NORTHERN ILLINOIS UNIVERSITY

FILLING IN THE GAPS IN DEMOGRAPHY, PHENOLOGY, AND LIFE HISTORY OF THE EASTERN MASSASAUGA RATTLESNAKE (*SISTRURUS CATENATUS*)

A DISSERTATION SUBMITTED TO THE GRADUATE SCHOOL
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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BY

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ABSTRACT

The Eastern Massasauga (*Sistrurus catenatus*) is a small, cryptic North American rattlesnake with a distribution centered on the Great Lakes. It is listed as threatened and endangered in Canada. In the United States, ongoing population declines due to habitat loss, habitat fragmentation, and harvest led to the species being listed as threatened under the U.S. Endangered Species Act in 2016. Estimates of population parameters are essential for modeling population dynamics, assessing population viability, and elucidating the effects of land management practices on population persistence. However, conservation of Eastern Massasauga populations has been hampered by information gaps related to life history and hibernation phenology. In additon, key demographic parameter estimates are lacking for populations near the range center of the species where the largest number of Eastern Massasauga populations may still persist. Consequently, biologically realistic population viability analyses and management guidelines related to the timing of habitat management activities have been difficult to develop. In this study, I address these data gaps by providing 1) a range-wide synthesis to evaluate geographic variation in life history traits, 2) critically needed demographic estimates, population viability analysis, and prescribed burn simulations from a centrally located population, and 3) a predictive hibernation ingress/egress model to assist managers in minimizing mortality during ground-disturbing land management activities.

To address life history data gaps, I compiled data from 47 study sites representing 38 counties across the range. I used multimodel inference and general linear models with geographic coordinates and annual climate normals as explanatory variables to clarify patterns of variation in life history traits. I found strong evidence for geographic variation in six of nine life history variables. Adult female snout-vent length and neonate mass increased with increasing mean annual precipitation. Litter size decreased with increasing mean temperature, and the size–

fecundity relationship and age-zero growth both increased with increasing latitude. The proportion of gravid females also increased with increasing latitude, but this relationship may be the result of geographically varying detection bias.

Next, I used eight years of data and contemporary capture-recapture and matrix model methods to estimate population parameters for an Eastern Massasauga population near the range center of the species in Cass County, Michigan. From 2009–2016, 826 Eastern Massasaugas were captured 1,776 times. On average, sexual maturity occurred at age three in both sexes. Mean litter size was 7.6. Annual survival increased with increasing age (age-zero=0.38, age 1=0.65, age 2=0.76, age ≥3 females=0.71) but declined slightly in age ≥3 males (0.66). Abundance estimates ranged from 84–140 adults and annual reproductive frequency was 0.44. Using these estimates, I developed a baseline population projection model to evaluate population persistence in Cass County and the degree to which increased mortality during spring, fall, and late fall prescribed burns might affect population growth 50 and 100 years into the future if current conditions persist. The baseline model, which incorporated current prescribed fire practices, indicated a stable population with only a 1% probability of extinction over 100 years, suggesting that management practices at this site are sustainable if they remain unchanged. Simulations of conservative increases in mortality due to fire changed the probability of extinction little over 50 years (0.000–0.003) but increased probability of extinction up to 14% over 100 years in the most pessimistic prescribed burn scenario.

Last, I installed on-site weather stations at seven Eastern Massasauga study sites in Iowa, Illinois, Ohio (2 sites), and Michigan (3 sites). I identified dates of spring emergence using a combination of intensive visual searches, radio telemetry, and camera traps. I used observation data and soil temperature data from logging stations to validate a predictive egress phenology model and clarify geographic patterns of variation in the timing of Eastern Massasauga emergence. Emergence from hibernation was clearly associated with a reversal in soil temperature gradients, although there were sometimes multiple reversals with hibernation egress lagging the first reversal by a week or more. Based on these patterns, I provide recommendations that minimize the risk for Eastern Massasauga mortality and avoid unnecessary curtailment of the burn season. This model has the potential to predict when prescribed fire or ground-disturbing management activities are least likely to cause direct snake mortality.

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