This is provided as an example proposal. It is important that you follow the current guidelines.

The mentor letter has been removed.
A PROPOSAL TO STUDENT ENHANCEMENT AWARD REVIEW COMMITTEE

DETERMINING OCCURRENCE, DENSITY, AND PREDICTORS OF ROAD MORTALITY FOR RECOVERING BOBCAT (Lynx rufus) POPULATIONS IN OHIO

NAME OF APPLICANT: Heidi Bencin

STATUS: _____ Undergraduate   X  Graduate   _____ Medical

CAMPUS/LOCAL ADDRESS: 320 Irvine Hall, Ohio University, Athens, OH 45701
E-MAIL ADDRESS: hb849416@ohio.edu
DEPARTMENT: Biological Sciences

EXPECTED GRADUATION DATE (Month and Year): December 2018

RE-SUBMISSION: ____ YES (Original Submission Date ______)   X  NO

PROPOSAL CATEGORY (select one):
  X  Life/Biomedical   _____ Social/Behavioral
  _____ Arts/Humanities   _____ Physical Sciences/Engineering

BUDGET: Total Request $6,000
(May not exceed $6,000)

FACULTY MENTOR INFORMATION:
  NAME: Viorel Popescu
  E-MAIL ADDRESS: popescu@ohio.edu
  CAMPUS ADDRESS: 423 Irvine Hall, Ohio University, Athens, Ohio 45701
  DEPARTMENT: Biological Sciences
  DEPARTMENT ADMIN./EMAIL: Wendy Kaaz, kaaz@ohio.edu

IRB AND IACUC APPROVAL:
To ensure that the University is in compliance with all federal regulations, complete the checklist below. Note: your proposal can be approved prior to IRB or IACUC approval (put “pending” or “to be submitted” instead of approval number), but funding will be withheld until notification of approval or exemption.

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SIGNATURES

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☐ Optional:
If selected for funding, I give permission to the Office of the Vice President for Research and Creative Activity to use my proposal as an example during training and workshop exercises.
(Sign below)
Signature: Date: 01.10.17
STUDENT ENHANCEMENT AWARD
APPLICATION CHECKLIST

Applicants must complete and sign the checklist. The checklist should be included as the second page of the application (following the cover page).

- Cover page
- Checklist
- Abstract*
- Resubmission Summary (For Re-submissions Only)*
- Project Narrative
- Glossary/Definition of Terms* (Not required)
- Bibliography (Not required)
- Presentation of Results
- Mentor’s Endorsement
- Biographical information (Applicant(s) and key personnel)
- Budget and Justification
- Appended Materials/Multimedia Files
- Electronic copy of proposal

Sections marked with a bullet (*) identify text sections that should be written in language understandable by an informed layperson to assist the Committee in its review.

**Please Note: The committee has the right to return without review any proposals that do not conform to these format requirements**

Applicant signature: [Signature]
Determining occurrence, density, and predictors of road mortality for recovering bobcat

*(Lynx rufus)* populations in Ohio

**Abstract:** Wildlife populations are dynamic, continually fluctuating in response to land use changes, hunting pressures, road mortality, disease, and other stressors. Documenting changes in these populations is an important step in the proper management and conservation of wildlife species. Such is the case for the Ohio bobcat (*Lynx rufus*), where populations are currently recovering from local extinction in the nineteenth century. The reemergence of bobcats has become evident in the past twenty years, and has sparked the interest of the trapping community. As no baseline population statistics for bobcats in Ohio currently exist, it is unclear if and where hunting could take place in a sustainable manner. To fill this gap in knowledge, I will: 1) use **camera traps** to determine where bobcats occur throughout Ohio; 2) carry out a genetically-based **capture-recapture** study using non-invasive **hair snares** to estimate the density of two known populations in South and Southeastern Ohio; 3) analyze a 10-year vehicle-strike data set compiled by the Ohio Department of Natural Resources (ODNR) to determine predictive variables of road mortality, the current greatest cause of death for bobcats in Ohio, and; 4) combine occurrence, density, and road mortality data to create spatial models depicting current and future estimates of population size and spread. Results of this study will be summarized in my master’s thesis on carnivore ecology and conservation, presented to the scientific community and broader general public at conferences and outreach events, and prepared for submission to peer-reviewed journals. Notably, results will establish important baseline statistics on an iconic locally recovering species, inform state agencies of scientifically-based suggestions for sustainable trapping restrictions or allowances, and contribute to our general understanding of recolonization events and carnivore-roadway dynamics.
Project Narrative

**Introduction:** The bobcat is a medium sized wild felid that occurs from southern Canada to Central Mexico, and is native to all states in the contiguous US [1]. During the nineteenth century bobcats were *extirpated* from a number of states along the eastern coast and throughout the Midwest that suffered heavy deforestation and overhunting [1], including Ohio in the 1850s [2]. In recent years, bobcat populations have begun to recover in many of these regions [3, 4]. While the first record of bobcat reemergence in Ohio happened in 1946, reestablishment of stable breeding populations most likely did not occur until around the year 2000, and has been limited to the South and Southeastern regions of the state [2].

There is evidence to indicate that bobcats are currently expanding their range [5], prompting ODNR to remove the species from the Ohio Endangered and Threatened Species list. As such, recent pressure has been building to open a trapping season for bobcats. As it currently stands, the permitting of a trapping season would be uninformed by science and could produce significant losses for small populations. Illinois faced a similar situation in early 2016, where a bobcat trapping season opened in the absence of reliable density or population data. This resulted in backlash from environmental groups and the public, and could carry devastating consequences for bobcat populations there. In order to determine if there are populations within Ohio capable of sustaining a hunting season, further investigation into the occurrence and density of bobcats throughout the state, which is currently unknown, must be determined.

Camera traps and hair snares are non-invasive methods for monitoring wildlife populations, allowing scientists to assess many aspects of wildlife dynamics, and are particularly useful for studying elusive species [6, 7, 8, 9, 10], such as bobcats. Camera traps typically answer questions regarding occurrence [6, 7], spatial patterns [8], and population abundance [9,
Hair snares provide DNA samples that can be used to assess population structure [11] and density [12, 13] of species. While camera traps can be used to accurately assess abundance or density in species such as leopards and jaguars [9, 10], bobcats’ pelage patterns are much less pronounced, making individual identification through use of cameras likely unreliable [14].

Bobcats exhibit sensitivity towards urbanization [15], and it has been suggested that the presence of roads may influence their movements and home ranges [16]. Specifically, for a bobcat population in New Hampshire, Litvaitis et al [17] found that road mortality was correlated with road density (state and interstate highways), suggesting that some regions may function as population sinks. Currently, vehicle collisions represent the single greatest source of mortality for bobcats in Ohio [5]; in 2013 there were 54 fatal vehicle-strikes to bobcats reported [18]. An accurate evaluation of such population sinks is key to understanding the future of bobcats in the state. In addition to having fatal consequences for wildlife, vehicle-strikes threaten the safety of humans and ensue negative economic consequences [19, 20]. Past studies have shown that successfully identifying and managing road mortality hot spots can be possible, and is a vital step in species protection and collision reduction [17, 20, 21, 22].

Objectives: 1) Determine the occurrence of bobcats throughout Ohio, especially in regions that border known populations to determine if and how populations are expanding their range; 2) estimate the density of two core populations in South and Southeastern Ohio using a capture-recapture technique with genetic samples gathered from baited hair snares; 3) evaluate population-level risks of road-mortality, determining predictors for vehicle-strikes using a 10-year spatially-explicit dataset collected by ODNR; 4) combine occurrence, density, and road-mortality data to infer population spread, predicting areas within that range with high risk of road mortality, and; 5) apply our results in real-world conservation applications by communicating
data gathered with ODNR and Ohio Department of Transportation (ODOT) so that they may make well-informed and scientifically-based wildlife management and infrastructure development decisions, respectively.

**Hypothesis:*** 1) Occurrence of bobcats will be detected beyond areas previously surveyed in South and Southeastern Ohio; 2) density estimates will show that in certain regions bobcats are still in the early stages of recovery, and support the continuation of restrictions on trapping in those areas; 3) significant relationships will be found between points of vehicle-strikes and variables such as road type, seasonality, and demographic factors (i.e. sex and age), and; 4) population spread will be projected to occur at a higher rate surrounding more dense populations.

**Methods:*** *Timeline* - Field work will take place from May to August of 2017. Camera traps and hair snares will be deployed for 90 days; the standard when studying wild cat species [10]. Biweekly, camera traps will be checked to maintain camera function, moved within the sample site to increase the probability of bobcat detection [23, 24], and rebaited to sustain lure attractiveness. Once weekly, hair snares will be checked to collect samples, and will be moved within each site to increase the probability of detection [23, 24]. Compiling and sorting of camera data will take place as it is collected and will be ongoing throughout the duration of the field season. Genetic samples will be sent for analysis at the end of the field season. Modeling and statistical analyses of occurrence, density, and road-mortality data will take place after the conclusion of the field season in order to maximize time allocated towards data collection during the field season.

**Occurrence** - Bobcat presence throughout Ohio will be determined using baited camera traps. I will use Caven’s Gusto from Minnesota Trapline Products as bait, which has been used previously by our lab and found to be effective in provoking a rubbing behavior in bobcats.
Following methods summarized in Mowat and Strobeck [25], a map of Ohio will be overlain with a 3x3 km grid. Bobcats have home ranges between 1km² and 168km² [26], and this size grid will allow balance between smallest possible range size and sufficient coverage of the area. The map will be stratified into physiographic regions and 70 sites proportionally distributed on public lands will be sampled, excluding regions that will be surveyed for density. Areas of moderate to intense urbanization will also be excluded, as bobcats generally do not prefer these habitats [15]. Probability of occurrence will be determined using occupancy modeling [27] within R Statistical Software.

Density - In south and southeastern Ohio, density will be determined using a spatial capture-recapture approach described by Efford 2009 [28] using hair samples collected via baited hair snares. For effective coverage of the area I will deploy 300 hair snares, which will be constructed following methods outlined in Kendall and McKelvey [29] with the addition of adhesive glue tape (four 1cm x 4cm strips per trap). Glue tape has been shown to collect higher amounts of hair than other methods (i.e. barbed wire or gun brushes) resulting in higher quality results [30]. Samples will be stored individually in dry paper bags until they are shipped to Wildlife Genetics International for analysis. Analysis will first verify species, after which 7 microsatellite loci will be used to identify individual bobcats [31]. Density will be estimated using a Spatial Capture-Recapture (SCR) model within R statistical software [32, 33].

Road Mortality - To identify predictors of road mortality I will use ODNR georeferenced locations of road kills for the years 2007-2016. Generalized mixed effects models will be used to describe significant relationships between points of vehicle-strikes and variables such as geographic location, habitat type, road type, traffic volume, seasonality, and demographic factors [17]. Predictive spatial distributions will be mapped using the spatial
Ultimately, this will allow me to estimate an overall risk of road mortality at the level of the entire Ohio bobcat population using a well-established approach developed by Hels and Buchwald [34].

**Significance:** This study will establish baseline population statistics (occupancy and density) for a recovering species in Ohio, where no such data currently exists. In my research, I am combining different types of data (occupancy, density estimates, and road mortality) for enhanced inference on population status. Combining different data types using novel statistical tools is an evolving area of research [35], and I will draw on the latest statistical developments to integrate multiple non-congruent data sources. The data generated during this study will also form a foundation for the development of a spatial **Population Viability Analysis** (PVA) for bobcats, a natural continuation of this work.

**Broader Impacts:** One of the most important aspects of conservation biology is bridging the gap between human and wildlife needs. I will provide ODNR with my findings so that they may determine scientifically-based and appropriate trapping limits for bobcats. I will share spatial predictive models with Ohio Department of Transportation (ODOT), enhancing their capacity to implement biologically meaningful mitigation systems that will allow for bobcat dispersal and recovery in Ohio, while reducing vehicle-strike hazards to humans and wildlife. I will train an undergraduate student in wildlife monitoring techniques through Ohio University’s PACE program, and plan to incorporate my research into OU’s Bio Bonanza, a biology-based outreach partnership with local libraries that aims to inspire a future generation of environmentally-conscious individuals. Overall, I trust that my research will inform relevant government agencies on the protection needs for an ecologically vital species, and foster appreciation for wildlife throughout communities in rural Appalachia.
**Glossary**

*Camera traps* – Cameras that are used in ecological studies to monitor wildlife. They are mounted in place, and programmed to take pictures when activated by a motion sensor. This allows scientists to observe animals that might otherwise not be seen in the presence of humans.

*Capture-recapture* – By capturing individuals in a population, marking them, and recapturing them, a population size estimate can be mathematically determined from the proportion of recaptured individuals. This can be done using camera traps or DNA samples by diving time into discrete occasions, within which individuals are ‘captured’ and ‘released’.

*Extirpated* – When a species suffers extinction specific to a particular geographic location but still exists elsewhere.

*Generalized mixed effects model* – Used to determine relationships between target and explanatory variables for longitudinal data sets with both fixed and random effects.

*Georeferenced* – This term refers to data points that are associated with physical locations.

*Hair snares* – A noninvasive method for sampling wildlife DNA by means of collecting hair via an adhesive or snagging mechanism that an animal walks past or rubs against.

*Microsatellite loci* – Simple tandem repeats of DNA. These are molecular markers that exhibit variation unique across individuals and can be used to identify them.
**Occupancy modeling** – A common method for analyzing presence-absence data to determine the probability that a species of interest occurs in a particular area. This method accounts for sampling errors such as false absences.

**Pelage patterns** – The unique and identifying markings on an individual animals’ fur, such as stripes or spots. For some animals (i.e. leopard, zebra) these markings are large and exhibit high contrast, making it easier to visually distinguish one individual from another.

**Physiographic regions** – areas of land that have distinctly different physical and biological attributes.

**Population sink** – When immigration into a population exceeds the rate of emigration out of the population, while at the same time the rate of death exceeds the rate of birth.

**Population Viability Analysis** – a statistical method that assesses population trends and life history traits to predict the probability that a population or species will become extinct within a certain timeframe.

**Spatial capture-recapture model** – A spatially-explicit extension of traditional capture-recapture models. These models can incorporate the probability of detecting individuals within a certain spatial range.
Bibliography


Presentation of Results

Preliminary results from this research will be presented to the broader scientific community in 2017 at The Wildlife Society conference in Albuquerque, New Mexico. Presenting preliminary results will allow me to draw from the suggestions of experienced wildlife professionals with diverse backgrounds, enabling me to better develop the analytical methods I will use to assess my data. Complete results will be presented in 2018 at The Wildlife Society Conference in Cleveland, Ohio. I will also present my work locally, at both the Ohio Natural History and the Ohio Fish and Wildlife Management Association conferences in 2018. These conferences will provide vital opportunities to receive feedback on my research and network with other wildlife professionals. The results of this study will be submitted to peer reviewed journals for publication, including Journal of Wildlife Management, American Midland Naturalist, and Biological Conservation.

I intend to share my work with fellow students at the Ohio University Student Research and Creative Activity Expo in 2018. I will also share my work during student-run outreach events at local libraries that aim to introduce biology to children. These opportunities will allow me to engage a diverse audience within the general public on issues pertaining to local conservation efforts, and help promote local appreciation of wildlife.
Biographical Information

Heidi Bencin
Department of Biological Sciences
320 Irvine Hall, Ohio University
Athens, OH 45701
Phone: 440-289-8957
Email: hb849416@ohio.edu

EDUCATION:

Present  Ohio University, Athens, Ohio
M.S., Ecology and Evolutionary Biology
GPA: 4.0

2015  Cleveland State University, Cleveland, Ohio
B.S., Environmental Science, Biology concentration
GPA: 3.82

TEACHING EXPERIENCE:

2016 – 2017  Teaching Assistant, Ohio University
BIOS 1715: Biological Sciences II Laboratory

RESEARCH EXPERIENCE:

08/16 – Present  Thesis Research: Determining occurrence, density, and predictors of road mortality for recovering bobcat (Lynx rufus) populations in Ohio
Advisor: Viorel Popescu, Ph.D.
Ohio University

01/16 – 06/16  Research Assistant: Dissertation research that investigated the influence of human disturbances on chacma baboon (Papio ursinus) social behavior
Advisor: Amanda Ellwanger, Ph.D. Candidate
Hermanus, South Africa

05/15 – 08/15  Sea Turtle Intern: Long-term nest monitoring and mark-recapture survey of nesting female loggerhead sea turtles (Caretta caretta)
Supervisor: Emily Hardin
Bald Head Island Conservancy, North Carolina

09/14 – 12/14  Student Researcher: Social survey that examined factors influencing the negative perceptions of 31 wildlife species near protected areas
Advisor: Christian Kiffner, Ph.D.
School for Wildlife Management Studies, Tanzania
Senior Thesis: Investigated wastewater treatment plant effluent as a source of microplastic pollution into Lake Erie
Advisors: Julie Wolin, Ph.D., and Sherri Mason, Ph.D.
Westerly Wastewater Treatment Plant, Ohio

REU Ecology Intern: Examined variation in growth and reproduction in mayapple (*Podophyllum peltatum*) at varying levels of human disturbance
Advisor: Oscar Rocha, Ph.D.
Kent State University, Ohio

PAPERS AND PRESENTATIONS:


2014 “Local people’s perceptions of wildlife species”
Speaker at the Karatu District Community Meeting, Rhotia, Tanzania

2014 “How microbeads and exfoliators pollute the Great Lakes and end up in the fish you eat”
Interviewed by News Net 5, Cleveland, Ohio

AWARDS:

2013 Transfer Scholarship ($4,000)
2010 Fine Arts Grant ($500)

PROFESSIONAL AFFILIATIONS:

The Wildlife Society
Society for Conservation Biology
Ecological Society of America
### Budget and Justification

#### Consumables

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Total funds requested: $6000
Density

- Rite in the Rain paper is necessary to place over each hair sample acquired from a glue trap once collected. This is primarily to keep the glue from sticking to other materials, which would compromise the integrity of the sample. Rite in the rain paper is easily removed from glue traps come time for analysis, and was specifically suggested for this purpose by Wildlife Genetics International. A ream of 200 sheets should be adequate, as each sheet one can be cut to accommodate multiple samples. Paper not used for covering hair samples will be used for data collection in the field.

- The JT Eaton adhesive glue boards budgeted for were also specifically suggested by Wildlife Genetics International, as these traps tend to work well in all weather conditions and the adhesive does not damage the sample. Each glue trap can be used to make 5 hair snares (100 glue traps x 5 hair snares = 500 possible hair snares) while we will be setting up only 300 hair snares, each time a glue trap is used it will need to be collected and replaced. If greater than 100 glue traps are needed, additional traps will be bought using advisor’s funds.

- Common nails will be needed to secure hair snares in place. Nails can be reused when traps are moved.

- Outdoor carpet of a neutral color and berber style is needed to hold lure and support glue boards. Each square foot of carpet can create two hair snares (150 sq ft x 2 snares/sq ft = 300 snares).

- Desiccant packets are needed to keep hair samples from degrading due to moisture before analysis. As I am unsure of how many samples we will obtain, I believe 100 desiccant packets will be a practical starting point, after which our lab will purchase more as needed.

- Coin envelopes are needed to store individual hair samples after collection. Again, I am unsure of how many samples we will obtain, but it is more practical to buy this item in a higher quantity, as lower quantities are similarly priced and may not be sufficient to cover the needs of this study.
Occurrence

- While our lab has fifty Moultrie M-990i camera traps from a previous study, my research calls for seventy total, requiring an additional twenty cameras. This will allow me to sufficiently survey the area needed to determine bobcat occupancy throughout Ohio. It is important that the cameras be of identical brand and model to the ones our lab currently has, in order to ensure consistency of variables such as photo quality and camera accuracy.

Conference

- Hotel prices are estimated from current listings of hotels in Albuquerque for September 2017. Flight rates are estimated from Columbus International Airport (CMH) to Albuquerque International Sunport (ABQ) for the dates of the conference. While the per diem costs requested are lower than the standard, I am confident I will not exceed the requested amount. Travel within Albuquerque will be paid through my advisor’s funds and through personal funds.

Travel to field sites

- Transportation to field sites throughout Ohio will require driving an average of 290 miles per week for 12 weeks, totaling 3,480 miles. The budgeted 3,412 miles leaves only 68 miles unaccounted for, which will be paid for using advisors’ funds.

Other funding and material sources

- Costs for genetic analysis of hair samples will depend entirely on how many samples are obtained, and how genetically isolated the two populations of bobcats are. More genetically isolated populations require identification of a higher number of microsatellite loci (up to 15 total) to distinguish one animal from another, adding to overall costs. Funding for genetic analysis has been formally requested from ODNR, and will likely be supported.

- Other materials not budgeted for that are necessary for the completion of this study are already available in our lab, such as barbed nails for hair snares, Caven’s Gusto lure, rubber gloves for collecting genetic samples, and fifty Moultrie M-990i camera traps.