APPLICATION FOR SCIENTIFIC STUDY IN BAXTER STATE PARK

TITLE: Integrating capture-recapture and population genetics to understand the spatial dynamics of a trapped American marten (*Martes americana*) population in Maine's industrial forests.

PERSONNEL

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CREDENTIALS

Dr. Shawn McKinney has investigated interspecific relationships in forest communities for over 16 years. His research has emphasized tying ecological theory to applied management action, and the results of his efforts have both elucidated the mechanisms of community dynamics and appropriate management practices for maintenance or restoration of forest community functionality.

Mr. John Clare has several years of experience surveying for mesocarnivores and other species using non-invasive techniques, and capturing, marking, and monitoring terrestrial species using radio-telemetry. His previous research is being used to revise the harvest management of the bobcat in Wisconsin.

BENEFITS DERIVED FROM RESEARCH

The American marten (*Martes americana*) is an important species for commercial and conservation purposes currently restricted to boreal and montane forests across North America. As a low-density forest obligate sensitive to forestry practices, martens can serve as both indicator species for ecosystem perturbation and umbrella species for forest conservation. Maine's preponderance of forest cover has left the state as a regional stronghold for martens.

The economic importance of forestry products statewide has created a unique legacy of marten research within Maine, particularly within and in the vicinity of Baxter State Park (BSP). Primary focuses have included either the habitat selection of individual marten under varied forest conditions or the influence of habitat or trapping upon population vital rates (e.g., Hodgman et al. 1994, Chapin et al. 1998, Payer 1999, Payer and Harrison 2003, Fuller and Harrison 2005). These studies imply that individual martens select against regenerating stands, practice home-range expansion in response to partial harvest, and that population indices are additively affected by trapping pressure and habitat composition. The development of detailed stand-level metrics for marten occurrence has been a highlight of previous research efforts.

Yet projections of marten population trajectories based upon previous metrics for occurrence clash with contemporary monitoring information. Accelerated rates of timber harvest over the previous 30 years are suggested to have triggered steep reductions in marten density on the landscape (Simons 2009), with climatic changes and trapping providing additional pressure on projected population trajectories (Carroll 2007). Current monitoring information is derived exclusively from annual marten harvest data, which shows no overall population trend. However, indices are rife with observation error (Anderson 2001), and of limited use without calibration based on parameter estimates (MacFarland and Van Deelen 2011).

The purpose of this study is i) to determine the utility of varied sampling analytical techniques for subsequent monitoring efforts conducted by Maine's Department of Inland Fisheries and Wildlife (MDIFW), and ii) to infer the drivers of marten population status by comparing the influence of forest

management, trapping pressure, and cyclical biotic factors (e.g., mast; Jensen et al. 2012) on marten vital rates. Because population persistence also depends upon broader connectivity (Hastings 2014), we will also incorporate measures of individual movement and population pair-wise gene flow. Baxter State Park, including its Scientific Forest Management Area (SFMA), comprises a unique forest community in northern Maine with a substantially greater density of mature conifers than the surrounding matrix. Furthermore, BSP contains the largest refuge from trapping in the state. These characteristics make BSP an ideal comparison to study sites more intensively managed for timber production and readily accessible to trapping. Moreover, the detailed records of forest management within the SFMA allow more precise derivation of the relationship between timber harvest and marten population dynamics than could be achieved within other parts of the state. Ultimately, we expect that our research will greatly improve our understanding of marten population responses to forestry practices within Maine, establish direct connections between specific practices and marten population responses, and identify the scale at which forest management is most influential. This information should be useful for targeting forest management objectives both within the SFMA and the state.

DETAILED DESCRIPTION OF RESEARCH

This study's focused objectives are to

1) Determine the relative efficacy of remote cameras and hair snares as techniques to estimate marten density. Both techniques have been used to survey martens (e.g., Williams et al. 2009, Siren 2013), but represent trade-offs between data quality (the amount of information in a genetic sample) and data quantity (the number of camera samples less dependent on the number of checks).

2) Determine an index or surrogate parameter correlated with density for use in subsequent monitoring. Beyond calibrating alternatives with marten density, understanding which metrics (e.g., spatial footprint, detection rate) best correlate with density may broadly improve the development of subsequent indices for other species.

3) Determine covariate predictors of marten density and population trajectory. Understanding how habitat characteristics, distance to trapping refugia, and trapping effort influence marten density and population growth or decline is critical information for forestry practices and marten population management.

4) **Determine the extent of genetic differentiation and evaluate barriers or sources of resistance between marten populations.** Because marten occurrence and density are partially dependent upon broader population connectivity, determining barriers to individual dispersal and subsequent reproduction is essential for understanding population patterns. Moreover, evidence of population structuring would suggest that management of harvest should be considered at finer scales. In contrast, metrics of connectivity might allow insight into the proper scale of habitat management for marten persistence.

5) Determine the association between marten harvest total/population growth and survival/ recruitment. Marten harvest totals follow biannual oscillation between high and low take that correlates with mast production. It is unclear whether harvest totals are tracking actual population trajectories or individual susceptibility to harvest. Succinctly, are marten populations regulated by bottom-up forces related to prey density, top-down forces such as direct exploitation, or indirect drivers such as forest management?

We focus on two study areas encompassing roughly 3,000 km^2 of Maine's central highlands region, including portions of Wildlife Management Districts 4, 5, and 9. All townships within the study areas with recorded marten harvest over the previous 5 years were considered potential sampling sites. Sites (n=5 per study area) were selected using generalized random tessellation sampling (Stevens and Olson 2004) with equal selection and no strata. Because of the quality of

stand-level information, we request that the SFMA within Baxter State Park be considered part of our northern study area with the potential to hold one survey site.

Field Sampling

Each site will be subject to non-invasive sampling during early winter 2015, 2016, or 2017; within each study area two sites will be sampled annually, with 3 sites sampled once each during the duration of the study. Detectors (n=64) will consist of Bushnell Trophy Cam 8MP cameras integrated with single catch hair traps visible to the camera (*sensu* Magoun et al. 2011). During a pilot season in 2014, 2 sites in the southern area surrounding Greenville will be sampled, with extension into the northern area beginning in early 2015. All stations will be baited with beaver meat, and a standard skunk-based lure will be applied to increase detection rates. Placement of detectors will follow a gridded system, with approximately 1 km spacing between detectors. Each site will be active for at least 14 days, and stations will be initially checked every 2-3 days. Individual marten will be identified on the basis of unique ventral fur markings and microsatellite DNA extracted from hair samples.

Sites will be revisited during summer months. Within all sites, a road-based network of Tomahawk 105.5 (Hazelhurst, Wisconsin) live traps will be set and baited with either available beaver meat or jam. Traps will be open for 1 week with daily morning checks. Live marten will be anesthetized using a ketamine-xyalzine mixture (Kreeger 2012). Once under, trapped marten will be checked for signs of lactation, receive a biopsy punch at the base of the ear to be used for genetic analysis, and marked with a labeled plastic ear-tag placed in the location of the biopsy punch to expedite identification of individuals over multiple years and allow recovery of marked animals from the trapped population. Multiple observers will always be on hand to monitor the animal's breathing rate and other vital signs (Kreeger 2012).

Finally, summer months will be used to collect fine-scale stand characteristics. A 10 m radius plot will be established surrounding each station. Within this plot, diameter at breast height (DBH) will be measured and tree height for all stems > 7.6 cm DBH (Payer 1999) will be estimated using a clinometer. DBH will be converted into an estimate of basal area (m^2/hectare). Coarse woody debris will be sampled using standard line intercept methods (Von Wagner 1964) along a 10 m transect starting at the trap site with random azimuth.

Using varied spatial capture-recapture models (Royle et al. 2014), we will model marten density, population connectivity, and population growth rate, using covariates when possible. Spatially-explicit models are comparable to distance sampling but incorporate individual encounters: individual activity centers are a primary latent parameter, with the occurrence or dynamics of an activity center estimated from the spatial detection history. One advantage of this methodology is that it allows modeling of density, survival, or associated parameters at finer scales than traditional techniques, and allows joint estimation of individual resource selection or landscape resistance (Royle et al. 2013a, Royle et al. 2013b).

Capture-recapture estimates can further be integrated (e.g., Adabi 2010) with estimates of marten movement and harvest mortality obtained from physically marked and recovered individuals to improve estimates of immigration and allow derivation of natural mortality rates and potential association with habitat covariates. A broader sample of harvested individuals will be used for analysis of genetic flow and structure using programs TESS (Chen et al. 2007) and BIMR (Faubet and Gaggiotti 2008) to estimate the number of distinct breeding units and pair-wise immigration between townships. By considering marten movement, density, and other vital rates across multiple scales, we will place marten population status in an appropriate spatial context, and highlight suitable scales for management of marten populations and habitat.

AREAS OF THE PARK FOR RESEARCH

We would like to include one randomly selected site (64 km^2; 8 km x 8 km) within the Scientific Forest Management Area for potential placement of noninvasive detection stations.

IMPACT

We anticipate Park impact in the following ways. 1) Non-invasive camera and hair snag stations will require bait plates to be drilled approximately two inches into trees while stations are active. We are willing to select station trees following guidelines preferred by the Park Authority. 2) Camera and hair snag stations could be visible to park visitors. We will camouflage stations and associated equipment to minimize the likelihood of being seen by a visitor. 3) Individual marten in the SFMA (likely less than 15 individual animals) will be trapped and marked with ear-tags. There is potential for marten mortality during the chemical immobilization or handling process. Reported research associated mortality rates are generally 1-2% (e.g., Potvin et al. 2004, Hearn 2007); but most mortality is due to poor individual condition or subsequent strangulation via radio-collars. Live-trapping in summer minimizes risk of death due to exposure, and we will not be fitting animals with radio collars. Protocols for all proposed research will first be approved by the University of Maine's Institutional Animal Care and Use Committee, a body dedicated to ensuring animals are handled safely, humanely, and with minimal risk of injury or mortality, prior to initiating field sampling. All sampling equipment will be removed at the end of each sampling season.

BUDGET

This project is funded via the University of Maine, MDIFW, and the Federal Aid in Wildlife Restoration Act. We do not request any additional funds from Baxter State Park.

TIMETABLE

We propose to begin summer sampling in either July 2014 or July 2015, and begin winter sampling in January 2015. All sampling will be completed by April 2017. The graduate student is expected to complete analysis and defend his dissertation by June 2018.

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