NSRC Special Request Grant 2015-2016 Final Report

1) Project title: Modeling and mapping the distribution of American marten in Vermont.

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3) Overview: The American marten (*Martes americana*) is a forest-dependent carnivore that historically ranged across the Northern Forest from the Canadian border to Massachusetts. The species declined to near extinction in the region from overhunting, habitat loss, and the reestablishment of competitors like fisher (*M. pennanti*). Martens are listed as a high-priority Species of Greatest Conservation Need in Vermont, and by 2010 were thought to be extinct in the state, despite a reintroduction effort. In recent years, martens have been discovered in far northern and southern Vermont, indicating that the species may be slowly recolonizing the state and expanding in range. As martens begin to recolonize, a primary concern is how best to prioritize areas for conservation that facilitate the species' recovery. Martens generally require movement corridors and large expanses of forest habitat; however, identifying areas to protect or manage requires information on the relative quality of habitats and other features of the landscape, which is lacking. The goal of this project was to provide a means for wildlife managers to assess the quality of the landscape for martens in Vermont. Our objectives were to 1) build a model that describes marten distribution, 2) develop a distribution map, and 3) estimate landscape quality for protected areas in the state. The project occurred from September 2015 to May 2016. Our timeline involved developing a modeling framework in the first four months of the project, then collecting data, modeling and mapping distribution, and assessing landscape quality in the following five months.

The project expanded to include a new and more robust modeling approach since we began. We initially planned to build the model based on expert-opinion using a framework called Elicitator. After working with the program, we found that it lacked certain components that would be helpful in our analysis. In response, we developed a new modeling approach in partnership with Dr. Therese Donovan in the Vermont Cooperative Fish and Wildlife Research Unit. The approach involves using a tool to elicit opinions online and uses these data to develop a model. We helped develop the online tool, uploaded maps and other spatial data for experts, developed an analytical structure, and tested the elicitation process. We also worked with two additional graduate students funded under different grants to combine efforts and collect expert data on multiple species. This led to synergies between students and research projects. We also expanded our focal area from Vermont to a four state region including Vermont, New Hampshire, Maine, and upstate New York. Experts were identified and contacted and we began the elicitation process in June 2016. Experts (n = 18) include trappers, state and federal biologists, state and federal land managers, and academic researchers. We also added another component of the project to identify corridors of movement between northern and southern populations in Vermont. We plan to use a circuit-theory approach to map connectivity between populations and identify barriers and pinch-points to movement that could help prioritize conservation efforts. This may be especially important for evaluating the role of protected areas as 'stepping stones' for

recolonization. We plan to complete the elicitation process in July and the model, distribution map, and connectivity map by September.

4) Methods: Our methods involve building a model of marten distribution based on the opinions of experts as empirical data is very limited. We helped develop an online tool for eliciting expert-opinion. This tool asks experts to estimate the probability of marten occurrence at several locations on composite maps of habitats and other landscape features. Results are then used to back-transform parameter estimates and develop a model. The model will then be applied on a pixel by pixel basis in GIS software to map marten distribution across the state. Landscape quality in protected areas will be estimated as the mean occupancy value among pixels in each protected area in the state. Lastly, movement corridors, barriers, and pinch-points will be identified using the program Circuitscape, which relates animal movement across a landscape to the flow of current through a circuit.

5) Accomplishments: To-date, our main accomplishment has been the development of the expert-elicitation modeling framework and approach. This also involved creating spatial maps of landscape features (n = 14 layers) such as habitats across the study region, identifying and soliciting experts to participate, and testing the approach before beginning the actual elicitation. As part of this process, a graduate student (C. Aylward) received training in species modeling, population dynamics, GIS, statistics, and decision-making techniques.

6) Relevance: The project is directly relevant to NSRC Theme 4: Biodiversity & Protected Area Management. It focuses on a species considered a high-priority component of biodiversity not only in Vermont, but across the Northern Forest, and develops new tools (map and model) for planning conservation activities. Few quantitative tools exist for planning and decision-making for marten. It will also result in an assessment of the quality of 80 protected areas for the species. This will serve as an important guide for marten recovery and restoration, and contribute to stated needs in the Vermont Wildlife Action Plan. The project built on outcomes from previous NSRC projects including Donovan et al. (2002), Donovan (2002-
2006), and Donovan and Manning (2010-2012).

The project directly benefits several stakeholders. It benefits state wildlife management departments across a four state region of the Northern Forest, such as the Vermont Fish and Wildlife Department and New Hampshire Fish and Game Department. It provides a quantitative tool that allows managers to better plan conservation activities. For example, managers can use the model to examine how marten distribution responds to changes in the landscape by mapping distribution under a variety of scenarios. The project also provides a tool that can be used to map movement corridors, barriers, and pinch-points, especially between protected areas, and depict gene flow across a region of interest. The results benefit non-profit organizations such as The Nature Conservancy, which is involved in protecting lands throughout the region. It provides a means of identifying priority areas for marten conservation and corridors between them, and information that could help guide restoration efforts on lands they manage. Lastly, the project benefits the trapping community in Vermont by providing them with a means to directly contribute to science and wildlife management in partnership with the Vermont Fish and Wildlife Department. This helps strengthen ties between state and community and we believe will lead to a greater investment in wildlife conservation.

7) Products and outcomes: The primary product to-date is an online tool for eliciting expert-opinion data on species distributions (not only for marten, but any species). The tool uses an R-Shiny platform and was built in collaboration with Dr. Therese Donovan of the Vermont Cooperative Fish and Wildlife Research Unit. The tool allows experts to estimate a species occupancy probability at sample locations on a map. Occurrence data from multiple experts can then be used to back-transform parameters values and develop an expert-opinion model.

   Our project has resulted in three important outcomes. First, we believe our project has galvanized support for marten conservation in the state and region. We solicited support from state and federal biologists, land managers, and academic researchers from five states to participate in the project, which we believe has generated increased interest in our expert modeling approach and fostered a greater sense of collaboration. We also actively sought the support of trappers in partnership with the Vermont Fish and Wildlife Department. This has provided trappers an opportunity to actively contribute to wildlife management by providing knowledge (and data). This has led to stronger connections between the trapping community and state wildlife departments. Second, the project also allowed us to link to a USDA McIntire-Stennis research project based at the University of Vermont, a part of which involves assessing climate change impacts on species. We were able to leverage additional funds from this grant, collaborate with PIs and graduate students, and contribute to broader analyses of wildlife in the region. Lastly, our project provides a model and map that will contribute to another project that is evaluating the origin of martens in northern and southern Vermont using genetic techniques. Our map will allow for gene flow to be evaluated across the state, and we received funds from a state grant to contribute to this project. Other expected outcomes include a graduate student thesis and peer-reviewed publication of results.

8) Events and announcements: Once we complete the final marten model, we plan to upload an easy-to-use guide to using the model for wildlife managers and practitioners to the NSRC website. We will also upload a map showing marten distribution across the state (based on the model) and another showing movement corridors, barriers, and pinch-points between the northern and southern Vermont populations (based on the distribution map). These maps will accompanied by base raster maps (e.g., forest cover) that can be used by managers to explore the effects of management actions or landscape change on the species. Lastly, we will upload a list of protected areas and the landscape quality of each for the species.

9) Future research: This project provides a quantitative means of assessing the distribution of marten in Vermont and across much of the Northern Forest. We envision that the next step is to expand the model to include an adaptive component. This would involve integrating new data on marten occurrence as it becomes available to update the model and provide a better depiction of marten distribution on a yearly basis. For example, new data on incidental captures by trappers or road kills could be applied to the model using a Bayesian framework. This would generate a 'living' model that constantly updates based on new data. Activities would involve developing a framework for updating the model and means of reliably collecting new data from the state, trappers, and public.