

U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

Scientific Name:

Sistrurus catenatus

Common Name:

eastern Massasauga

Lead region:

Region 3 (Great Lakes-Big Rivers Region)

Information current as of:

04/29/2013

Status/Action

Funding provided for a proposed rule. Assessment not updated.

Species Assessment - determined species did not meet the definition of the endangered or threatened under the Act and, therefore, was not elevated to the Candidate status.

New Candidate

Continuing Candidate

Candidate Removal

Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status

Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species

Range is no longer a U.S. territory

Insufficient information exists on biological vulnerability and threats to support listing

Taxon mistakenly included in past notice of review

Taxon does not meet the definition of "species"

Taxon believed to be extinct

Conservation efforts have removed or reduced threats

___ More abundant than believed, diminished threats, or threats eliminated.

Petition Information

___ Non-Petitioned

X Petitioned - Date petition received: 05/11/2004

90-Day Positive:05/11/2005

12 Month Positive:05/11/2005

Did the Petition request a reclassification? **No**

For Petitioned Candidate species:

Is the listing warranted(if yes, see summary threats below) **Yes**

To Date, has publication of the proposal to list been precluded by other higher priority listing?
Yes

Explanation of why precluded:

Higher priority listing actions, including court?approved settlements, court?ordered and statutory deadlines for petition findings and listing determinations, emergency listing determinations, and responses to litigation, continue to preclude the proposed and final listing rules for this species. We continue to monitor populations and will change its status or implement an emergency listing if necessary. The Progress on Revising the Lists section of the current CNOR (<http://endangered.fws.gov/>) provides information on listing actions taken during the last 12 months.

Historical States/Territories/Countries of Occurrence:

- **States/US Territories:** Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, Wisconsin
- **US Counties:** Black Hawk, IA, Bremer, IA, Buchanan, IA, Chickasaw, IA, Clinton, IA, Louisa, IA, Muscatine, IA, Pottawattamie, IA, Scott, IA, Clinton, IL, Cook, IL, Fayette, IL, Knox, IL, Lake, IL, Madison, IL, Piatt, IL, Warren, IL, Will, IL, Allen, IN, Carroll, IN, Elkhart, IN, Fulton, IN, Kosciusko, IN, Lagrange, IN, La Porte, IN, Marshall, IN, Noble, IN, Porter, IN, Pulaski, IN, Steuben, IN, St. Joseph, IN, Tippecanoe, IN, Alcona, MI, Allegan, MI, Alpena, MI, Arenac, MI, Barry, MI, Berrien, MI, Calhoun, MI, Cass, MI, Cheboygan, MI, Clinton, MI, Crawford, MI, Eaton, MI, Genesee, MI, Grand Traverse, MI, Hillsdale, MI, Iosco, MI, Jackson, MI, Kalamazoo, MI, Kalkaska, MI, Kent, MI, Lake, MI, Lapeer, MI, Lenawee, MI, Livingston, MI, Mackinac, MI, Macomb, MI, Manistee, MI, Mason, MI, Midland, MI, Missaukee, MI, Montcalm, MI, Muskegon, MI, Newaygo, MI, Oakland, MI, Presque Isle, MI, Roscommon, MI, Saginaw, MI, St. Joseph, MI, Van Buren, MI, Washtenaw, MI, Wayne, MI, Goodhue, MN, Houston, MN, Wabasha, MN, Winona, MN, Chariton, MO, Holt, MO, Linn, MO, Livingston, MO, Genesee, NY, Onondaga, NY, Ashtabula, OH, Champaign, OH, Clark, OH, Clinton, OH, Columbiana, OH, Crawford, OH, Cuyahoga, OH, Defiance, OH, Erie, OH, Fairfield, OH, Fayette, OH, Franklin, OH, Fulton, OH, Greene, OH, Hardin, OH, Huron, OH, Licking, OH, Logan, OH, Lorain, OH, Lucas, OH, Marion, OH, Medina, OH, Montgomery, OH, Ottawa, OH, Paulding, OH, Portage, OH, Preble, OH, Sandusky, OH, Seneca, OH, Stark, OH, Trumbull, OH,

Warren, OH, Wayne, OH, Wyandot, OH, Butler, PA, Mercer, PA, Venango, PA, Buffalo, WI, Chippewa, WI, Columbia, WI, Crawford, WI, Jackson, WI, Juneau, WI, La Crosse, WI, Monroe, WI, Pepin, WI, Rock, WI, Trempealeau, WI, Walworth, WI, Wood, WI

- **Countries:** Canada

Current States/Counties/Territories/Countries of Occurrence:

- **States/US Territories:** Illinois, Indiana, Iowa, Michigan, Minnesota, New York, Ohio, Pennsylvania, Wisconsin
- **US Counties:** Black Hawk, IA, Bremer, IA, Buchanan, IA, Chickasaw, IA, Clinton, IA, Louisa, IA, Muscatine, IA, Scott, IA, Bond, IL, Clinton, IL, Cook, IL, Fayette, IL, Knox, IL, Lake, IL, Madison, IL, Piatt, IL, Warren, IL, Will, IL, Allen, IN, Carroll, IN, Elkhart, IN, Fulton, IN, Kosciusko, IN, Lagrange, IN, La Porte, IN, Marshall, IN, Noble, IN, Porter, IN, Pulaski, IN, Steuben, IN, St. Joseph, IN, Tippecanoe, IN, Alcona, MI, Allegan, MI, Alpena, MI, Arenac, MI, Barry, MI, Berrien, MI, Calhoun, MI, Cass, MI, Cheboygan, MI, Clinton, MI, Crawford, MI, Eaton, MI, Genesee, MI, Grand Traverse, MI, Hillsdale, MI, Iosco, MI, Jackson, MI, Kalamazoo, MI, Kalkaska, MI, Kent, MI, Lake, MI, Lapeer, MI, Lenawee, MI, Livingston, MI, Mackinac, MI, Macomb, MI, Manistee, MI, Mason, MI, Midland, MI, Missaukee, MI, Montcalm, MI, Muskegon, MI, Newaygo, MI, Oakland, MI, Presque Isle, MI, Roscommon, MI, Saginaw, MI, St. Joseph, MI, Van Buren, MI, Washtenaw, MI, Wayne, MI, Houston, MN, Wabasha, MN, Winona, MN, Genesee, NY, Onondaga, NY, Ashtabula, OH, Champaign, OH, Clark, OH, Erie, OH, Fairfield, OH, Greene, OH, Licking, OH, Montgomery, OH, Trumbull, OH, Warren, OH, Wayne, OH, Wyandot, OH, Butler, PA, Mercer, PA, Venango, PA, Buffalo, WI, Crawford, WI, Jackson, WI, Juneau, WI, La Crosse, WI, Monroe, WI, Pepin, WI, Rock, WI, Trempealeau, WI, Walworth, WI, Wood, WI
- **Countries:** Canada

Land Ownership:

The eastern massasauga rattlesnake is found on both public and private land (approximately 59 percent of the populations occur wholly or in part on public land). The majority of public land is State managed, although populations also occur on county and U.S. Army Corps of Engineers lands. A population possibly occurs in the LaCrosse District of the Upper Mississippi National Wildlife and Fish Refuge.

Lead Region Contact:

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Biological Information

Species Description:

The eastern massasauga rattlesnake (Figure 1) is a small, heavy-bodied snake with a heart-shaped head and vertical pupils. The average length of an adult is approximately 0.6 meters (two feet). Adult eastern massasaugas are gray or light brown with large, light-edged chocolate brown blotches on the back and smaller blotches on the sides. The snakes belly is marbled dark gray or black and there is a narrow, white stripe on its head. Its tail has several dark brown rings and is tipped by gray-yellow horny rattles. Young

snakes have the same markings as adults, but are paler than adults and the rattle is represented by a single terminal segment called a button.

Figure 1. An eastern massasauga rattlesnake (*Sistrurus catenatus*), Clinton County, Illinois. Photo by Michael Redmer©

Taxonomy:

The eastern massasauga rattlesnake, described by Rafinesque in 1818, has a variety of common names: eastern massasauga rattlesnake, eastern massasauga, prairie rattlesnake, spotted rattler, and swamp rattler (Gloyd 1940, p. 44; Minton 1972, p. 315). The U.S. Fish and Wildlife Service (Service) previously recognized the eastern massasauga rattlesnake as a subspecies (*Sistrurus catenatus catenatus*) of a wider ranging species (*Sistrurus catenatus*). Due to recently published scientific information on the phylogenetic relationships of the massasaugas we now recognize the eastern massasauga rattlesnake as a distinct species (*Sistrurus catenatus*). The rationale for recognizing this taxonomic change is as follows.

As previously recognized, the massasauga, *Sistrurus catenatus* was one of three species of rattlesnakes within the genus *Sistrurus*, and included three recognized subspecies: *S. c. catenatus* (eastern massasauga), *S. c. tergeminus* (western massasauga), and *S. c. edwardsii* (desert massasauga) (Gloyd 1940, pp. 44-55; Minton 1983, pp. 332.1-332.2), Conant and Collins (1998, pp. 231-232). It was long thought that populations of *S. c. catenatus* and *S. c. tergeminus* intergraded in Missouri, southwestern Iowa, Kansas, and Oklahoma (Conant and Collins 1998, pp. 231-232; Evans and Gloyd, 1948, pp. 225-232; Gloyd 1940, pp. 44-55). Recent phylogenetic analyses of the genus *Sistrurus*, as well as morphological differences and allopatric (occurring in clearly defined and different areas) distributions between the three taxa of massasaugas provide multiple lines of evidence to indicate that the eastern massasauga is distinct from the remaining two subspecies (Kubatko et al., 2011, p. 13; Gibbs et al. 2011, 433-439). In addition, populations occurring in central and northwestern Missouri and extreme southwest Iowa were formerly considered part of the eastern massasauga distinct population segment (USFWS 1998); however, recent evidence suggests these populations cluster genetically with the western and desert massasaugas (Chiucchi and Gibbs, 2010, pp. 5345-5358; Gibbs et al. 2011, pp. 433-439; Gerard et al. 2011, p. 291; Gibbs 2011, pers. comm.). Similar phylogenetic results have been suggested by other researchers working on this group of snakes (Douglas 2010, pers. comm.; King 2011, pers. comm.).

An article by Holycross et al. (2008, pp. 421-424) examined taxonomic conflicts with an old and unused scientific name and the names traditionally used for the three North American massasaugas. The International Commission for Zoological Nomenclature (ICZN) was recently petitioned to conserve binomial usage of, and designate neotype specimens for both *Sistrurus catenatus* and *Sistrurus tergeminus* (Crother et al. 2011, pp. 271-274). Until the ICZN rules on the petition, the Service will follow the recommendation of Holycross et al. (2008, p. 423), and will use the traditional scientific names, with the binomial name, *Sistrurus catenatus*, applied only to populations of the eastern massasauga rattlesnake as described below.

The best available information supports the recognition of the eastern massasauga rattlesnake as a distinct species, *Sistrurus catenatus*. In 2011 we recognized this taxon as a distinct species, which resulted in elevating the eastern massasauga rattlesnake listing priority number from priority of 9 to a priority of 8.

Furthermore, we revised the range of the eastern massasauga rattlesnake to the states of New York, Pennsylvania, Ohio, Michigan, Indiana, Illinois, Wisconsin, Minnesota, the eastern half of Iowa, and the Canadian province of Ontario. Extant populations in Missouri and southwest Iowa, previously thought to be included in the eastern massasauga range, no longer are considered to include the eastern massasauga rattlesnake. Massasaugas in those two areas are now understood to be the western massasauga subspecies.

Habitat/Life History:

The eastern massasauga rattlesnake generally occupies shallow wetlands and adjacent upland habitat, though this species has a wide range and shows some variation in the types of habitats it occurs in across this range. Suitable wetland habitat includes peat lands, marshes, sedge meadows, and swamp forest; typical upland habitat includes open savannas, prairies, wet open woodlands, and old fields. A high water table with places to hibernate, such as crayfish burrows or rock crevices, is an important habitat component of this species. Seasonal use of these habitats also varies greatly across the range of the species.

Historical Range/Distribution:

The historic range of the eastern massasauga rattlesnake included sections of western New York, western Pennsylvania, southeastern Ontario, the lower peninsula of Michigan, the northern two thirds of Ohio and Indiana, the northern three quarters of Illinois, the southern half of Wisconsin, extreme southeast Minnesota, and the eastern third of Iowa (Fig 2). Although the limits of the current range of the eastern massasauga rattlesnake resemble the boundaries of its historic range, the geographic distribution has been restricted by the loss of the populations from much of the area within the boundaries of that range. The eastern massasauga is probably extirpated from Minnesota (USFWS 1998, p. 7). Rangelwide, approximately 40 percent of the counties that were historically occupied by eastern massasauga no longer support the species. The eastern massasauga is currently listed as endangered or threatened in every state or province where it occurs except for Michigan, where it is designated as a species of special concern (USFWS 1998).

Figure 2. The historic range of the eastern massasauga rattlesnake (*Sistrurus catenatus*) indicated by tan shading, and the composite range of the western massasauga rattlesnake (*Sistrurus cf. tergeminus tergeminus*) and desert massasauga rattlesnake (*Sistrurus tergeminus edwardsii*) indicated by blue shading (based on Conant and Collins 1998). Three black arrows indicate locations formerly considered to be within the eastern massasauga distinct population segment, but now considered to be within the range of the western massasauga.

Current Range Distribution:

See above under historical range

Population Estimates/Status:

Complete demographic information is not available across the range of the eastern massasauga rattlesnake. However, information regarding the historical and current number of populations, recruitment potential, distribution and proximity of subpopulations, and quantity and quality of habitat give an indication of the species long-term viability (USFWS 1998, pp. A6-A17). Each state and Canadian province across the range of the eastern massasauga has lost more than 30 percent of their historic populations, and most areas have lost more than 50 percent of their historic populations. Furthermore, less than 35 percent of the remaining populations are thought to be secure. The Service, partner organizations and several species experts have recently completed a rangewide extinction risk model for the eastern massasauga (Faust et al. 2011, pp. 1-66). The model provides an analysis of population trends across the range, as well as an analysis to help better understand how multiple factors may affect populations (discussed below under Threats).

Distinct Population Segment(DPS):

In the 1998 status assessment, the eastern massasauga rattlesnake was considered a distinct population segment of the wider ranging massasauga rattlesnake. However, since the DPS almost completely overlaid the range of the previously recognized subspecies, we treated this entity as a subspecies in subsequent assessments and Candidate Notices of Review. Recognition of the distinct population segment is no longer warranted because the range of the eastern massasauga rattlesnake no longer includes extant massasauga populations in Missouri and extreme southwest Iowa. These populations were included in the eastern massasauga DPS because they were of uncertain taxonomic status (USFWS 1998, p. 1-3).

Threats

A. The present or threatened destruction, modification, or curtailment of its habitat or range:

Habitat loss is an important factor in the decline of the eastern massasauga rattlesnake. The effects of past, widespread wetland loss continue to impact eastern massasauga populations. Development and agricultural practices continue to cause habitat loss, although to a lesser degree than in the past. Habitat loss increases the distance between populations and can isolate seasonally used habitats within individual populations, can restrict gene flow and other effects of small population dynamics (see Factor E), as well as increase exposure to sources of mortality.

Destruction or modification of habitat is affecting at least 50 populations rangewide (USFWS 1998, p. 16). A few examples are as follows. In Illinois, the Des Plaines River Valley population has been fragmented into smaller subpopulations isolated by development or otherwise unsuitable habitat (Mierzwa 1993, p. 67). In Michigan, a major residential development in Oakland County eliminated much of the existing habitat and severely degraded the remaining habitat (Legge 1996, p. 8). At Wixom, Michigan, both wetland and upland habitat were degraded by agricultural practices and highway construction (Legge 1996, pp. 1-17). Similarly, in Bremer County, Iowa, a golf course is encroaching on massasauga habitat (Christiansen 1993, p. 8). In Wisconsin, cranberry farming may threaten massasauga populations (Cathy Carnes 1997, pers. comm.). In Pennsylvania, four companies applied for sand and gravel mining permits in areas supporting massasauga populations in the same year (Shiels 1997, pers. comm.). Habitat occupied by one of Ohio's largest populations (Killdeer Plains) was bulldozed and plowed-under in 1994. More recently, a sizeable area that included hibernation and gestation habitat in Pennsylvania was converted from suitable grassland habitat to row-crop agriculture unlikely to be used by the species (Jellen 2008, pers. comm.).

Studies on the spatial ecology of eastern massasaugas indicate that home ranges and movement lengths both vary considerably across the range (Johnson 2000, pp. 186-192; Reinert and Kodrich 1982, pp. 394-395; Moore and Gillingham 2006, pp. 742-751; Dreslik 2005, pp. 83-169), with populations on the northern edge of the range having greater movements (DeGregorio et al. 2011, pp. 75-77). Greater movement sizes increase the likelihood of exposure to threats such as predation or other pressures associated with barriers where mortality is more likely (DeGregorio et al. 2011, pp. 71-79). For example, roads act as dispersal barriers to eastern massasaugas, as well as sources of mortality (Shepard et al. 2008a, pp. 288-296; Shepard et al. 2008b, pp. 350-359; Rouse et al., 2011, pp. 443-456). In a two year study at one site in the state of Illinois, 42 cases of mortality on roads were documented (Shepard et al., 2008b, pp. 350-359).

In addition, urban encroachment has disrupted the natural disturbance processes (such as hydrological cycles and fire frequency), and subsequently, changes in habitat structure and vegetative composition have occurred. Prolonged flood conditions may have contributed to localized declines of eastern massasaugas in Illinois (Dreslik 2005, pp. 190), Iowa (T. VanDeWalle 2013, pers. comm.), Wisconsin (Keenlyne 1978, p. 373) and the closely related western massasauga in Missouri (Seigel et al. 1998, pp. 127-131) by making wetlands too deep for use by massasaugas. Conversely prolonged drought conditions may affect crayfish populations and thus reduce the number of suitable hibernacula available for massasaugas. Woody succession, especially by introduced species such as Eurasian and glossy buckthorn (*Rhamnus cathartica* and *R. frangula*), that results in habitat becoming too shaded may reduce or eliminate these sites as suitable places for massasaugas to bask and thermoregulate. For example, in New York State, eastern massasaugas relate spatially with areas where woody stems are in low density (Johnson 1995, pp. 43-46). In Pennsylvania increasing woody vegetation was cited as a threat at 75 percent of the eastern massasauga sites surveyed (Reinert and Buskar 1993, p. 57), and in Illinois the Service has worked with county forest preserve districts to enhance occupied habitat by funding habitat management that included removal of invasive woody species from the few remaining locations with extant eastern massasauga populations.

The Service, partner organizations and species experts from throughout the range of the species recently completed a rangewide extinction risk model for the eastern massasauga (Faust et al. 2011). Based on expert inputs, vegetative succession and habitat fragmentation were found to be the two of the three most commonly occurring detrimental factors (with the third being late season prescribed burns) occurring at sites with active eastern massasauga populations (Faust et al. 2011, pp. 12-15, 56-62). These factors may interact to restrict gene flow, and lead to small population dynamics.

Summary of Factor A

In summary, we find the best available data indicates the continued existence of the eastern massasauga rattlesnake may be threatened by habitat destruction, modification, or curtailment caused by development (e.g., residential or commercial development) or conversion to other uses (including agriculture). Although many populations occur on protected land, increased habitat loss from vegetative succession continues to contribute to overall population declines. Increased isolation between remaining populations, as well as a potential reduction in connectivity between seasonal habitats, can restrict gene flow and increase mortality rates of individuals. Habitat alteration may affect wetland hydrology, indirectly impacting massasauga populations. Since massasauga rely on crayfish burrows for hibernacula, any alterations to wetland hydrology that impact crawfish ecology will likely negatively impact the species.

B. Overutilization for commercial, recreational, scientific, or educational purposes:

Persecution, collection, and overutilization of eastern massasaugas remain a threat, with several populations having been collected beyond a recoverable threshold. These populations are thus functionally extinct, meaning that they have declined to such small sizes that they cannot grow. For example, a bounty was offered on this species in Wisconsin until 1975 (Wisconsin Department of Natural Resources 2011). Since the species was listed as endangered by the state in 1975, illegal collection of the species has been documented despite many years of legal protection (Christiansen 1993, pp. 13-14; Wisconsin Department of Natural Resources 2011). In 1998, an Indiana Department of Natural Resources law enforcement investigation uncovered a well-organized, multi-state effort to launder State-protected reptile species (including eastern massasauga). The investigation concluded with the indictment of 40 defendants. In 2009, a similar joint investigation by law enforcement agents in the United States and Canada uncovered at least 33 eastern massasaugas poached from a Canadian population, and then smuggled into the United States (New York Department of Environmental Conservation, 2009).

While scientific studies of this species are needed, at least one study (Keenlyne 1978, pp. 368-375; Keenlyne and Beer 1973, pp. 381-382) on the diet and reproductive ecology of the eastern massasauga in Wisconsin decimated the study population (USFWS 1998, p. 18; Vogt 1981, pp. 165-169). Also, numerous studies have used radiotelemetry to gather important data on behavior and habitat use of eastern massasaugas throughout the range of the species. Typically, radio transmitters are surgically implanted within the snakes. However, a recent laboratory study notes a high frequency of infection and other effects, such as changes in blood chemistry and possibly behavior, associated with implanted transmitters in individual eastern massasaugas as compared to a control group, though frequency of such effects in implanted snakes released into the wild is unknown and difficult to assess (Lentini et al. 2011, pp. 107-125). More information is needed to determine whether radiotelemetry studies may lead to adverse health effects or unacceptable levels of mortality in wild massasaugas.

C. Disease or predation:

Under normal conditions (i.e., sufficient, non-fragmented habitat) predation would not be a significant threat to this species. However, increased mortality, regardless of whether it is natural or unnatural, can detrimentally affect viability of small populations. The loss of suitable habitat forces massasaugas to utilize and traverse areas that increase their vulnerability to predation (Hay 1996, pers. comm.). At a site in

Wisconsin, for example, owl predation appears to be significant. Of the nine individuals being tracked at that site, three were taken as prey (Hay 1996, pers. comm.).

Presently, we have limited knowledge regarding disease dynamics in eastern massasauga populations. However, Cryptosporidiosis spp., a protozoan parasite that often results in a fatal, contagious infection has been diagnosed in some captive massasaugas held at the Metro Toronto Zoo (Prior and Weatherhead 1996). Another study that surveyed for exposure to West Nile Virus (WNV) and Ophidian Paramyxovirus (OPMV) in a wild population in Illinois detected no exposure to WNV (Allender et al. 2006, p. 107). Though all individuals tested were seropositive for OPMV (Allender et al. 2006, p. 107), various factors other than direct exposure to the virus could have influenced these results (Allender et al. 2006, p. 111; Allender et al. 2008, pp. 358-361; Allender et al. 2011, pp. 2383-2384). In 2009-2010, four individual eastern massasaugas from the only remaining large population in Illinois were found to have a fungal infection that apparently attacked scales around their heads. The fungal pathogen was identified as a species of *Chrysosporium* (Allender 2010, pers. comm.). Another individual collected in 2012 at the site had similar symptoms. All four individuals were collected and later died. Currently it is not known how this fungus is transmitted, or whether it is contagious between individuals. Previous to its discovery in Illinois massasaugas, *Chrysosporium* spp. were not known to infect wild populations, but have reportedly caused mortality in captive snakes (Allender 2010, pers. comm.; Paré et al. 2003, pp. 10-15; Rajeev et al. 2009, pp. 1264-1268; Vissienon et al. 1999, pp. 107-110). This and similar fungal pathogens of snakes have tentatively been termed Snake Fungal Disease (SFD) by the National Wildlife Health Center. In addition, wild timber rattlesnakes (*Crotalus horridus*), pigmy rattlesnake (*Sistrurus miliarius*), northern watersnakes (*Nerodia sipedon*), black rat snakes (*Pantherophis obsoletus* complex), and milk snakes (*Lampropeltis triangulum*) have been diagnosed with SFD, as announced by the National Wildlife Health Center Bulletin (Sleeman 2013, p. 2). In 2010, the Illinois Department of Natural Resources funded a study of this population to determine the prevalence and pathology of the *Chrysosporium* fungus.

D. The inadequacy of existing regulatory mechanisms:

Eastern massasauga is listed as endangered in the states of Illinois, Indiana, Iowa, Minnesota, Missouri, New York, Ohio, Pennsylvania, and Wisconsin; as threatened in the Canadian province of Ontario; and as special concern in the state of Michigan. Although the species is afforded some level of state protection across its range, protection of its habitat is nearly nonexistent. Given the significance and pervasiveness of habitat loss, the decline of eastern massasauga will continue without additional protections..

E. Other natural or manmade factors affecting its continued existence:

Small population size and isolation

The thermoregulatory behavior of the gravid cohort renders female massasaugas most vulnerable to collection, predation, and other sources of mortality. This species is viviparous (live-bearing), and gravid females at some sites are known to congregate in areas that allow them to maintain body temperatures that are optimal for gestation. Two studies using a population viability analysis indicated that eastern massasauga populations are most sensitive to adult mortality (Seigel and Sheil 1999, pp. 19-20). In addition, survival of females to sexual maturity appears important to population viability (M. Dreslik 2012, pers. comm.). Females do not bear their first litter until three years of age, or older, and then they usually do so only once every other year. This low biological replacement rate means that eastern massasauga populations occurring at low densities are particularly sensitive to losses, both natural (e.g., predation) and human (e.g., collection or mortality due to land use practices). Thus, premature death or loss of just a few individuals could greatly diminish reproductive potential in such populations. Active-season survival varies greatly across the species range or between study sites (Bailey et al. 2011, pp. 167-173; Bissel 2006, p. 87; Harvey and Weatherhead 2006, pp. 66-73; Jellen and Kowalksi 2007, pp. 994-1000; Jones et al. 2012, p. 1578; King 1999, p. 80), though it appears to increase along a south to north latitudinal gradient (Jones et al. 2012, p. 1578). Given the species low biological replacement rate, even small increases in adult mortality can lead to irreversible

declines. These biological traits and the threat factors identified above interact synergistically, which exacerbates the effect of individual factors and can lead to an extinction vortex for those populations affected by one or more factors.

The Service and partners recently completed a rangewide extinction risk model for the eastern massasauga (Faust et al. 2011, pp. 1-69). A key finding of the model was that several factors mentioned above may be simultaneously affecting massasauga populations. For example, vegetative succession, habitat fragmentation, and habitat management approaches were found to be affecting many extant populations of this species beneficially, adversely, or in a potentially offsetting manner. Throughout the species range, its habitat (graminoid-dominated wetlands or adjacent uplands) are often characterized as fire-dependent, and land managers use prescribed fire to maintain vegetative structure. However, late-season fires can also lead to high mortality, including of reproductive age adults (Durbian and Lenhoff 2004, pp. 21-25; Durbian 2006, pp. 320-334). The rangewide extinction risk model also found that many extant populations across the range of the species are very small, and may be subject to effects of small population size (e.g., limited genetic diversity, Allee effects, wherein it becomes increasingly difficult for mature adults to find one another to mate) and small population dynamics (Faust et al. 2011, p. 59-60).

Climate change

Climate change is believed to be actively leading to declines in reptile populations (Gibbons et al. 2000, p. 654). While there are still few data on how climate change will affect the eastern massasauga, a climate change vulnerability model for species occurring in Illinois considered the eastern massasauga to have attributes that would make it moderately vulnerable to the effects of climate change (Walk 2011, pers. comm.). Climate change may affect reptiles through a variety of factors, including altered precipitation regimes, food shortages, phenological shifts, or by changing incubation/gestation patterns (Gibbons et al. 2000, pp. 654, 660). While any of these could affect the eastern massasauga, there is no data specific to this species. To date most literature on the effects of climate change on vipers (including the eastern massasauga) centers on hypotheses that past climate change cycles (especially cooling), or occurrence in cool climates, influenced the evolution of modes of parity, and that viviparous species diversified at a greater rate during cooling cycles than did oviparous species (Lynch 2009, p. 2457). This theory implies that viviparity allows females to more closely regulate incubation conditions through their behavior (Lourdais et al. 2004, p. 551; Lynch 2009, p. 2458; Madsen and Shine 1992, p. 40-47; Shine 2004, p.145). In addition to physiological or evolutionary effects, climate change may also affect the habitat of the eastern massasauga. It is also theorized that climate change will promote the expansion of invasive plant species (Thuiller et al. 2007, pp. 197, 200). If this is the case, enhanced invasion/range expansion of invasive woody species in particular could increase the magnitude of this threat to the habitat of eastern massasauga. Other ways that climate change may affect the eastern massasauga may include loss of hibernacula (e.g., if crayfish colonies experience die-off during prolonged drought), or mortality due to prolonged flooding in periods of higher than normal precipitation.

Summary of Threat E

In summary, we find the best available data indicates the continued existence of the eastern massasauga rattlesnake may be threatened by other natural or manmade factors, including, increased risks associated with thermoregulation behavior (e.g., exposure leading to increased predation, collection) and climate change (e.g., precipitation changes, incubation/gestation patterns). Gravid or gestating females may be particularly vulnerable to an increased risk of mortality from predation and illegal collection because their tendency to congregate in areas for thermoregulation makes them more visually exposed during portions of the year when they bask more. Many eastern massasauga populations have declined to critical levels, increasing susceptibility to low birth rates and small population dynamics. Although the effects of global climate change on this species are still unknown, at least one climate change model indicates a moderate vulnerability to predicted climate change.

Conservation Measures Planned or Implemented :

Management and monitoring guidelines for the eastern massasauga were developed under Region 3 guidance and made available as *The Eastern Massasauga Rattlesnake: A Handbook for Land Managers* in 2000. This handbook was broadly distributed and is currently being used by public land managers to assist them in developing candidate conservation agreements.

We have developed several candidate conservation agreements (CCA) for the eastern massasauga, and are preparing several more. A CCA is a formal agreement between the Service and one or more parties to address the conservation needs of proposed or candidate species, or species likely to become candidates, before they become listed as endangered or threatened. Landowners voluntarily commit to conservation actions that will help stabilize or restore the species with the goal that conservation increases to a level where listing will become unnecessary. In 2004, a CCA with the Lake County Forest Preserve District in Illinois was completed. In 2005, a CCA with the Forest Preserve District of Cook County, Illinois, was completed. In 2006, a Candidate Conservation Agreement with Assurances (CCAA) with the Ohio Department of Natural Resources Division of Natural Areas and Preserves was completed for Rome State Nature Preserve in Ashtabula County, and a CCAA with the Wisconsin Department of Natural Resources was completed for the lower Chippewa River in 2011. Other state-wide and/or site-specific CCAs and CCAAs are currently being developed in Illinois and Michigan.

In addition, we have continued to gather status information on eastern massasauga populations in the states where it occurs, including several priority sites, and we work with state and local partners to implement conservation actions for the species. The following is a brief listing of ongoing actions being taken as part of the region-wide massasauga conservation initiative.

Illinois Carlyle Lake Project:

The Service and Illinois Department of Natural Resources funded field and laboratory work to assess of the prevalence and pathology of the *Chrysosporium* sp. fungus in wild massasaugas at the Carlyle Lake population (Clinton County) in 2011.

Conducted surveys and radio telemetry work at Carlyle Lake (Clinton County) to determine spatial & temporal habitat use. The 2012 field season was the fourteenth consecutive year of this research.

Developing a CCA for the Carlyle Lake population.

Northeast Illinois Project:

Conducting surveys and habitat management assessments in Knox, Lake, and Cook Counties, with Illinois DNR and local partners.

Continuing habitat management actions as needed at the sites in Lake, Cook and Will Counties.

Completed an agreement with the Association of Zoos and Aquariums (AZA), Forest Preserve District of Cook County, Forest Preserve District of Lake County, the Illinois Department of Natural Resources, Lincoln Park Zoo, and Brookfield Zoo, to capture, house and breed eastern massasauga rattlesnakes from a non-recoverable population in northeastern Illinois.

Indiana

Developing and distributing education/outreach materials (including brochure and recommendations of how to approach landowners) for region-wide use.

Iowa

Conducted radio telemetry studies at Sweet Marsh Wildlife Management Area (WMA) in Bremer County.

Contacted pertinent private landowners adjacent to Sweet Marsh WMA.

Michigan

Provided funding and technical assistance for a multi-year assessment of a massasauga population in southwest Michigan, in partnership with researchers from Northern Illinois University and the Association of Zoos and Aquariums (study ongoing as of 2013).

Conducting ongoing surveys in known and potential massasauga areas to identify "core" protected properties in the following counties: Alcona, Allegan, Alpena, Barry, Benzie, Berrien, Calhoun, Cass, Cheboygan, Clinton, Crawford, Emmet, Huron, Iosco, Jackson, Kalamazoo, Kalkaska, Lapeer, Lenawee, Livingston,

Mackinac, Manistee, Missaukee, Montcalm, Montmorency, Muskegon, Newaygo, Oakland, Oceana, Ogemaw, Presque Isle, Roscommon, Sanilac, St. Joseph, Van Buren, and Washtenaw.

Conducting a habitat characterization for massasauga in Michigan.

Developing a state wide umbrella CCAA document.

Finalizing a statewide review of all available element occurrence records to assess stats and trends of known massasauga localities with the Michigan Natural Features inventory.

Minnesota

Conducting surveys along the Mississippi River floodplains in Houston, Wabasha, and Winona counties to determine eastern massasauga presence in this area.

Ohio

Conducting relative abundance surveys at Rome and Pallister Nature Preserves in Ashtabula County.

Developed CCAA document for Pallister Nature Preserve.

Wisconsin

An analysis of the vegetation and hydrologic conditions of the Chippewa River Bottoms was completed to determine the extent of change that has occurred since 1939.

Completed a CCA for Chippewa River Bottoms and Black River populations in Buffalo, La Crosse, Pepin, and Trempealeau counties (September 2011).

Rangewide

The Service is an invited non-zoo advisor to the Association of Zoos and Aquariums Species Survival Plan for the eastern massasauga rattlesnake. As such we actively provide technical assistance, or collaborate on/contribute to several ongoing discussions or studies into massasauga conservation, diet and nutrition, reproductive biology, physiology, and population dynamics. The Species Survival Plan also has an important outreach function, and is able to provide informative materials to thousands of zoo visitors and other AZA audiences (e.g., through web sites).

Environmental awareness and public outreach efforts are being implemented throughout the range of the eastern massasauga. In 2003, Region 3 of the Service published and helped to distribute a 10-page, full-color, educational brochure entitled Live and Let Live: People and the Eastern Massasauga Rattlesnake, which was developed in conjunction with the Indiana Department of Natural Resources Wildlife Diversity Section. Demand for these brochures has been high, and Region 3 has had additional copies printed. In addition, multiple fact sheets about massasaugas remain available on the Region 3 internet site (<http://midwest.fws.gov/Endangered/lists/candidat.html>).

Summary of Threats :

Habitat loss is an important factor in the decline of eastern massasauga. The effects of past, widespread wetland loss continue to impact eastern massasauga populations. Development and agriculture practices continue to perpetuate habitat loss, although to a lesser degree than in the past. The majority of extant populations of the eastern massasauga occur on public preserves or other land that is protected (USFWS 1998). However, recent information indicates that fragmentation and loss of suitable habitat area is continuing even on such sites, and especially where invasive woody vegetation is altering the vegetative structure of massasauga habitat. In general, habitat loss increases the distance between populations and can isolate seasonally used habitats within individual populations. Consequently, eastern massasauga populations become more susceptible to road mortality, predation, and persecution as snakes disperse from populations or make their seasonal movements between habitat types.

The biological traits and the threat factors identified above interact synergistically, which exacerbates the effect of individual factors and small population dynamics. In such cases, these factors can lead to an extinction vortex for those populations affected by one or more factors.

We find that this species is warranted for listing throughout all its range, and, therefore, find that it is unnecessary to analyze whether it is threatened or endangered in a significant portion of its range.

For species that are being removed from candidate status:

_____ Is the removal based in whole or in part on one or more individual conservation efforts that you determined met the standards in the Policy for Evaluation of Conservation Efforts When Making Listing Decisions(PECE)?

Recommended Conservation Measures :

Since many extant populations of this species occur on preserves or otherwise protected tracts of habitat, as well as adjoining private property, we recommend that state, local, or non-government agencies, or private landowners responsible for massasauga habitat explore the possibility of entering Candidate Conservation Agreements (CCA) or Candidate Conservation Agreements with Assurances (CAAA) with the Service. CCAs or CCAAs allow the partner agency or landowner to work cooperatively with the Service to identify land management measures that would be beneficial to the species. Examples of such actions include: wetland and other habitat restoration activities or control of invasive species to improve habitat for massasaugas, strategic roadside mowing to discourage snake use of areas around roads, reduce likelihood of mortality by adjusting prescribed burn prescriptions or other land management activities for times when massasaugas are dormant. In addition to proactive land management practices, we also recommend outreach activities that might lessen public persecution of this relatively secretive, but venomous snake.

Priority Table

Magnitude	Immediacy	Taxonomy	Priority
High	Imminent	Monotypic genus	1
		Species	2
		Subspecies/Population	3
	Non-imminent	Monotypic genus	4
		Species	5
		Subspecies/Population	6
Moderate to Low	Imminent	Monotypic genus	7
		Species	8
		Subspecies/Population	9
	Non-Imminent	Monotype genus	10
		Species	11
		Subspecies/Population	12

Rationale for Change in Listing Priority Number:

Magnitude:

The magnitude of threats is considered moderate at this time. About 59 percent of extant populations occur wholly or in part on public lands, many of which are currently preparing CCAs that will protect the snakes in perpetuity. As land managers increase their knowledge of this species, management practices that conflict with massasauga conservation are being addressed. Public outreach efforts and simple word-of-mouth are also raising the awareness of the importance for massasauga-friendly management among adjacent properties owners. However, some extant populations are now very small, and have a low to moderate likelihood of persisting and remaining viable. Other populations are likely to suffer additional losses in abundance and the species may lose genetic diversity if additional local populations are extirpated in the near future. Declines

have continued or may be accelerating in several states (Faust et al. 2011, pp. 18-56). Thus, we are monitoring the status of this species to determine if a change in listing priority is warranted.

Imminence :

Threats of habitat modification, habitat succession, incompatible land management practices, illegal collection for the pet trade, human persecution, and emerging diseases are all ongoing. In addition, the potential effects of climate change on this species are of concern. The rangewide extinction risk model completed by the Service and partners (Faust et al. 2011) indicates that populations of this species are particularly vulnerable in situations where multiple factors and threats work together to effect population trajectories. Thus these threats remain an imminent threat to many remaining populations, particularly those located on private lands.

Yes Have you promptly reviewed all of the information received regarding the species for the purpose of determination whether emergency listing is needed?

Emergency Listing Review

No Is Emergency Listing Warranted?

Emergency listing is not warranted at this time because approximately 59 percent of populations occur wholly or in part on public lands, and many of the land managers are currently preparing CCAs and/or voluntarily practicing massasauga-friendly management practices.

Description of Monitoring:

Throughout the year, Service biologists within Regions 3 and 5 informally coordinate with each other, as well as with state and provincial biologists, state endangered species program staff, and other species experts throughout the range of the subspecies.

In addition, the Services Endangered Species Program Coordinators from each state in Region 3 join their counterparts from the state wildlife agencies each fall for a 3-day coordination meeting. During this annual meeting, recently completed and/or ongoing research efforts, survey results, and conservation activities at the state and local levels and other concerns (e.g., emerging disease issues) regarding massasaugas are discussed.

Because the Service has provided funding to several states for gathering baseline data and for investigating and developing CCAs, new and updated data are being generated for many populations. The Service is receiving this information in the form of annual/interim reports and population updates from these recent and/or ongoing regional survey efforts. Another source of information has been from the scientific literature.

Indicate which State(s) (within the range of the species) provided information or comments on the species or latest species assessment:

Illinois,Indiana,Iowa,Michigan,Minnesota,New York,Ohio,Pennsylvania,Wisconsin

Indicate which State(s) did not provide any information or comment:

none

State Coordination:

In preparing this document, we have consulted with local species experts, biologists, or program administrators from state and local governments, as well as Service field offices, regional offices, or national wildlife refuges known to have eastern massasauga populations, in all states within the species range (Iowa,

Illinois, Indiana, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, and Wisconsin). In addition, eastern massasauga is included in State Wildlife Action Plans in every state across the species range. The eastern massasauga is also considered a threatened species in Ontario, Canada. In addition to coordinating with the states, the Service also coordinates with our counterpart agency (Parks Canada) responsible for conserving the species in Canada.

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Approval/Concurrence:

Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve:



05/28/2013

Date

Concur:



10/28/2013

Date

Did not concur:

Date

Director's Remarks: