# Recovery Plan for

# the

# Eastern Massasauga Rattlesnake

# (*Sistrurus catenatus*)

July 2021

Midwest Region (Region 3)
U.S. Fish and Wildlife Service
Bloomington, Minnesota

**Approved:** _____

**Regional Director, Region 3**
**U.S. Fish and Wildlife Service**

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This recovery plan can be downloaded free of charge from the USFWS website: http://www.fws.gov/endangered/species/recovery-plans.html

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## I. Introduction

The eastern massasauga rattlesnake (*Sistrurus catenatus*) was listed as a threatened species under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*; Act) on October 31, 2016. The species is listed as endangered in southern Ontario and threatened in northern Ontario.

Multiple risk factors affect this species, though habitat loss (for example, through development) and fragmentation (for example, through development or vegetative succession from invasive species) are the two that are most widespread (Szymanski *et al.* 2016, Executive Summary, p. v). Over the species' range, habitat varies, but generally includes components of gramminoid (grass and sedge) dominated plant communities, either in or adjacent to shallow wetlands (summarized in Szymanski *et al.* 2016, p. 15).

The primary purpose of the Act is the conservation of endangered and threatened species and the ecosystems upon which they depend. The ultimate goal of such conservation efforts is the recovery of these listed species, so that they no longer need the protective measures of the Act. Subsection 4(f) of the Act requires the USFWS to develop and implement recovery plans for the conservation of endangered and threatened species.

The USFWS recovery planning process entails developing a recovery plan and a recovery implementation strategy (RIS). This document provides the recovery plan for the eastern massasauga rattlesnake. The plan describes the recovery vision, strategy, and the required elements per section 4(f)(1)(B) of the Act. These elements include site-specific management actions; objective, measurable criteria; and estimates of time and costs to carry out those measures needed to achieve recovery.

The RIS is separate from the Recovery plan and is developed in close cooperation with states and other partners. It is an operational plan for turning the higher-level recovery actions into specific tasks and includes detailed plans for how the partners can work together to accomplish those tasks. The RIS will be updated as new information becomes available and as progress toward recovery is achieved. The current version of the RIS is available on the USFWS website at https://www.fws.gov/midwest/endangered/reptiles/eama/index.html.

We conducted a species status assessment (SSA) to evaluate the viability of the species. The assessment described the species' taxonomy, natural history, habitats, ecology, and range. We then analyzed the population and species requirements, the current condition of the species, and the factors that have led to the species' current status. We then predicted the state of factors and their influence on numbers and distribution into the future. Given the change in the number and distribution of populations over time, we described eastern massasauga viability by evaluating the ability of the species to maintain a sufficient number and distribution of healthy populations to withstand environmental stochasticity and perturbations, catastrophes, and novel changes in its environment. A summary of the SSA analysis is documented in the Species Status Assessment Report (Szymanski *et al.* 2016) (https://www.fws.gov/midwest/Endangered/reptiles/eama/pdf/SSAFinalV2July2016EMR.pdf).

## A. Recovery Vision.

The eastern massasauga rattlesnake (*Sistrurus catenatus*) is a small pit viper that occurred historically in ten of the United States (Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, and Wisconsin) as well as in Ontario, Canada. Populations have been extirpated in at least two states (Minnesota and Missouri). Please refer to the SSA Report (Szymanski *et al.* 2016) for a full discussion of the species' biology.

The recovery vision for eastern massasauga rattlesnake is that healthy populations are conserved in sufficient number and distribution to ensure the species' long-term viability. The species is able to recover from disturbances and fluctuations in the environment (for example, stochastic events such as fire, flooding, and storms, as well as normal variation in rainfall and temperature). Specifically,

- Eastern massasauga rattlesnake populations have positive growth rates and numbers of individuals are sufficient to avoid the negative impacts of small population sizes. That is, population sizes are large enough not to be strongly influenced by demographic (for example, higher chance of skewed sex ratios), environmental (for example, greater vulnerability to fluctuations due to bad years that lead to extinction), and genetic (for example, higher chance of losing genetic variation, and hence, increase homozygosity) stochasticity (Szymanski *et al.* 2016, p. 35).

- Eastern massasauga rattlesnake populations occur across longitudinal and latitudinal gradients to maintain evolutionary drivers such as gene flow and natural selection. Maintaining existing genetic diversity and the diversity of selection pressures experienced by eastern massasauga rattlesnake populations will conserve the eastern massasauga rattlesnake's ability to adapt to future changes in its physical (habitat, climate) and biological (for example, predators, competitors, diseases) environment.

- Eastern massasauga rattlesnake populations occur in sufficient number and distribution to guard against catastrophic events (such as widespread drought, flooding, and disease).

- Eastern massasauga rattlesnake populations have high quality summer and winter habitat with intact ecological processes to maintain the high quality habitat, connectivity among these habitats, and limited or managed exposure to other threats such as disease and persecution (Szymanski *et al.* 2016, pp. 23-25).

## B. Recovery Strategy

The eastern massasauga rattlesnake is impacted by habitat loss due to development, conversion of habitat to agriculture, changes to land cover due to succession by invasive woody species, persecution, poaching, flooding, drought, and emerging diseases. Maintaining the healthy populations described in the Recovery Vision will necessitate protecting sufficient quantity of high-quality habitat and the reduction or management of threats. Given the loss of populations to date and the predicted continued decline (Szymanski *et al.* 2016), an important part of the recovery strategy includes the following considerations to ensure reduction of these stressors that are impacting existing populations:

- Habitat loss: A large proportion (estimated at >60% of populations) of extant eastern massasauga rattlesnake populations occur on protected lands owned by public or non-governmental organizations (NGO). Some important populations also occur on private lands where formal protection (through purchase or easement) and increased stewardship may be beneficial to improve population health.

- Increase in woody invasive species: Ensure that adequate management takes place to allow preferred eastern massasauga rattlesnake habitat structure (early successional, gramminoid-dominated plant communities). Track and measure increased areas suitable for the eastern massasauga rattlesnake after habitat treatments occur and, when possible, determine if population response is positive, thus improving population health.

- Catastrophic floods: Ensure, through land protection or connectivity, that there are refugia available to populations that occur in areas prone to catastrophic flooding. Assess populations after flood events to determine the likelihood that they will continue to contribute to the species' viability.

- Drought: Manage water levels to ensure adequate hydrology (for example, to allow persistence of crayfish populations with which many eastern massasauga rattlesnake populations are associated for hibernation) is available during drought cycles. Assess populations after drought events to determine the likelihood that they will continue to contribute to the species' viability.

- Snake fungal disease and other emerging pathogens: Improve our understanding of how the pathogen is distributed and determine routes of infection. Network and disseminate information if new pathogens are detected so that threats can be researched quickly and risks mitigated. Explore novel or existing veterinary disease treatments using either captive or wild-caught eastern massasauga rattlesnakes, on an experimental basis, to determine whether they may have application to wild populations. To minimize the possibility of disease transmission, evaluate best field hygiene practices for eastern massasauga rattlesnake biologists or habitat managers and adopt such practices in the field.

- Persecution: Increase public tolerance and support for eastern massasauga rattlesnake conservation.

Given the likelihood of limited resources, we need to focus management and protection on specific populations that will ensure that the breadth of adaptive diversity is maintained. Recovery plans do not come with dedicated funding sources. In the case of this widespread but declining species, recovery will depend on engagement and/or funding or other contributions from agencies at the Federal, State, and local levels, as well as non-governmental and private sector organizations and Native American tribes. Several extant populations occupy large complexes on private land. Due to the potential for these populations to be viable, habitat protection or incentives to private landowners to help manage habitat in ways beneficial to the eastern massasauga rattlesnake are important. Because this species also occurs in Ontario, Canada, which is part of the Eastern Conservation Unit, we also consider the trajectory and population status of Canadian populations when evaluating the overall status of the species. We

will continue to coordinate with Canadian counterparts on shared opportunities to conserve populations of the eastern massasauga rattlesnake.

We need to increase public tolerance and support for eastern massasauga rattlesnake conservation by working with landowners, partners, and the public. Through working with local outreach partners, we plan to increase outreach that highlights the role and benefits to the ecosystem when eastern massasauga rattlesnakes are present.

Successful recovery will benefit from an adaptive management approach. We need research to better understand some fundamental aspects of eastern massasauga rattlesnake ecology. Using an adaptive management framework and monitoring during recovery implementation will allow us to evaluate how to best manage for suitable habitat conditions, protect against disease epidemics, and lessen the effects of environmental stressors to ensure that the recovery actions are effective in recovering the eastern massasauga rattlesnake. In order to adequately assess recovery and guide adaptive management efforts, baseline data will be critical. In most cases, the baseline data do not yet exist and will need to be collected.

## II. Recovery Criteria

The recovery criteria provide the objective, measurable targets for achieving the recovery vision. The recovery criteria represent our assessment of conditions that would likely support a determination that listing under the Act is no longer required for the eastern massasauga rattlesnake. The criteria described below provide one road map to species recovery for the eastern massasauga rattlesnake, but other configurations, with variations in distribution of self-sustaining populations and numbers and distributions of robust populations, could also support a delisting determination if the species is not likely to become in danger of extinction in the foreseeable future.

To assess the species status and to guide species recovery efforts, we delineated three conservation units across the range of the eastern massasauga rattlesnake (Figure 1). The units generally capture the range of adaptive diversity and are based on genetics (including a population genetics study by Ray *et al.* 2013 that described three genetic haplotypes) as well as differing selective pressures and threats across the species' range. As recovery implementation proceeds, the use of various conservation measures (for example, habitat protection or conservation, habitat management, research, and outreach) may occur in differing proportions, depending on priorities and status in each unit.

Achieving the recovery vision will take managing the primary threats for a sufficient number of populations in each conservation unit to where the species is unlikely to become in danger of extinction in the foreseeable future. The primary risk factors for the eastern massasauga rattlesnake are late-stage vegetative succession, habitat fragmentation, and total or moderate habitat loss or modification (Szymanski *et al.* 2016, p. iii). To provide assurances that threats will continue to be managed as necessary to prevent declines in populations after removal from the List of Endangered and Threatened Wildlife, the need for management plans and long-term commitments for habitat management is included in the recovery criteria. We define long-term as "at least 25 years after delisting" based on 3-4 generations for this species and intended to provide assurances that the population will persist after delisting.

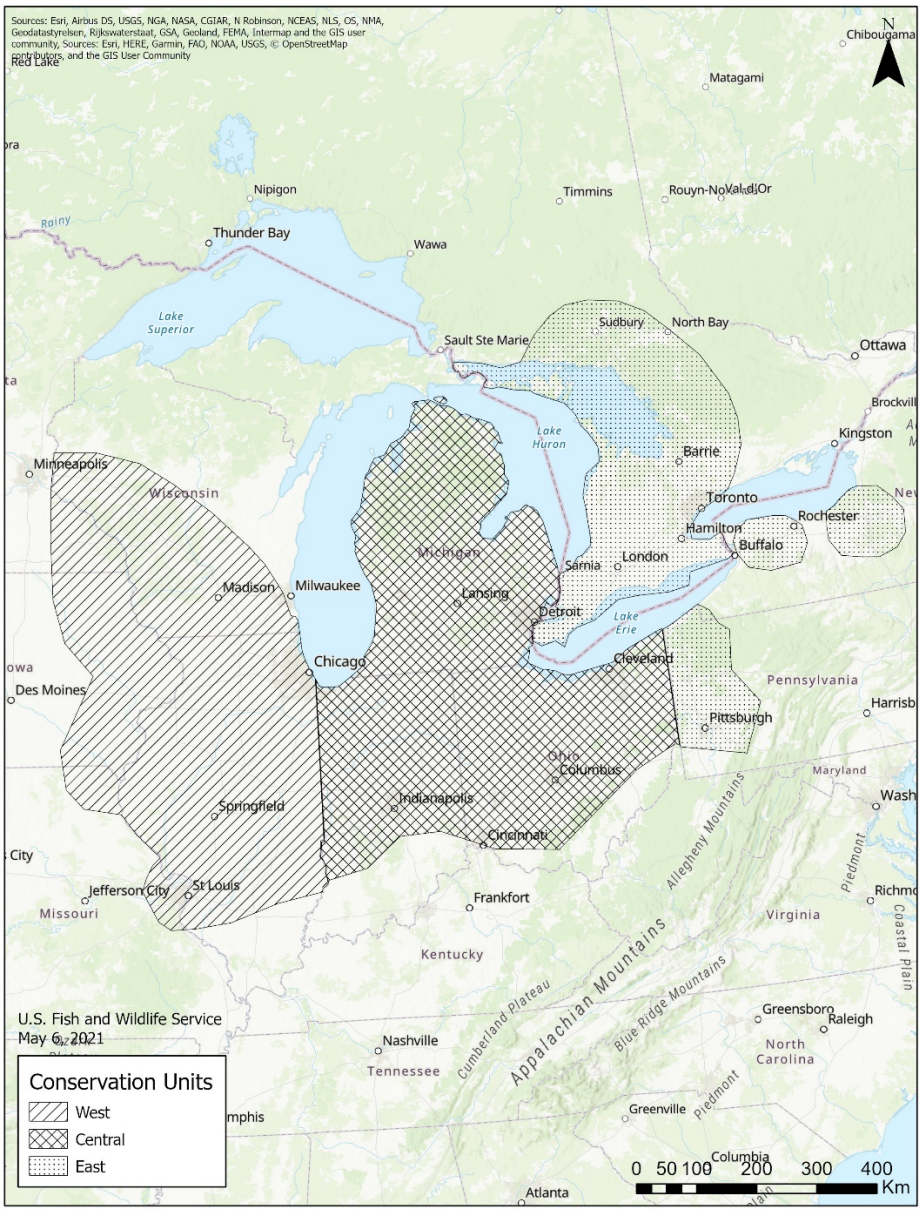


Figure 1. Three conservation units for the eastern massasauga rattlesnake – west unit (Minnesota, Wisconsin, Illinois, Iowa, Missouri), central unit (Michigan, Indiana, Ohio), east unit (Pennsylvania, New York, Ontario)

We may initiate an assessment of whether recovery has occurred and delisting is warranted when the following has been accomplished:

**Criterion 1**: 135 robust populations are distributed among the 3 conservation units (Figure 1) as described below. A robust population has more than 50 adult females and a stable or increasing growth rate. Of these 135 robust populations, at least 80 have threats managed to a level where the populations become self-sustaining, by additionally meeting criteria 2 and 3 below.

**Western Conservation Unit** (Southwestern Minnesota, Southern Wisconsin, Eastern Iowa, Eastern Missouri, and Illinois): 11 robust populations. At least 4 of those populations also meet criteria 2 and 3 below.

**Central Conservation Unit** (Michigan's Lower Peninsula, Indiana, and Ohio): 87 robust populations. At least 53 of those populations also meet criteria 2 and 3 below.

**Eastern Conservation Unit** (Western/Central New York, Western Pennsylvania, and Southeastern Ontario): 37 robust population. At least 23 of those populations also meet criteria 2 and 3 below.

**Criterion 2:** An adequate quantity and configuration of land is managed and is expected to continue to be managed in a way that will support a robust eastern massasauga rattlesnake population into the future. This criterion will be met when the number of robust populations identified in Criterion 1 occur on lands that have management plans and long-term commitments (extending at least 25 years after delisting) to ensure implementation of those plans.

Management plans should identify how the land manager will maintain suitable summer and winter habitats, control threats (including collection and persecution), and monitor the population. Potential funding sources to ensure adequate management should be identified.

**Criterion 3:** Threats from climate change and disease are addressed in a way that supports a robust eastern massasauga rattlesnake population into the future. This criterion will be met when the number of robust populations identified in Criterion 1 have management plans that evaluate and address threats from climate change and disease:

a. Eastern massasauga rattlesnake populations exist in locations that may be subject to the effects of climate change (for example, catastrophic drought or flooding). Effects of climate change will be better understood through research and modeling. Habitat will be managed to best assist populations to adapt and ensure robust populations persist into the future. Examples include managing altered hydrology and protecting natural hydrological regimes.

b. The potential effects of current and emerging disease are understood and sufficiently reduced.

## III. Recovery Actions

This section provides broad categories of the actions that are necessary to achieve the recovery vision and meet the recovery criteria for the eastern massasauga rattlesnake. These actions apply to each of the three conservation units, but specific implementation may differ geographically (specific tasks will be population-specific). These broad categories of actions are used to develop step-down recovery implementation strategies. The recovery implementation strategies are adaptable and developed and updated in coordination with interested conservation partners.

To address threats to and recover the eastern massasauga rattlesnake, we plan to work with interested conservation partners to implement actions in the following broad categories:

## A. Halt and Reverse Declines

**1.** Monitor select eastern massasauga rattlesnake populations and assess viability to help guide and evaluate conservation efforts for the eastern massasauga rattlesnake. Regular monitoring of select eastern massasauga rattlesnake populations is important to help provide information on their presence or absence, population size, and other demographic information to help assess population resiliency or persistence. Monitoring a suite of select viable populations where management is occurring can also help determine if population goals are being reached and evaluate the effectiveness of conservation efforts. Efforts to survey or inventory historic sites or immediately adjacent sites can also help identify declining populations, which can then be targeted for management strategies. Recovery implementation strategies developed by individual states and stakeholders can be used to identify the sites where surveys and population monitoring are most needed. Surveys should use established (for example, mark-recapture or other census-based techniques) and/or new (genetics-based) techniques to estimate the effective population size and long-term viability of select eastern massasauga rattlesnake populations, especially when needed to confirm whether populations are robust. We recognize that only a subset of known extant sites can be monitored due to time and funding constraints. Across the range, a select subset of sites that are actively managed for eastern massasauga rattlesnake should be identified (through the Recovery Implementation Strategies) and monitored to inform management elsewhere. We anticipate that this action will take 25 years of implementation. **Est. Cost: $850,000**

**2.** Implement habitat management and restoration efforts. Active habitat management is needed to fulfill eastern massasauga rattlesnake habitat requirements in each season and life stage. Furthermore, habitat should be managed in such a way as to allow connectivity among all of the habitat components (basking sites, foraging areas, retreat sites, gestation sites for gravid females, and hibernacula). This action was identified by state and NGO stakeholders as the greatest need for eastern massasauga recovery. This action is already being implemented by most stakeholders as part of routine natural areas management. Greater focus directed to sites with viable populations of this species may be a key in implementing recovery. Ongoing collaboration and cooperation among all stakeholders, including with private landowners, is essential in adopting and implementing land management practices and providing feedback on effectiveness of these practices. We anticipate that this action take 25 years of implementation. **Est. Cost: $18,750,000**

**3.** Habitat Protection. Develop a land protection strategy for the eastern massasauga rattlesnake to focus on conserving sufficient quality and quantity of occupied habitat areas and adjacent habitat to provide buffer or to provide additional space for population expansion, with the goal being to preserve resiliency, representation, and redundancy of the eastern massasauga rattlesnake (Szymanski *et al.* 2016). This could be done through various mechanisms including short-term conservation programs (for example, USFWS Partners for Fish and Wildlife agreement or U.S. Department of Agriculture Conservation Reserve Program), as well as longer term agreements or land acquisition (for example, fee title, conservation easements – for example, through the North American Wetland Conservation Act or Forest Legacy Programs). This action will likely take ten years of implementation. **Est. Cost:**

**$2,500,000**

4. Develop and refine recommendations on methods to reduce direct mortality of eastern massasauga rattlesnakes from vehicular strikes, persecution, and collection and incorporate these recommendations into land management plans. The eastern massasauga rattlesnake is reliant on habitat management, but some management actions may increase the risk of mortality (Baker *et al.* 2016). New approaches and best management practices need to be developed to help managers implement needed actions while minimizing regulatory burdens. This action will likely take ten years of implementation. **Est. Cost: $2,250,000**

5. Develop and implement conservation strategies that help remediate the effects of climate variability and subsequent hydrological fluctuations in eastern massasauga rattlesnake habitat. A climate change vulnerability assessment (CCVA) indicated that extreme fluctuations in the water table are demographic stressors for the eastern massasauga rattlesnake (Pomara *et al.* 2014). Eastern massasauga rattlesnake conservation should include strategies to minimize the effects of hydrological fluctuations during drought and flooding events, such as management or conservation of natural vegetative cover and hydrology within occupied eastern massasauga rattlesnake habitat (Pomara *et al.* 2014, p. 2,097). Remediation strategies for climatic stressors in the western, central, and southeastern portions of the range should be developed, since these areas were shown to have high extinction probabilities in the CCVA (Pomara *et al.* 2014, p. 2,097). This action will likely take ten years of implementation. **Est. Cost: $1,500,000**

**B. Ensure that the breadth of adaptive diversity is maintained.**

1. Identify key populations to prioritize for protection within each conservation unit in order to maintain adaptive diversity. Use genetic, geographic, and ecological data to identify populations that are robust and represent the range of adaptive capacity for this species. We anticipate that this action will take three years of implementation after States adopt their individual Recovery Implementation Strategies. **Est. Cost: $80,000**

2. Survey for previously unknown eastern massasauga rattlesnake populations in areas that are important to preserving adaptive capacity and meeting recovery criteria and where the status of populations is unknown. It is important to survey in an effort to find previously undiscovered eastern massasauga rattlesnake populations. These newly identified populations can be monitored for population demographics and targeted for conservation efforts, particularly if they are genetically distinct or adapted to a specific set of environmental conditions. Such populations may prove to be important to the species' adaptive capacity and the preservation of its representation across the range. Survey efforts in areas where populations previously occurred, but have since become unknown, can also be useful for eastern massasauga rattlesnake recovery efforts. In some cases, populations have gone without monitoring for an extended period. In others, the eastern massasauga rattlesnake has simply gone undetected in spite of survey efforts. The eastern massasauga rattlesnake's secretive behavior and cryptic coloration make it a difficult species to detect, especially when populations are small or dispersed in low densities over large areas. The

absence of eastern massasauga rattlesnake detection at a site where this species has previously been recorded does not necessarily prove it has been extirpated. Long-term survey efforts should be conducted before extirpation is assumed, particularly if such populations are believed to be important to the preservation of this species' adaptive capacity. We anticipate that this action will take five years of implementation. **Est. Cost: $200,000**

**C. Increase public tolerance and support for eastern massasauga rattlesnake conservation.**

1. Engage and provide cooperative support for landowning organizations and private landowners when they can assist in eastern massasauga rattlesnake conservation. We anticipate that this action will take 25 years of implementation. **Est. Cost: $400,000**

2. Incentivize actions that benefit the eastern massasauga rattlesnake and its habitat, while also recognizing the needs of landowners. Some landowners may wish to continue using land in ways that are compatible with eastern massasauga rattlesnake management (such as upland bird hunting), but do not have the resources to improve habitat in a way that benefits both targets. We anticipate that this action will take ten years of implementation. **Est. Cost: $200,000**

3. Work with local outreach partners to increase outreach that highlights the role and benefits to the ecosystem when eastern massasauga rattlesnakes are present. We anticipate that this action will take ten years of implementation. **Est. Cost**: **$300,000**

**D. Increase our knowledge and understanding to ensure effective recovery of the eastern massasauga rattlesnake**.

1. Evaluate the effects of habitat management activities, including species and habitat responses to management treatments (to support effective habitat management and restoration efforts (action A.2)). Additional research, monitoring, and analysis are needed to determine appropriate management options for maintaining, enhancing, and restoring eastern massasauga rattlesnake habitat in an adaptive management approach. Research on best management practices should be re-examined and refined with the goal of effectively reducing mortality to the eastern massasauga rattlesnake, while also achieving habitat management objectives. We anticipate that this action will take 25 years of implementation. **Est. Cost: $100,000**

2. Investigate the risks of disease to populations of the eastern massasauga rattlesnake and potential management options. Epidemiological surveys and research are needed to determine the extent of snake fungal disease and other disease-causing pathogens that could potentially be a stressor to populations of the eastern massasauga rattlesnake. Research should be conducted to determine the factors that influence the prevalence of

snake fungal disease among eastern massasauga rattlesnake populations (Allender *et al.* 2016), and populations should be assessed for their potential vulnerability to the risk of a disease outbreak. Strategies to minimize the impacts of disease at the population and species level as well as to enhance the health of individual eastern massasauga rattlesnakes should be developed. This action would likely take ten years of implementation. **Est. Cost: $1,500,000**

3. Address effects of climate change through research, reconnaissance, and adaptive management. This action will also support developing and implementing conservation strategies that help remediate the effects of climate variability and subsequent hydrological fluctuations in eastern massasauga rattlesnake habitat (action A.5). Climate change has been projected to impact eastern massasauga rattlesnake populations through increased catastrophic flooding, localized droughts, and increasing invasion by woody species. Identifying key/specific sites (adjacent to water-control reservoirs where flooding is likely) that are at high risk from climate-driven factors affecting key populations needed for recovery, and finding ways to remediate for impacts could be crucial for maintaining adaptive capacity, especially near the edges of the range of the eastern massasauga rattlesnake. Identify new management approaches for established invasive species and identify new invaders that may be a potential threat to the preferred habitat of the eastern massasauga rattlesnake. We anticipate that this action will take 25 years of implementation. **Est. Costs: $1,500,000**

4. Explore the need, cost/benefits, and feasibility of eastern massasauga rattlesnake population restoration efforts through captive propagation and augmentation. Populations that are believed to be at high risk for extirpation may benefit from targeted captive propagation or attempts at population augmentation, especially if, and after, the threats to those populations are addressed. While this may increase resiliency of some populations, and adaptive capacity of the species, attempts to augment or introduce the eastern massasauga rattlesnake to the wild should be considered investigational and the USFWS should consider use of experimental populations per section 10(j) of the ESA, where appropriate. This action would likely take ten years of implementation. **Est. Costs: $750,000**

5. Collaboratively use genetic data for assessing population viability and guiding captive management, if captive management is deemed needed for recovery (see Action D4). Recent advances in population genetics techniques allow adaptive variation, demography, and effective population size to be estimated without long-term monitoring in the field. The eastern massasauga rattlesnake has been the subject of several range-wide and population level genetics studies. These existing studies and additional genetics research should guide management of captive populations, should they be deemed necessary for recovery, to ensure appropriate diversity is available for potential future reintroductions. Collaboration among the USFWS, stakeholders, and researchers will be crucial to standardize data reporting and analysis. We anticipate that this action will take five years of implementation. **Est. Cost: $250,000**

6. Achieve a better understanding of genetic diversity in the eastern massasauga rattlesnake. The eastern massasauga rattlesnake is a wide-ranging species that can have detectable genetic structure between neighboring populations in small portions of its range. Adaptive significance of this is not fully understood and may help inform recovery implementation (for example, action B.1). This action would likely take five years to investigate priority questions. **Est. Costs: $250,000**

## IV. Time and Costs

The time needed to implement recovery is a guide for meeting the recovery goals, objectives, and criteria discussed in this plan. The initiation and completion of recovery actions is subject to the availability of funds, as well as other constraints affecting the parties involved. The total cost of recovery is only an estimate and may change substantially as efforts to recover the species continue. Thus, detailed cost breakdowns for each conservation unit, with expected annual costs are not known at this time and estimates above are for all three conservation units. While we have the statutory responsibility for developing and implementing this recovery plan, recovery of the eastern massasauga rattlesnake across the coterminous United States will necessitate the involvement and contributions of Federal, Tribal, State, private, and local interests. The continued expertise and contributions of these, and additional agencies and interested parties, is needed to implement the recovery actions identified in this plan. While this recovery plan contains an overall framework of broad actions for attaining recovery, to enhance the effectiveness of this recovery plan, we intend to develop and carry out recovery implementation strategies as a flexible way to move these actions into specific activities that can be updated or modified as needed, independently of revising the recovery plan. The recovery implementation strategies can be updated as needed to reflect lessons learned from recovery implementation and next highest priorities for recovery implementation.

We do not anticipate that recovery of the eastern massasauga rattlesnake will be achieved sooner than 25 years, due to the widespread threats, uncertainty about cost/benefit trade-offs to the species from management techniques, likely availability of funds, as well as due to biological characteristics of the species. If all actions are fully funded and implemented as outlined, including full cooperation of all partners needed to achieve recovery, we expect recovery criteria for delisting could be met by 2046

**Total Estimated Cost of the Recovery Actions identified above: $31,380,000**

**Literature Cited**

Allender, M.C., J. Moore, E.T. Hileman, S. Tetzlaff. 2016. *Ophidiomyces* Detection in the Eastern Massasauga in Michigan in 2015. Technical Report to the Fish and Wildlife Service, East Lansing Field Office.

Baker, S.J., M.J. Dreslik, D.B. Wylie, and C.A. Phillips. 2016. Sources of mortality in the endangered eastern massasauga (*Sistrurus catenatus*) in Illinois. Herpetological Conservation and biology 11: 335-343.

Pomara L.Y., O.E. Ledee, K.J. Martin, and B. Zuckerberg. 2014. Demographic consequences of climate change and land cover help explain a history of extirpations and range contraction in a declining snake species. Global Change Biology. 20(7):2087–99.

Ray, J.W., R.B. King, M.R. Duvall, J.W. Robinsin, C.P. Jaeger, M.J. Dreslik, B.J. Swanson, and D. Mulkerin. 2013. Genetic analysis and captive breeding program design for the eastern massasauga *Sistrurus catenatus catenatus*. Journal of Fish and Wildlife Management 4: 104-113.

Szymanski, J., C. Pollack, L. Ragan, M. Redmer, L. Clemency, K. Voorhies, and J. Jaka. 2016. Species Status Assessment for the Eastern Massasauga Rattlesnake (*Sistrurus catenatus*). Unpublished, U.S. Fish and Wildlife Service July 2016 (version 2).

## APPENDIX A

### Future Eastern Massasauga Rattlesnake Status Review or Delisting Process

If recovery criteria are met or the USFWS otherwise determines that the threats to eastern massasauga rattlesnake have been effectively managed and sufficiently reduced in a conservation unit, we may initiate an assessment of whether recovery has been achieved. In the case of eastern massasauga rattlesnake, each of the conservation units may later be determined to meet the definition of a distinct population segment (DPS) under our Policy Regarding Recognition of Distinct Population Segments (61 FR 4722, Feb. 7, 1996). Consequently, we may consider, consistent with applicable law, whether it is possible to delist at the conservation unit (DPS) scale. Any proposal to delist the eastern massasauga rattlesnake or any potential DPSs will be published in the Federal Register. After analyzing the comments received on the proposed rulemaking, we would decide whether to complete the proposed delisting action or leave the protections of the Act in place. Our final decision would be announced in the Federal Register. The comments received and our responses would be addressed in the final rule.