best of Santa Fe Dog Training Award – 2021

Presidential Scholar, Humboldt State University – 2012-2015

University of Pennsylvania - Wildlife Futures Program
Curriculum Vitae
K9 Victoria

EDUCATION
Penn Vet Working Dog Center Puppy Program – 2021-2022

RESEARCH EXPERIENCE
Conservation K9 – Mar 2022-present
Wildlife Futures Program, University of Pennsylvania, Kennett Square, PA, USA

ODORS KNOWN
- CWD-positive deer feces
- UDC – Universal Detection Calibrant
- TENNIS BALLS!!!!