A Climate Change Vulnerability Assessment
for the
Eastern Massasauga Rattlesnake
an Endemic of the Upper Midwest and Great Lakes Region

Prepared for the

UPPER MIDWEST AND GREAT LAKES LANDSCAPE CONSERVATION COOPERATIVE
Effective conservation through collaboration and sound science
Climate change vulnerability assessment is a tool for understanding ecological responses of species to environmental stressors, particularly across the large spatial scales and time frames at which climate change occurs. Climate change, which is occurring globally, is also occurring rapidly in the Upper Midwest and Great Lakes region, with a warming trend and increases in spring, summer, and autumn precipitation during the past half-century. Vulnerability assessment can aid conservation strategies by identifying regional differences in a species’ exposure to climatic and landscape-level stressors, so that local management implementations can be developed appropriately. We conducted a range-wide assessment for the Eastern Massasauga Rattlesnake *Sistrurus c. catenatus* (EMR), a declining species identified as a top climate change priority by federal, state, tribal, and private natural resource management professionals in the Upper Midwest and Great Lakes region. EMR is associated with semi-wetland habitats such as bogs and fens in much of its range, and these habitats may be particularly sensitive to long-term changes in precipitation. Drought and flooding events pose a risk because EMR depends on a stable water table near the soil surface, especially during winter hibernation.

We compiled population data across the range of EMR for the period 1965 to 2008, using Natural Heritage Inventory data sets, USFWS species status reports, and additional sources. Populations were classified as extant, extirpated, or at imminent risk of extirpation, the latter category indicating an extremely small and declining breeding population (fewer than 100 females; in practice, most of these populations had fewer than 25). Separately, we used the results from existing studies of adult survival to examine relationships between adult breeding season survival, winter survival, climate variables, and land cover. Our choice of climate and land cover variables reflected input from species experts and published studies on the potential sensitivities of EMR. We focused on drought risk, flooding risk, and extreme temperatures, and we measured the proportion of agricultural and urban land in landscapes surrounding occupied EMR habitat. Results showed that high winter drought risk, high maximum precipitation during summer months (a proxy for flood risk), and high urban and agricultural land cover in surrounding landscapes were all associated with low adult survival rates in the active season. We used these relationships to predict adult survival rates for all EMR populations, including how these rates may vary over time with these weather variations. We then simulated population dynamics over the historical time period using these survival rates, and compared the resulting patterns of population growth and decline to the actual population status data. The simulations correctly classified 75% of the 189 sites we examined as extant or extirpated/imminent risk.

These results show that the distributions of historical extirpations and currently at-risk populations are linked to the climatic and landscape conditions we studied. Extirpations have been most prevalent in the southern and western parts of the range across the period we studied, so that the species’ range appears to be contracting in a northeastern direction. In addition to successfully predicting documented extirpations, the models predicted more moderate declines for many extant populations that are not considered to be in imminent risk, suggesting that climatic factors such as drought and flooding risk are also impacting these populations.

The good performance of these models gave us confidence using them with climate forecasts to predict future population changes, given expected climate change. We did this by running the population simulations from 2008 to 2050 for all currently extant populations, including those in imminent risk of extirpation. These forecasts suggest that, without significant management intervention, demographic decline and range contraction will continue in a geographic pattern roughly similar to the historical trend, given expected climate change. It is important to consider that our models were not perfect predictors of all local extirpations, but predicted the general pattern of range contraction well. Uncertainty in future projections is also influenced by uncertainty in the underlying climate models.
Management implications

Our findings support the idea that extreme fluctuations of the water table in EMR habitat locations, especially near hibernacula, represent demographic stressors. Further, these stressors are likely to continue to intensify with future climate change. EMR habitat management may therefore require local water table manipulations that can mitigate such extreme fluctuations. Historically, the dominance of natural vegetation cover in surrounding landscapes may have lessened the impact of drought and flooding on the water table, and larger populations were likely less susceptible to local flooding events. Landscape-level habitat restoration efforts to improve habitat connectivity and appropriate vegetation may also have a positive influence on local hydrological conditions. However, a significant portion of extant populations occur on lands under public or private wetlands conservation management, and in some such cases opportunities may exist for direct water table manipulation. Levees and dikes are considered to have been critical in mitigating the worst effects of large flood events on Massasauga populations in Missouri, whereas inappropriate water level manipulations may have contributed to local extirpations in Wisconsin. In regions where climatic stressors are clearly an issue, water table management should be considered in concert with other habitat conservation recommendations, such as the regulation of woody plant succession in bog, fen, and other wetland habitats. However, this does not necessarily apply in the same way to all regions where EMR occurs, and any direct manipulations should be sensitive to local conditions.

Northern regions within the EMR range may act as long-term refugia for the species, as they show low drought and flood risk in future predictions relative to
more southern regions, as well as lower prevalence of urban and agricultural lands. Ontario and northern Michigan populations are distributed across many locations and show less evidence of strong decline than do the more southern and western populations. Low to medium likelihood of local extirpations was also forecast for the New York and Pennsylvania populations, given low predicted risk of climatic stressors. This region harbors only a handful of small populations, which are widely separated and in several cases are in imminent risk of extirpation, as reflected both in local population assessment data and in model results for the historical period. These populations may represent high-priority opportunities for investing in local habitat management, because effective habitat creation (e.g., management of vegetation structure) combined with the potentially favorable climatic context could translate to long-term persistence.

In central, southern, and western portions of the range showing high extirpation likelihoods, there is a clear need for management implementations that can respond to climatic stressors in general, and winter drought and summer flood events specifically. This is most notably true in southwestern Michigan where there is a high density of populations. A few populations in the western and southern part of the EMR range showed high persistence likelihood in models forecasting to the near future (2020-2029; e.g., central Wisconsin and northern Indiana), but even these showed high extirpation likelihood at mid-century (2040-2049) without significant management intervention. Although predictions to the end of the century are much less certain, they show a continuing pattern of extirpation from southwest to northeast.

A discussion of all aspects of EMR habitat management and detailed habitat manipulations is beyond the scope of this study—for this, we refer readers to Johnson et al. (2000). We hope, though, that our findings contribute to the current state of knowledge regarding EMR conservation and management by placing overall management efforts in the context of climate change. In particular, increasingly strong climatic variability is likely to place stress on EMR populations by exacerbating water table fluctuations, and this is likely to act in concert with other stressors including vegetation succession and habitat loss. We expect that active efforts to stabilize such fluctuations locally, in concert with habitat improvement efforts, will enhance the capacity of EMR populations to persist.
For additional information, contact the authors or refer to the Upper Midwest and Great Lakes LCC project report.

References


