Status Assessment for the Eastern Massasauga (Sistrurus c. catenatus) 1998

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SISTRURUS CATENATUS CATENATUS
STATUS ASSESSMENT

Taxonomy

Sistrurus catenatus is one of three species of rattlesnakes within the genus *Sistrurus*. Three subspecies of *Sistrurus catenatus* are recognized*, S. c. catenatus, S. c. tergeminus, and S. c. edwardsii* (Gloyd 1940, Minton 1983, Conant and Collins 1991, Johnson 1995). *Sistrurus. c. catenatus* was described by Rafinesque in 1818. The species is commonly known as the eastern massasauga. Synonymy includes prairie rattlesnake, spotted rattler, and swamp rattler (Minton 1972).

The northern limit of *Sistrurus catenatus* range is described as central New York and southwestern and west-central Ontario and extends south to extreme southeastern Arizona and the Gulf Coast of Texas (Schmidt and Davis 1941, Stebbins 1966, Minton 1983, Conant and Collins 1991, Johnson 1995, Prior and Weatherhead 1995), including northwestern Pennsylvania, Ohio, Michigan, Indiana, Illinois, Wisconsin, southeastern Minnesota, Iowa, Missouri, Kansas, southeastern Nebraska, Oklahoma, eastern Colorado, Arizona, New Mexico, and Texas (Figure 1).

The distribution of *S. c. catenatus* (eastern subspecies) is typically given as western New York and southern Ontario to Iowa and Missouri (Conant 1951, Minton 1972, Prior 1991, Beltz 1992, Hay and Kopitzke 1993, Johnson 1995, Kingsbury *in press*). Conant and Collins (1991) reported the range of *S. c. tergeminus* as southwest Iowa, extreme western Missouri, Kansas, Colorado, Oklahoma, and Texas; and the range of *S. c. edwardsii* as west-central Texas, southern New Mexico, and southwest Arizona. They also indicated zones of intergradation between *S. c. catenatus* and *S. c. tergeminus* in Missouri, and overlap between *S. c. tergeminus* and *S. c. edwardsii* in Texas (Figure 1). Minton (1983) delineated a small zone of intergradation between *S. c. catenatus* and *S. c. tergeminus* in southwestern Iowa, and a broader zone between *S. c. tergeminus* and *S. c. edwardsii* in Texas, Colorado, and New Mexico. Conversely, Schmidt and Davis (1941) reported *S. c. catenatus* occurrence into Kansas, Oklahoma, and Nebraska with a zone of intergradation in Kansas and Oklahoma.

Recent and ongoing studies further confound the subspecies delineation. A venom protein analysis of *S. catenatus* in Missouri failed to detect major differences between individuals believed to be *S. c. catenatus* and *S. c. tergeminus* (Steve Mackessy, Colorado State University, pers. comm. 1996). This is consistent with the results of Seigel's morphological evaluation of Missouri specimens purported to be *S. c. catenatus* and *S. c. tergeminus*. Data (obtained from Reinert 1978) were used to compare morphological characters of the two putative subspecies. Of the 26 morphological traits analyzed, 24 overlapped (Richard Seigel, Southeastern Louisiana University, pers. comm. 1996). Given these results, Seigel postulates that there is a clinal variation in morphological features rather than an abrupt change, which suggests that specimens in Missouri are likely the same species, i.e, *S. c. catenatus*.

Habitat utilization differences between *S. c. catenatus* and *S. c. tergeminus* support Mackessy's and Seigel's findings. *Sistrurus c. catenatus* occupies wetland or mesic prairie habitat, whereas *Sistrurus c. tergeminus* is found in xeric grasslands (Stebbins 1966). Although massasaugas throughout the eastern population, may for a portion of the active season utilize upland habitat, they are wetland inhabitants.

Based on the MacKessy's genetic and Seigel's morphological findings and the habitat utilization behavior of these individuals, it is believed that all *S. catenatus* individuals inhabiting Missouri and Iowa are likely *S. c. catenatus* (Rich Seigel, pers. comm. 1996; James Christiansen, Drake University, pers. comm. 1996).

Although it is suspected that *S. catenatus* is imperiled rangewide, cogent evidence is available only for the eastern subspecies. Given the disparity between published subspecies delineation and the current understanding, it is appropriate to address the eastern population rather than the eastern subspecies.

The eastern population (hereafter, referred to as the eastern Distinct Population Segment, DPS) includes all *Sistrurus catenatus* populations found north and east of the Missouri River (Figure 2). The ranges of the eastern DPS and *S. c. catenatus* are identical according to the most recent information, and are nearly identical to the distribution described in published literature (as described in Conant and Collins 1991).

As required by Service policy (61 FR 26, February 7, 1996), the eastern DPS fulfills the requirements necessary for designation as a Distinct Population Segment. First, the eastern DPS meets the "discreteness" criterion in that the eastern population is separated from other *Sistrurus catenatus* populations by natural and anthropogenic barriers. Historically, *Sistrurus catenatus* spanned the Missouri River in Missouri, Iowa, Kansas, and Nebraska. Currently, however, extant populations are relegated to small, isolated areas. Physical features, behavioral traits, and anthropogenic barriers (e.g., highways, inhospital land, etc.) substantially limit movement between populations. The Missouri River separates the *Sistrurus catenatus* populations occupying Iowa and Missouri from the *Sistrurus catenatus* populations found west and south of the river in Nebraska and Kansas (Seigel pers. comm. 1996). Radio-telemetry has demonstrated that when necessary massasaugas will traverse waterbodies (Michel Villeneuve, Georgian Bay Islands National Park, pers. comm. 1996). However, the size and current of the waterway, as well as the physiological need of the snake are critical factors influencing the snake's willingness and/or ability to do so. Although it is unlikely that the Missouri River serves as a complete and total barrier, the size and current of this river undoubtably severely restricts movement across.

Another important factor is the distance between extant populations east and west of the Missouri River. The closest known population east of the Missouri River is approximately 16 km (10 miles) with no intervening suitable habitat. The closest population west of the river is 322 km (200 miles), although there are sporadic occurrence records 11 to 13 km (7 to 8 miles) from the Missouri border (Joe Collins, University of Kansas, pers. comm. 1996). Radio-telemetry studies across the eastern part of the range have shown that massasaugas have limited dispersal capabilities (e.g., greatest movement documented is 3156 m, Richard King, U.S. Fish and Wildlife Service, *in litt*. 1997). Given the formidable barrier of the Missouri River and the limited dispersal capability of *S. catenatus,* it is reasonable to conclude that genetic interchange is minimal. Therefore, the eastern DPS is considered discrete from the other conspecific population units west and south of the Missouri River.

Second, the eastern DPS meets the "significance" criterion because loss of this population would result in a substantial void in the range of *S. catenatus*. The eastern DPS comprises nearly 50 percent of the *Sistrurus catenatus* range. Furthermore, morphological, behavioral, and preliminary genetic analyses show there is great variation among and within the eastern and western populations. Thus, loss of the eastern DPS would result in a significant reduction in the range of the species, and a loss of the unique characteristics found within the eastern DPS of the taxon. Ascertaining whether the eastern DPS meets the third criterion, endangered or threatened status, is the purpose of this status assessment.

Physical Description

Sistrurus c. catenatus (hereafter, referred to as massasauga) are thick-bodied, small snakes with heart-shaped heads. Typically, massasaugas are described as gray to light brown with large, dark dorsal blotches. Technical physical descriptions of *S. c. catenatus* are numerous in the literature (e.g., Schmidt and Davis 1941, Evans and Gloyd 1948, Gloyd 1940, Minton 1972, Johnson 1995, Kingsbury *in press*). Evans and Gloyd (1948) identified the chief diagnostic characters as the number of ventral scales (male:133-146; female: 139-149); the number of dorsal blotches (21-37 red-brown colored blotches), and general coloration, particularly the degree of mottling or blotching of the ventral surface (ground color of gray-brown with a very dark venter). Other distinguishing features include 25 mid-body dorsal scales; a moderate size head with a non-symmetrical dorsal pattern; stout and subcylindrical body tapering toward the head and tail; and a rounded snout and a small but well developed rattle. Average lengths for males and females are 612 mm and 523 mm, respectively. Young are well-patterned but paler than adults (Johnson 1995) and the rattle is represented by a single "button" (Hallock 1991).

Distribution and State Status

The range of *S. c. catenatus* is believed to have expanded north and eastward following the retreat of the Wisconsin glacier approximately 18,000 years ago (Schmidt 1938, Cook 1993). Early accounts suggest that massasaugas were not only widespread but were common at most localities as well. Olin (1930 *in* Vogt 1981) reported "hundreds of massasaugas" near Milwaukee, Wisconsin in the 1830's.

Hay (1893) described the massasauga as "extremely abundant" in Illinois. Conant (1951) characterized the massasauga as common at several localities in Ohio in 1938. Vogt (1981) documented a report of "thousands of massasaugas" near Portage, Wisconsin in 1849. Minton (1972) stated that massasaugas were once plentiful throughout the northern Indiana lake plains. However, by the mid-1970s, massasaugas were recognized as nationally imperiled, and believed to be threatened in more than 75 percent of their range (Ashton 1976). Even within the most robust populations noticeable declines were apparent by 1972 (Vogt 1981). Although the current range of the massasauga resembles the species' historical range, the geographic distribution has been restricted (Figure 3), and consequently, massasaugas are afforded some level of legal protection in every state/province where they occur (Table 1).

For most States, estimates of population size from the past or the present are not available. Devising quantitative population estimates are typically difficult for imperiled species because of low abundance. Given the species' inconspicuous behavior, this is especially true for massasauga populations. Nevertheless, other factors are useful in making reliable population assessments. For example, factors such as the number of healthy populations, relative size of existing populations, recruitment potential, distribution and proximity of subpopulations, quantity and quality of habitat, presence of potential and imminent threats, and historical observation information reliably reflect the species' long-term status. Thus, in assessing the massasauga's status, these factors were used to devise population status and trend criteria (Appendix A6). Occurrences are assigned "secure" population trend if there is evidence of reproduction and suitable habitat is available. "Presumed secure" trend is assigned to sites with seemingly secure populations but data is inconclusive. Vulnerable rank is given to populations whose long-term viability may be threatened but declines are not patent. Populations assigned "declining" trend are threatened with extirpation. "Presumed declining" trend is assigned to populations that appear to be declining but conclusive data is lacking. Populations with little or no data are assigned "unknown" trend.

Across the species' range, massasaugas are tracked at different population scales. Some States/Provinces (e.g., Michigan, Pennsylvania, and Ontario) track on an occurrence basis, some (e.g., Iowa and Wisconsin) employ a metapopulation approach, and others (e.g., Illinois, Indiana and Ohio) prefer a combination of the two. Consequently, in reporting massasauga status, some use the term population to refer to an occurrence while others use it to denote a metapopulation (hereafter, the terms population and occurrence are used synonymously). As a result, States that track on an occurrence-by-occurrence basis report a greater number of populations than States that track massasaugas at the metapopulation scale. Further, the criteria used to define occurrence and metapopulation vary across the species' range. For example, in Ontario occurrences separated by impassable barriers or by distances of more than five kilometers are treated as separate populations unless habitat continuity makes population continuity likely. In Michigan, however, occurrences separated by more than four miles or at least one mile of unsuitable habitat or a major barrier to dispersal are considered distinct populations.

Given the disparity of how massasaugas are tracked (i.e., occurrence vs metapopulation) and the subjectivity in defining population terms, comparisons of population numbers among States/Provinces is neither appropriate nor reflective of the true population status. Moreover, habitat fragmentation and modification eliminates, isolates, and divides occurrences. While doing so, the health of the massasauga metapopulations decline but the actual number of occurrences increases. That is, fragmentation inflates the number of occurrences. The number of secure populations, however, may or may not be affected. In some instances, fragmentation may subdivide a single metapopulation into two, distinct occurrences. Although habitat loss has occurred, the long-term viability of the two may not be threatened. Conversely, habitat fragmentation can subdivide a population into two or more isolated, nonviable occurrences. In this scenario, the number of occurrences increases but the number of secure populations decline. Therefore, the number of secure populations, rather than the actual number of extant populations, provides a more accurate reflection of massasauga status.

<u>Illinois</u>- Historically, massasaugas occurred throughout the northern four-fifths of the state (Smith 1961). Today, the range is greatly reduced, and extant populations are widely disjunct and isolated. Of the 25 historical populations, only five and possibly two others persist (Table 2). Of these seven populations two are vulnerable, three are declining, and the population trend of the remaining two is unknown. Imminent threats, limited habitat, and small population size threaten the continued survival of the massasauga in Illinois. Due to drastic range constriction, massasaugas were afforded state endangered status in 1994 (Herkert 1994).

<u>Indiana</u>- Historically, massasaugas were widely distributed across the northern half of the state. The range has been severely restricted and currently includes only a third of the area that it once covered (Kingsbury *in press*). The largest and most robust populations were along the Lake Michigan lakeshore and the northeastern corner of the state. Although numerous distinct occurrences exist across the state, many of these were historically interconnected populations forming metapopulations. Remnants of five metapopulations still exist today but, in all, habitat fragmentation has eliminated some occurrences and isolated others. For example, many of the sites along Lake Michigan have been extirpated and only a few small, isolated occurrences remain (Kingsbury *in press*).

Of the 44 historical populations, 12 and possibly three others are extirpated (Table 3). Massasauga occurrence at ten sites has not been documented since mid-1980s, and the current status of these populations is unknown. At this time, no sites in Indiana are considered secure, and of the remaining, eight are declining or presumed declining and 11 have unknown population trend. Massasaugas are state listed as endangered (Katie Smith, Indiana Department of Natural Resources, pers. comm. 1997).

<u>Iowa</u>- The historical range of the massasauga included everywhere suitable habitat existed in the eastern and the southern two-thirds of Iowa. The current range is restricted to discrete, isolated areas. Based on discussions with several residents, Christiansen (1993) believes that massasaugas in the early 1900s were abundant throughout the Wapsipinicon River corridor (located in eastern Iowa). Today, however, massasaugas are rarely, if ever, encountered there. Massasaugas are specimen documented

from 10 historical sites in 11 counties. An additional three historical sites in four counties (Black Hawk, Buchanan, Chickasaw, and Cedar counties) are believed to have valid records despite the lack of specimens. Although massasaugas have not been documented from Upper Wapsipinicon River (southern Buchanan and northern Linn counties), Skunk River (Des Moines County) and an unnamed site (Washington County), these areas are possible historical localities as well (because of the proximity to known populations and the presence of excellent habitat)(Christiansen 1993).

Currently, five populations are extant; all of which are declining (Table 4). Loss of habitat, incompatible landuse, collection and intentional killing are the primary causes of the massasauga decline (Christiansen 1993). Massasaugas have been considered imperiled since the 1980s (Christiansen 1981 *in* Christiansen 1993) and are currently on the State's endangered species list (Iowa Dept. of Natural Resources, ftp://ftp.heritage.tnc.org/ pub/nhp/us/ia/species.html, April 21, 1998).

<u>Michigan</u>- The historical range of the massasauga includes most of the lower peninsula with occurrences documented in 50 of 68 lower peninsula counties. Although somewhat inflated relative to other states (as previously explained), the large number of extant occurrences in Michigan suggest that it is--and probably was--the stronghold for the species. Of the 204 historical localities, 40 and possibly 10 others are extirpated, 137 are extant, and 17 have unknown status. Of the 154 possibly extant populations, 21 are secure, 19 are presumed secure, 64 are vulnerable, 14 are declining (or presumed declining), and 36 have unknown the population trend (Table 5). Despite the large number of occurrences that persist, it is apparent that the Michigan massasauga population has declined. Forty populations, comprising one-quarter of the counties that massasaugas were found historically, are now extirpated; and nearly one-third of the remaining historical occurrences have not been reconfirmed in the past ten years (Legge 1996). Further, approximately half of the existing populations are considered threatened at some level (Table 5).

It is noteworthy that the northern sites have not been surveyed as intensely as the southern areas; thus, despite lacking evidence, several of these populations may still persist. The populations in the south, however, are isolated and many are restricted to public land or nature preserves. Urban encroachment and other factors continue to threaten many of the southeastern populations. Specifically, 8 of the 21 secure populations occur in the area with the highest developmental pressure (i.e., southeastern Michigan), and it is probable that such pressure will intensify in the near future. Furthermore, massasaugas are widely persecuted (e.g.,documented persecution at nine sites) despite their statewide protected status. As human encroachment continues, this problem will only be exacerbated. Although quantitative population estimates are not available, researchers most familiar with the species in Michigan have observed declines at several sites (Craig Weatherby, Adrain College, MI, pers. comm. 1998; James Gillingham, Central Michigan University, MI pers. comm. 1998). If these trends continue the massasauga will become imperiled in Michigan as the species has elsewhere.

Minnesota- Massasaugas are specimen documented from one site in Wabasha County, and reported by reputable scientists from four other sites (two in Wabasha County, one in Houston County, and one in Goodhue County) (Table 6). Two additional sites are anecdotally reported from Wabasha County (Reads Landing and Weaver Dunes). The precise historical distribution of the massasauga in Minnesota is difficult to ascertain, but the presence of once-robust populations on the Wisconsin side of the Mississippi River, the sightings by reputable herpetologists, and the abundance of good habitat suggests that massasaugas occurred at least along Mississippi River. Until 1989, several southwestern counties of Minnesota offered a bounty for both massasaugas and timber rattlesnakes (*Crotalus horridus*) (Oldfield and Morairty 1994). Although many of the massasaugas collected and bountied were probably captured from the Wisconsin side of the Mississippi River, the large number of snakes harvested would have severely affected any resident populations.

Two of the five historical populations are extirpated and the other three are likely extirpated. The last reported sighting was in 1986 (MCBS 1994). A 1994 survey failed to document massasauga occurrence. If populations persist in Minnesota, they are threatened by small population size and habitat fragmentation. Massasaugas are listed as endangered in Minnesota (Minnesota DNR 1996).

Missouri- Massasaugas are historically known from 13 sites in eight counties. Eight populations (comprising four counties) are extirpated and two others are likely extirpated. Of the remaining three populations one is secure and two are vulnerable. Massasaugas were state listed as endangered in 1974 (Johnson and Figg 1993).

New York- Historically, massasaugas were reported from five localities, three of which have been verified (Table 8). Although the two unverified localities (Wayne County and Chautauqua County) were visited numerous times subsequently, researchers and state personnel have failed to validate the purported sightings. At the Wayne County site, peat mining has altered the habitat and the Chautauqua County no longer provides (and may never have) suitable habitat. Johnson (1995) suggested that the specimen collected at the latter site may have been accidentally introduced from an Ontario site (through a shipment of peat moss).

Extensive muck farming has rendered the Cayuga County site unsuitable and massasaugas are believed extirpated from Cayuga County. The remaining populations are well documented (Moesel 1918, Wright 1919, Breisch 1984, Johnson 1990 *in* Johnson 1995; Wibbe 1883, Rust 1883, Whiffen 1913, Breisch 1984, Johnson 1988, 1990 *in* Johnson 1995; Johnson and Breisch 1992). Historically, the Onondaga County population may have extended further northwest and east into Madison County but agriculture has severely restricted the extent of suitable habitat. Monitoring of this population in the early 1980s showed a 92 percent reduction in capture success over a three-year sampling period (Johnson 1995). The results from a vegetation study at this site (LeBlanc 1988) indicate that the habitat is rapidly losing its value for hibernation and basking. Unregulated collection and habitat loss are threatening the Onondaga population. Similarly, the Genesee County population is threatened by vegetative succession (Alvin Breisch, New York Dept. of Conservation, pers. comm. 1996). Although both populations are protected, collection and habitat loss threaten these populations. The State of New York lists the massasauga as endangered (Johnson 1995).

Ohio- According to Conant (1951), massasaugas historically occurred over much of glaciated Ohio. He believed, based on the large number of museum specimens and reports from local residents, that massasaugas were common in many areas. For example, he identified New Haven Marsh and Mt. Victory localities as relatively abundant populations stating, ".. massasaugas are found frequently and snake bites are not rare...". Despite subsequent searches, massasaugas have not been documented from either site since 1964.

The documented historical range includes 38 sites in 31 counties. The species is extirpated from 25 sites. Of the 13 possibly extant sites, three are vulnerable, one is declining, six are presumed declining, and three have unknown population trend (Table 9). Anecdotal information and recent surveys clearly indicate that the Ohio massasauga population has declined substantially. For example, longtime herpetologist, Charles Strong (pers. comm. *in* Davis et al. 1996) asserts, after spending hundreds of hours searching for massasaugas in Ashtabula County, that populations have declined. Similarly, Laux and Tuke (1973 *in* Davis et al. 1996) claimed that during class field trips to a Champaign County locality, massasaugas were frequently encountered (i.e., 39 times before mid-May); however, subsequent visits by others have not been nearly as successful (Davis et al. 1996). All remaining populations in Ohio are small and isolated (Davis et al. 1994). Seven of the 14 populations are threatened by habitat modification, indiscriminate killing, and highway mortality (Davis et al. 1994, Davis et al. 1996). Collection, gene pool contamination (i.e., introducing individuals from distant populations), incompatible management practices, and habitat loss are the major factors threatening massasauga populations in Ohio. The species was state listed as endangered in 1996 (Ohio DNR, http:/www.dnr.state.oh.us, 24 July 1998).

Ontario- The historical range of the massasauga in Canada extended throughout most of southwestern and west-central Ontario. As much as half of the historical range of the species has been lost over the past two centuries (Weller and Oldham 1993). Thirtyfive of the 79 verified historical populations are extirpated and an additional three may be as well (Table 10). Of the 41 possibly extant populations, 5 are secure, 5 are presumed secure, 5 are vulnerable, 13 are declining or presumed declining, and the remaining 10 have unknown population trend (Table 10). These populations occur in four geographically isolated regions of Ontario (Weller and Parsons 1991). Two of these regions support large metapopulations over a considerable area, while the other two harbor smaller populations in a very restricted area (Michael Oldham, Ontario Ministry of Natural Resources, *in litt*. 1997). The two large regions include the east and northern shore regions of Georgian Bay and the Bruce Peninsula. Although they presumably were at one time, these populations are no longer connected. Because of the drastic reduction in their range, the species was listed in 1990 as threatened pursuant to the Ontario Ministry of Natural Resources' Game and Fish Act (Weller and Oldham 1993).

Pennsylvania- Historically, massasaugas were restricted to western Pennsylvania (Reinert 1990). The species is documented from 65 historical occurrences (comprising 13 metapopulations) in six counties (Table 11). However, by 1977 the decline of the massasauga was apparent (Reinert and Bushar 1993). A 1977-1978 survey revealed that massasaugas, as a result of habitat loss, were extirpated from two counties (Reinert and Kodrich 1978, Reinert and Bushar 1993). A follow-up survey in 1988 revealed that habitat loss and deterioration continued in all but one of the populations revisited. For example, the Tippery metapopulation, which had the largest contiguous area of habitat and the largest population of massasauga in Pennsylvania was subjected to habitat modification as a result of housing developments, vegetative succession, and oil wells. By 1988, the population declined noticeably. Currently, 24 of the 65 historical occurrences are extirpated. An additional nine sites are likely extirpated and another 10 sites have unknown status. Of the 32 possibly extant occurrences, one is considered secure, five are presumed declining, 3 are declining, and the remaining 23 have unknown population trend. Vegetative succession and urban encroachment are the major causes of the decline. As these threats continue unabated, existing populations will become increasingly isolated by dispersal barriers (Reinert and Bushar 1993). The Pennsylvania Fish and Boat Commission listed the massasauga as endangered in 1978 (Reinert 1985).

Wisconsin- Historically, the massasauga occurred over much of southern, central, and west-central Wisconsin. Based on reports of "hundreds and thousands" of snakes being harvested from several localities, it is believed that the species was abundant in Wisconsin historically. However, by the turn of the century, the decline of the massasauga was already evident (Holford 1900 *in* Vogt 1981) and by 1970 the last strongholds had also dwindled (Vogt 1981).

Massasaugas are known from 21 sites in Wisconsin (Table 12). Of these populations, eight have been extirpated and another four are likely extirpated. Of the remaining nine populations, six are declining and three have unknown population trend. Until the 1970s, observations of massasaugas were assured at several robust localities; however, encounters are now exceedingly rare. Within the past five years (1991-1996), massasaugas were reported from only four sites. Habitat loss, indiscriminate killing, and collection are the major threats to existing populations. Massasaugas were listed as endangered (October 1975) shortly after the rattlesnake bounty was terminated in the summer of 1975 (Bob Hay, pers. comm. 1996).

Summary- From a geographic distribution perspective, the massasauga has suffered a noticeable decline (Figure 3). Of the 203 counties, which massasauga occurrence has been documented, 40 percent no longer harbor populations (Figure 4). Although differences in population scale prevent a single rangewide population summary (i.e., total number of populations remaining), a State-by-State summary of the percent of populations that remain and of those which are secure provide insight to the rangewide population trend for the species (Table 13 & Figure 5). Nine of the 11 States/Provinces that historically supported massasauga populations have lost more than 50 percent of their historical populations, while the remaining two have lost more than 30 percent of their occurrences. In all states, less than 45 percent of their extant populations are considered secure.

Habitat

A broad array of vegetation communities are identified in literature as massasauga habitat: bogs, marshes, old fields (Smith 1961), prairies, meadows (Wright 1941), fens, coniferous forests (Weatherhead and Prior 1992), peatland, swamp forest (Johnson 1995), and sedge meadow, mesic grasses adjacent to lowland hardwood forest (Hay and Kopitzke 1993). Although massasaugas show a strong affinity for aquatic habitats, they tend to avoid open water (Wright 1941, Weatherhead and Prior 1992, Hutchinson et al. 1993). However, massasaugas were observed swimming across narrow stretches of water in Missouri, Wisconsin, and Ontario (Seigel *in litt*. 1996; King *in litt*. 1996;Villeneuve pers. comm. 1996).

Recent studies suggest that massasaugas utilize both upland and wetland habitats. Reinert and Kodrich (1982), based on radio-telemetry studies (n=25) in Pennsylvania, reported that snakes utilize low, poorly drained habitat in the spring and fall, and shift to sparsely vegetated and dry areas in the summer. Similar shifts in habitat utilization are documented for populations in Illinois (Dave Mauger, Will County Forest Preserve District, *in litt*. 1996), Missouri (Seigel 1986), New York (Johnson 1995), Ontario (Weatherhead and Prior 1992), and Wisconsin (King 1997). Most researchers believe that massasaugas select wet environments to prevent desiccation during hibernation (Ernst 1992, Maple 1968). Atkinson and Netting (1927), however, suggested an alternative theory for wetland use. They speculated that the massasauga occurrence in wetland habitat was a result of isolation to marginal habitat due to encroachment of woody vegetation in former prairie habitat.

Interestingly, the shift in habitat utilization seems to vary regionally and among populations. Unlike in Pennsylvania, massasaugas in Ontario had a preference for wetland and coniferous habitat in the summer and fall (Weatherhead and Prior 1992). In New York, Johnson (1995) found that throughout the summer, gravid females stayed in the peatland habitat and the males and nongravid females dispersed to the adjacent swamp forest habitat. In Wisconsin, King (1997) discovered that the gravid female cohort dispersed to drier upland sites, and the nongravid female and male cohorts remained in the lowland habitat. Still, others (e.g., Wright 1941, Maple 1968) did not detect any seasonal shift in habitat utilization. Johnson (1995) postulated that the observed variability in habitat use is attributed to the resource variability among sites. His contention is that because massasaugas disperse in the spring and summer to more favorable-foraging habitat, a shift in habitat utilization would only be necessary if the overwintering sites did not provide adequate food resources.

Although it appears intuitive that habitat selection would be guided by food availability, the activity patterns of the gravid female cohort deviate from this theory. Radio-telemetry studies (Reinert and Kodrich 1982; King 1997) found that gravid females showed the greatest habitat divergence. Given they rarely, if at all, eat during gestation, it is unlikely that prey availability is influencing their movements (Reinert and Kodrich 1982). Many viviparous species can exert some control over embryonic development by thermoregulation (Seigel and Collins 1993), and it seems likely that female massasaugas could also exhibit this ability. Johnson (1995) found that the mean body temperature (until parturition) and the body-to-air temperature ratio were significantly greater for gravid females than males and nongravid females. This suggests that gravid females have a greater need for thermoregulatory behavior. Moreover, Reinert and Kodrich (1982), found that the habitat areas selected by gravid females maintained significantly higher maximum daily temperatures than the areas utilized by males and nongravid females. These findings indicate that habitat selection by the gravid cohort is influenced by their thermoregulatory needs. Thus, massasaugas are likely to select habitat based on their individual physiological needs (e.g., gestation, hunger, etc.,), and consequently, selection of habitat (i.e., seasonal movements) will vary among cohorts and populations.

In an attempt to better define the habitat requirements of massasaugas, researchers during an international symposium analyzed the various habitat types reported throughout the range. There was consensus that the structural characteristics of a site rather than the vegetative associates are the critical determinants of habitat suitability (Beltz 1992). Specifically, three components are common at all sites: (1) open, sunlit intermixed with shaded areas for thermoregulatory purposes; (2) presence of the water table near the surface for hibernation; and (3) variable elevations between adjoining lowland and upland areas. In recent attempts to further describe specific habitat components, Johnson (1995) analyzed and compared occupied swamp forest (male and nongravid female habitat), occupied peatland (gravid female habitat), and unoccupied, random sites. He found that the swamp forest habitat selected had lower canopy coverage and was in closer proximity to overstory trees and fallen logs. The peatland area utilized by gravid females had lower stem densities, reduced canopy coverage, and a lower percentage of bryophytes in the ground cover. Similar efforts by King (*in litt*. 1997; 1997) revealed lower canopy cover and higher average distance to overstory trees for female sites. Hutchinson et al. (1993) in Ontario showed that the upland habitat used by massasaugas had low tree density (<10%) and low tree height. Mauger (*in litt*. 1996) concluded that in Illinois grass-forb dominated habitat was essential. He also found that the predominant pattern for thermoregulatory behavior consisted of micro-movements between tall-dense and short-open structure.

Additionally, there are reports of massasauga occurrence in human-altered landscapes such as lawns and dikes. These areas are likely serving as surrogates for natural upland habitats that have been modified or destroyed. However, as discussed under Factor A, these unnatural habitat types also pose serious threats to massasauga survival.

Ecology

General: Massasaugas are most conspicuous during April, May, and October. During these times, they are active during the warmest part of the day (1200 - 1600h). In parts of the range, nocturnal activity occurs during summer (Seigel 1986). Carnivorous mammals, birds-of-prey, and ophiophagous (i.e., prey upon snakes only) snakes are potential predators (Ernst and Barbour 1989).

Massasaugas begin to emerge from their hibernacula in late March (Seigel *in litt*. 1997) and early April (Seigel 1986; Johnson 1995; Mauger, *in litt*. 1996). Mauger (*in litt*. 1996) found that emergence occurred when the shallow ground temperature was near air temperature (i.e., six inches beneath the surface). Anecdotal observations suggest that individuals may stay near their burrows for prolonged periods, up to several weeks, before dispersing to their summer activity areas (Mauger, *in litt*. 1996). Throughout the summer, nongravid females and males search for food and mate. The mating season has been reported as: August through September in New York (Johnson 1995); July and August in Pennsylvania (Reinert 1981); August in Wisconsin (King pers. comm. 1996); and late July through early September in Illinois (Mauger *in litt*. 1996). Parturition has been documented in late July through August in Pennsylvania (Atkinson and Netting 1927) and August through September in Pennsylvania (Reinert 1981, Reinert and Kodrich 1982) and in New York (Johnson 1995). Ingress (i.e., movement to hibernacula) activities occur in mid-September through late October (Seigel 1986; Johnson 1995; Mauger, *in litt*. 1996).

<u>Reproductive cycle</u>: Like all rattlesnakes, massasaugas bear live young (Conant 1951; Klauber 1972; Johnson 1992, 1995). Both annual and biennial reproductive cycles have been reported (Keenlyne 1978, Reinert 1981, Seigel 1986, Johnson 1995). Johnson (1995) cited the low number of gravid snakes encountered each year, the observation of mating by nongravid females, and the parturition by gravid females in late summer as evidence for biennial reproduction. Reinert (1981) indicated that the observed 1:1 ratio of gravid to nongravid females and mating during July and August as evidence of a biennial reproduction in Pennsylvania. Keenlyne (1978), in Wisconsin, reported an annual cycle of reproduction based on the high percentage of gravid females encountered (e.g., 93% of the 82 females necropsied). However, he acknowledged that gravid females are more vulnerable to capture than nongravid females, which may have skewed the results of his study. Notably, Seigel (1986) found that the proportion of gravid females observed varied between years, 33 percent in 1980 (N=6) and 71.4 percent in 1982 (N=14). Brown (1991), studying timber rattlesnakes, found that the proportion of gravid rattlesnakes varied from 25 percent in 1985 to 77 percent in 1988. Thus, the relative number of reproductive females over a short time period may be an unreliable indicator of reproductive cycle.

The female's reproductive cycle may be related to body size which is influenced by prey availability and length of active season (Klauber 1972, Prior 1991). MaCartney and Gregory (1988) found that *Crotalus viridis* females who gained 95 percent of their postpartum body weight after parturition bred biennially, whereas those that gained only 39 percent in the first season delayed their next breeding attempt for three years. Those individuals that do reproduce annually most likely mate in the spring and bear young in the late summer or autumn. Conversely, biennially reproductive females probably mate in the autumn and either store sperm until the following spring (Johnson 1992) or suspend embryo development over winter and bear young the next summer (Prior 1991).

Similarly, brood size appears to vary greatly and may be related to body size (Seigel 1986). The following mean brood sizes have been recorded: 5.2 in Wisconsin (King *in litt*. 1996), 6.55 in Pennsylvania (Reinert 1981), 6.35 in Missouri (Seigel 1986), 9.28 in New York (Johnson 1990 *in* Johnson 1995), 11.6 in Ontario (Weller and Parson 1991), and 11.1 in Wisconsin (Keenlyne 1978). Age of first reproduction has not been determined through field experiments (e.g., mark-releaserecapture studies); however, sexual maturity in captive bred snakes was documented as early as 27 months (Johnson 1995). These results are consistent with Keenlyne's (1978) findings that only seven percent of third-summer females were non-reproductive. Sex ratios have not differed greatly from 1:1 (Johnson 1995).

Population Ecology: There is a paucity of published data regarding the population ecology of massasaugas. A few studies, however, provide some insight on population size and density. Maple (1968) estimated, using the Petersen Index, a population size of 35 individuals (1.97 per ha) at a site in northeastern Ohio. Similarly, Mauger (*in litt*. 1996) estimated a population size of 36 at a 22 acre (9.2 ha). However, he noted that this was probably an underestimate because nearly one-half of the population was adults, and subadults and juveniles/neonates equally comprised the remaining half. Reinert (1978) reported densities of 0.59 to 3.78 individuals per hectare at a 8.1 ha site in Pennsylvania. Johnson (1995) estimated a population size of 38.5, with a density between 0.56 and 2.53 rattlesnakes per hectare, at a 37 ha site in New York.

Keenlyne (1968) prepared life tables for male and female massasaugas and found that in the first five years of life, mortality rates were the highest for first year animals (50%) and the mean expectation of further life for the 0-1 year class was 2.85 years. Based on one year of observations, King (*in litt*. 1996) found that neonate mortality was 78 percent from parturition to the first hibernation season.

Diet: Massasaugas acquire prey through a sit-and-wait foraging tactic (Reinert et al. 1984 *in* Prior 1991). Prey can be initially detected by thermal, visual, vibration, or chemical cues or any combination of these (Prior 1991). Rodents and snakes are the major prey items (Keenlyne and Beer 1973, Seigel 1986, Hallock 1991, Johnson 1995), although rodents appear to be preferred (Hallock 1991, Johnson 1992). Scant information is available regarding neonate diet and life history in general. Keenlyne and Beer (1973), Seigel (1986) and Mauger (*in litt*. 1996) found new born and juvenile massasaugas to be ophiophagous.

Hibernation: Hibernacula typically occur in wetland and other poorly drained areas (Conant 1951, Hallock 1991, Reinert and Kodrich 1982, Johnson 1995). Over much of the species' range, hibernation occurs primarily in crayfish burrows (Maple and Orr 1968, Mauger *in litt*. 1996), although other structures are utilized as well, such as hummocks of sphagnum and shrubs (Johnson 1995), small mammal burrows (Hallock 1991), and tree roots (Conant 1951, Parsons 1984 *in* Prior 1991, King *in litt*. 1996). The presence of water that does not freeze is an important determinant of hibernaculum suitability (Johnson 1995). Mauger (*in litt*. 1996) found that although hibernacula were not located in areas with substantial surface inundation, seasonal high water tables were common at most sites. Massasaugas apparently remain in the water through much of the overwintering period (Reinert 1978, Beltz 1992, King *in litt*. 1996). Maple (1968) postulated that massasaugas, by overwintering in moist soil, avoided lethally low temperatures and reduced the risk of desiccation.

In the fall, massasaugas remain very close (i.e., within a half meter) to their hibernacula (Hallock 1991, Mauger *in litt*. 1996). Likewise, movement away from the hibernacula in the spring does not occur until weather is consistently warm (Johnson 1995, Mauger *in litt*. 1996). This behavioral trait of remaining close to the hibernacula coupled with the death of a massasauga individual caused by a hard frost (Mauger *in litt*. 1996) suggests that massasaugas are susceptible to freezing.

Unlike other species of rattlesnakes, adult massasaugas hibernate individually (Hallock 1991, Prior 1991, Johnson 1995), although Conant (1951) reported observing a massasauga and a blue racer (*Coluber constrictor flaviventris*) utilizing the same hibernaculum. Prior (1991) observed hibernaculum site fidelity. Johnson (1995) observed only one individual utilizing the same hummock in consecutive years; however, all but one of the snakes tracked (n=10) selected overwintering sites within 54 m of the previous year's site. He also found a notable overlap in yearly movements by males. These observations suggest that site fidelity may occur but is not den specific.

<u>Home Range:</u> Activity range is defined as the space used by an animal, over a period of time, to acquire adequate resources to meet its needs for survival, growth, and reproduction (Johnson 1995). Studies of massasauga movement are numerous (Reinert and Kodrich 1982, Hallock 1991, Weatherhead 1991 *in* Prior 1991, Weatherhead and Prior 1992, Johnson 1995, King 1997, Mauger *in litt*. 1996). Many factors influence the size and shape of the activity range. For instance, Johnson (1995) suggested that the distribution of prey and receptive females, as well as gestation, basking, and overwintering sites as the key factors. Linke (1985 *in* Prior 1991) found that distance moved was correlated with both body and surface temperatures; however, Reinert (1978) failed to find a significant correlation between environmental temperatures and daily movements.

Similar to other aspects of its ecology, vagility varies among the different massasauga cohorts. Weatherhead and Prior (1992) reported significantly smaller activity ranges for females than males. They attributed the size difference in activity range to the need for males to occupy a more extensive area to increase their probability of encountering receptive females. King (1997) found that males, nongravid females, and juveniles had average distances moved and mean daily movements greater than gravid females. Similarly, Johnson (1995) observed long movements interspersed by periods of little movement by males, nongravid females, and postpartum females. Although Reinert and Kodrich (1982) did not observe a difference in range area or mean distance moved per day, significantly shorter range lengths (i.e., the distance between any two points an individual snake moved) for gravid females were documented. They suggested that the difference in observed range length was a reflection of the very specific habitat requirements of gravid females. Reduced vagility in gravid females has been observed in other snake species as well (Johnson 1995). Johnson found a brief but significant increase in the size of territory utilized by gravid females following parturition.

Hallock (1991) reported the greatest range length as 164 m in Michigan; Mauger (*in litt*. 1996) documented the maximum movement in Illinois, excluding dispersal from the hibernacula, as 493 m; Weatherhead and Prior (1992) documented 1430 m as the greatest movement in Ontario; Johnson

(1995) reported the maximum range length as 1347 m in New York, and King (*in litt*. 1997) documented the greatest range length as 3,156 m in Wisconsin. King (1997) reported average range lengths of 50 m for neonates, 1,331 m for adult males, 653 m for gravid females, and 334 m for nongravid females. He also observed mean home ranges of 161 ha for males, 2.3 ha for neonates, 2.8 ha for gravid females, and 6.7 ha for nongravid females. Reinert and Kodrich (1982) documented a mean range area of 9794 m^2 (i.e., <1 ha), mean range length of 89 m, and mean daily movement of 9.1 m. Mauger (*in litt*. 1996) documented range lengths between 209 and 420 m, and an average activity area of 2 ha. Weatherhead and Prior (1992) reported a 25 ha activity range and an average daily movement of 56 m. Johnson (1995) documented a mean activity range of 26.2 ha and an average daily movement of 19.5 m. The smaller activity range and range length observed by Reinert and Kodrich may be an artifact of their forced-fed methodology, which could have altered the snakes' dispersal behavior (King 1997).

Threats

A. The present or threatened destruction, modification, or curtailment of its habitat or range: Similar to many other imperiled species, habitat loss is one of the primary factors in the decline of *S. catenatus* across the eastern DPS. It is well documented that the United States has lost a high percentage, approximately 53 percent, of its original wetlands (Dahl 1990). Specifically, Illinois has lost 85 percent, Indiana 87 percent, Iowa 89 percent, Michigan 50 percent, Minnesota 42 percent, Missouri 87 percent, New York 60 percent, Ohio 90 percent, Pennsylvania 56 percent, and Wisconsin 46 percent (Dahl 1990, Dahl and Johnson 1991). The principal cause of these losses was land conversion to agricultural use. This was especially true from 1950 through the 1970s, when agriculture was cited as the source of 87 percent of wetland loss nationwide (Dahl and Johnson 1991). Since that time, other land uses and modifications such as dredging, stream channelization, road construction, and commercial and residential development have played a more significant role in the loss of massasauga wetland habitat (Prior 1991, Legge and Rabe 1994). Wetland habitat loss has had profound impacts on massasauga populations in Illinois, Indiana, Missouri, New York, and Wisconsin (Minton 1972, Vogt 1981, Seigel 1986, Beltz 1992, Mierzwa 1993, Johnson 1995, Kingsbury *in press*).

In addition to wetland habitat loss, essential upland habitat has also been destroyed and fragmented. Unlike wetland habitat, upland areas are not regulated by State or Federal law. As discussed previously (Habitat Section), the juxtaposition of wetland and upland habitats is critical for massasauga survival. The loss and fragmentation of continuous tracts of suitable snake habitat prevent access to the seasonally used areas (for gestation, hibernation, and foraging) that are necessary to sustain a viable population over time. In the United States, 99 percent of native prairies have been destroyed (Myers 1994). Although surrogate upland areas are utilized, such sites (e.g., railroads, agriculture fields, roadsides, open areas) often increase the massasauga's vulnerability to indiscriminant killing, road mortality, and predation.

Development and agricultural practices continue to perpetuate the loss of habitat (Beltz 1992, Christiansen 1993, Moran 1993, Kingsbury *in press*, Legge 1996). Loss, destruction, or modification of habitat is affecting at least 50 populations rangewide. A few examples are as follows. In Illinois, the Des Plaines River Valley population continues to be fragmented into smaller subpopulations isolated by development or otherwise unsuitable habitat (Mierzwa 1993). In Michigan, a major residential development, at the Green/Union Lakes site in Oakland County, Michigan, recently eliminated much of and severely degraded the remaining habitat (Legge 1996). At Wixom, Michigan both wetland and upland habitat were degraded by agricultural practices and highway construction (Legge 1996). Similarly, in Bremer County, Iowa, a golf course is encroaching upon massasauga habitat (Christiansen 1993). In Wisconsin, cranberry beds and associated water level manipulations are potential threats to massasauga populations (Cathy Carnes, U.S. Fish and Wildlife Service, *in litt*. 1997). The Wisconsin Cranberry Association recently notified the Wisconsin Department of Natural Resources that they plan to triple the acreage for cranberry production in Wisconsin from 15,000 to 45,000 acres (Hay, *in litt*. 1997). In Pennsylvania, four companies within the last year have applied for sand and gravel mining permits in areas supporting massasauga populations. The State believes that the future suitability of these wetlands for the massasauga is threatened (Andrew Shiels, Pennsylvania Fish & Boat Commission, *in litt*. 1997). One of Ohio's largest population (Killdeer Plains) was bulldozed and plowed under in 1994. Only one individual was located in a subsequent survey (Doug Wynn *in litt*. 1997).

Additionally, vehicle-caused mortality and injury increase as suitable habitat becomes fragmented by transportation corridors. Road mortality threatens at least 10 populations rangewide. Seigel (1986) reported that vehicular traffic was the most important factor affecting the Squaw Creek massasauga population in Missouri. Of the 172 snakes collected, 40 were found dead on the road. Similarly, within the last three years, four road-killed specimens, from the Yellow River population in Wisconsin, were found (King 1997), and at least one road-killed specimen is found on Wisconsin Highway 54 (Black River Bottoms population) annually (Hay and Kopitzke 1993).

Several researchers have cited vegetative succession as a major threat to habitat availability (Riexinger and Peterson 1982 *in* Prior 1991, Beltz 1992, Reinert and Bushar 1993, Mierzwa 1993, Seigel 1994, Johnson 1995). Although succession is a natural process, the habitats inhabited by massasaugas are communities that depend on natural disturbance regimes to maintain their early successional structure. Human intervention, through current landuse practices, hydrological changes, and fire suppression policies, alters and eliminates these natural disturbance processes (Vogl 1964, Christensen 1981 *in* Johnson 1995). As vegetative succession proceeds it degrades or eliminates essential micro-habitat components. A Geographical Information System (GIS) analysis of the Yellow River in Wisconsin revealed that since 1933, the canopy cover of the river bottom has become completely closed (due to fire suppression). The consequential loss of understory vegetation severely degrades the area in terms of massasauga habitat (King *in litt*. 1997). In Pennsylvania, encroachment of woody vegetation was the major cause of habitat loss at 75 percent of the sites surveyed (Reinert and Bushar 1993).

Similarly, vegetative succession was cited as an imminent threat to several populations in Illinois, Indiana, New York, and Ohio (Beltz 1992, Kingsbury *in press*, Johnson 1995, Davis et al. 1996).

Although disturbance is necessary to maintain massasauga habitat, improper mowing and fire-related management activities can also cause mortality. Seigel (1986) observed numerous burned snake carcasses, including massasauga specimens, following a early spring burn. In addition to direct mortality, habitat management activities conducted too frequently can reduce the suitability of a site. A further problem is that several massasauga populations occur on wildlife areas which are managed for waterfowl. Standard management practices include manipulating water levels, and mowing and burning dikes and grassy areas (Seigel 1986), all of which can cause mortality or reduce habitat suitability for massasaugas.

There is anecdotal evidence that suggests water level manipulation has had a significant impact on massasauga populations. Traditional waterfowl management involving post-waterfowl season drawdowns (early winter) appears to be a factor contributing to population declines at least two Wisconsin sites, one a state wildlife area and the other a national wildlife refuge. Drawdowns conducted after hibernation is initiated can result in desiccation or freezing throughout the winter (Hay, *in litt*. 1997). Similarly, water level manipulations associated with cranberry operations can cause mortality during hibernation. This may be particularly problematic during drought cycles, where water tables are already low and building up reservoirs can leave sedge meadows and bogs unnaturally dry. Given that massasaugas demonstrate some degree of hibernation site fidelity, these individuals may not be capable of obtaining suitable over-wintering sites (Hay, *in litt*. 1997). Thus, managers unaware of massasauga biology could unknowingly, by improperly timed management activities, render the habitat unsuitable for the long-term persistence of resident populations.

Beyond outright loss, habitat quality is also being adversely affected by nonpoint source pollution. Nonpoint source pollution is responsible for more than half of all water pollution in the U.S. (Chesters and Schierow 1985). The major contributors of nonpoint source pollution include run-off from agricultural, urban (e.g., roads, lawns, golf courses, etc), construction, and silvicultural activities (Myers et al. 1985). Although studies on the direct effects of poor water quality on massasaugas are lacking, there is evidence that the plant community is drastically affected, which indirectly affects massasaugas by altering the microhabitat. A population in southern Wisconsin, for example, is currently threatened by habitat modification due to agricultural run-off (Gary Casper pers. comm. 1996). The subsequent change in the nutrient load of the wetland has precipitated an invasion of exotic plants (especially purple loosestrife *Lythrum salicaria*), and subsequently, has altered the plant community by crowding out the native sedge species. This has made the site less suitable for crayfish; and as a result, the availability of crayfish burrows for hibernation may now be a limiting factor for this massasauga population.

B. <u>Overutilization for commercial, recreational, scientific, or educational purposes</u>: Counties within the states of Illinois, Iowa, Minnesota, and Wisconsin at some time in the past offered a bounty for massasaugas (Tom Anton, Cook County Forest Preserve; Carol Hall, Minnesota County Biological

Survey; Christiansen; Hay; pers. comm. 1996). In Wisconsin, information from bounty hunters indicate that harvesting of 20 snakes per hour was not uncommon (Hay pers. comm. 1996). In a four-township area (Juneau County, Wisconsin) alone, 4,286 massasauga bounties were paid between 1952 and 1972 (Thiel undated). Similarly, in Minnesota, according to a 1989 news article, 4955 rattlesnakes (note, the article did not differentiate between timber and massasauga rattlesnakes) were harvested in Houston County (Hall pers. comm. 1996).

The pervasive effects of overharvesting are still present today. Hay (Pers. comm. 1996) postulates that bounty collection decimated populations to such low numbers that natural re-establishment of viable populations is not possible. His contention is based on the following. Many of the Wisconsin populations that were targeted by bounty hunters had depressed population numbers prior to elimination of the bounty. Despite state protection and the abundance of suitable habitat, massasauga numbers remain very low. For example, the Black River Bottoms population was known as a collection "hot spot" for massasaugas. This site provides excellent habitat and is almost entirely under public ownership; however, only two recent massasauga sightings have been reported although numerous searches have occurred.

Furthermore, anecdotal and empirical information suggests that massasauga bounty hunting targeted the female cohort. A rattlesnake bounty hunter recently commented that, "I always thought it was peculiar that every massasauga I ever bountied was pregnant" (Hay, *in litt*. 1997). King's (1997) research suggests that gravid females are more susceptible to collection because of their thermoregulatory behavior. Recent findings (see Factor E) indicate that because massasauga populations have low recruitment rate and high juvenile mortality, viability is greatly dependent on adult survivorship. Thus, overharvesting of adults, especially gravid females, could have reduced populations below the minimum viable population threshold (i.e., pushed beyond the species' ability to recover).

Collection for the pet trade is considered a contributor to the decline of the massasauga (Prior 1991, Beltz 1992, Johnson and Breisch 1993, Kingsbury *in press*, Ken Mierzwa *in litt*. 1996, Anton pers. comm. 1996). Recent events suggest that collection is problematic. Most recently, an Indiana Department of Natural Resources investigation culminated in the indictments of 40 defendants in laundering of State-protected reptile species including massasaugas (John Cannarella, Indiana Department of Natural Resources, *in litt*. 1998). The investigators noted that the rarer the animal, the more it was desired and the higher price it fetched. Similarly, in March 1997, a southern Illinois man pleaded guilty to trafficking venomous snakes collected from the wild (U.S. Fish and Wildlife Service 1997). Among other species, a *Sistrurus catenatus* specimen was seized by law enforcement. Investigators found that the individual frequently traded venomous snakes including specimens collected from national wildlife refuges and national parks. In another situation, individuals from California applied for a permit to captive rear poisonous snakes including *Sistrurus catenatus* (Stafford Lauret, California Dept. of Fish and Game, pers. comm. 1998). Although neither of these latter incidences directly involve massasaugas from the eastern DPS, they along with the Indiana event do indicate that a demand for snakes such as the massasauga exists. There is evidence of collection at least 17 massasauga populations.

Scientific research could adversely impact massasauga populations as well. A 1973 Wisconsin study, for example, resulted in the sacrifice of more than 300 adults and 800 unborn young. This research coupled with collection decimated the affected population (Hay pers. comm. 1996). Today, there is a greater awareness of the potential effects of scientific study and the plight of the massasauga; thus, it is unlikely that a research program with such deleterious impacts would be undertaken.

C. Disease or predation: Under normal conditions (i.e., sufficient, non-fragmented habitat) predation would not be a significant threat. However, increased mortality, regardless of whether its natural or unnatural, can detrimentally affect small populations. The loss of suitable habitat forces massasaugas to utilize and traverse areas that increase their vulnerability to predation (King 1997; Hay pers. comm. 1996). At a site in Wisconsin, for example, owl predation appears to be significant--of the nine individuals being tracked, three were taken as prey (Hay, pers. comm. 1996). Upland habitat for this site is limited to railroad embankments. Although these areas provide the open habitat structure necessary for the female's thermoregulatory needs, they also provide easy massasauga foraging for owls.

Disease has not been identified as a factor in the decline of natural 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).

D. The inadequacy of existing regulatory mechanisms: The massasauga receives varying degrees of protection through the designation as endangered, threatened, or species of concern throughout the eastern DPS. Although State laws and regulations protect the species from take, the lack of uniform protection throughout the United States hampers enforcement and imperils the species by creating loopholes for illegal take and trade. More importantly, State and Federal provisions for protection and management of habitat are inadequate or non-existent for non-Federally listed species. The massasauga, for example, has been State-listed endangered in Missouri since 1974, but habitat is not well protected and habitat loss is a threat to extant populations (Johnson and Figg 1993). In Pennsylvania, placement on the threatened and endangered species list affords protection from catching, taking, killing, or possessing of specimens (Reinert and Bushar 1993). In Michigan, the State in accordance with the Director's Order (DFI-166.93) prohibits take, kill, trap, or participation in commercial activities of massasaugas. While protection from direct take is important and has been successful in attenuating the loss of individual massasaugas, it is ineffective in halting the decline of the massasauga. Destruction and alteration of habitat are the primary reasons for the species' decline; thus, without habitat protection, the demise of the massasauga will continue unabated.

Since the mid-1970s and into the mid-1980s, Federal, State, and local government programs and policies have begun to affect wetland use and conversion. While these programs have generated support for the conservation of wetlands and have been successful in slowing the rate of wetland loss, alteration and destruction of wetland habitat is still occurring. The most notable example of a successful Federal governmental program is the Clean Water Act of 1972. Section 404 of the Clean Water Act requires project proponents to obtain permits from the U.S. Army Corps of Engineers to undertake all activities (except those which are specifically exempted) that would result in the deposition of fill material into navigable waters and wetlands of the United States. While some level of protection is afforded to wetlands, full protection is not provided.

Although the goal of the program is to avoid impacts, wetland loss can be mitigated through replacement. Replacement of habitat, in most cases, has limited benefit for massasaugas. In order for replacements to be beneficial, a properly functioning wetland must be replaced (i.e., restoring the processes that maintain the flora and fauna), a source massasauga population must be within dispersal distance, and suitable upland habitat must be close to the replacement wetland with a suitable travel corridor connecting it. Many massasauga populations are isolated and disjunct making recolonization of replacement wetlands impossible.

Furthermore, as previously discussed, essential upland habitat is not afforded Federal or State protection. Federal listing as threatened or endangered would, however, provide protection for both upland and wetland habitat through sections 7 and 9 of the Endangered Species Act of 1973. Listing would also provide better protection by invoking greater penalties than State laws, providing section 6 funding for research and management, qualifying for Land and Water Conservation funding, and providing a forum for developing a coordinated, rangewide recovery strategy.

E. <u>Other natural or manmade factors affecting its continued existence</u>: Although annual reproduction has been reported, it appears that biennial reproduction is far more typical. A female's reproductive potential is influenced by her ability to regain body weight following parturition (Prior 1991). Consequently, as habitats become degraded and prey less abundant, reproductive potential could decrease significantly.

A preliminary Population Viability Analysis (PVA) indicated that massasauga populations are most sensitive to adult mortality, a common finding in reptiles (Seigel 1994). The model showed that a minimum of 83 percent adult survival is necessary to maintain a stable population. Seigel found juvenile mortality also influenced population viability, although to a lesser extent. King *(in litt*. 1997) observed only 22 percent (n=32) survival following the first hibernation period for neonates. This is consistent with the findings of Keenlyne's prepared life tables (1968). In the first five years of life, mortality rates were the highest for first year animals (50%) and the mean expectation of further life for the 0-1 year class was 2.85 years. These findings suggest that even small increases in adult mortality can cause populations to decline very quickly, and that recovery from such disturbances is greatly impeded by the low biological replacement rate and the high mortality associated with juvenile individuals (Seigel 1986, Johnson 1995).

Indiscriminant killing of massasaugas is well documented from early times to the present (Whiften 1913; Conant 1951; Knutsen 1954; Johnson 1989; Prior 1991; Vogt 1981; Christiansen 1993; Hay and Kopitzke 1993; Legge and Rabe 1994; Kingsbury *in press*; Mierzwa *in litt.* 1996). For example, Vogt (1981) cites "thousands of massasaugas were killed near Portage, Wisconsin in 1849." Even with State protection, there is evidence of persecution at least 23 sites rangewide. As development and encroachment continue, the incidence of contact with humans and intentional killing will increase. The significance of this factor cannot be overstated given that adult mortality greatly influences the long-term stability of massasauga populations. In parts of its range, the gravid female cohort is, because of its thermoregulatory needs, more vulnerable to persecution. Consequently, the gravid female cohort is disproportionately persecuted, which further increases the significance of indiscriminant killing as a factor in the decline of the massasauga.

The threats posed by the above factors are exacerbated by the small population sizes of those remaining. Small populations are predisposed to extinction (Noss and Cooperrider 1994). Environmental, demographic, and genetic changes have pronounced implications for small populations. Although environmental variation, random or predictable, naturally cause fluctuations, populations with small numbers are more likely to fluctuate below the minimum viable population threshold. Likewise, chance variation in age and sex ratios can affect birth and death rates. Skewing the demographics of a population may lead to death rates exceeding birth rates, and if this occurs in small, isolated populations there is a higher risk of extinction. Lastly, decreasing genetic variability in small populations increases the vulnerability of the species to extinction. Small populations are more susceptible to inbreeding depression and genetic drift. A recent study of adders in Sweden found that inbreeding depression in isolated populations resulted in smaller litter size, higher proportion of deformed and stillborn offspring, lower degree of genetic heterozygosity due to fixation or near-fixation of alleles, and higher genetic similarity among individuals (Madsen et al. 1996). All of these effects cause reduced fertility and survivorship. Thus, in small populations, environmental, demographic, and genetic changes can contribute to an accelerating slide toward extinction.

Conservation Activities:

As explained earlier, the massasauga is recognized by the State/Provincial Natural Resource agencies and by herpetological societies as a species in need of protection. In recognition of this, two international workshops for the conservation of the eastern massasauga rattlesnake were convened. During these events, researchers, educators, and managers shared data and information regarding massasauga biology, management, and outreach efforts. This information is useful for agencies and researchers striving to conserve the species. In particular, steps towards establishing an international massasauga conservation network has been taken.

Populations in several States/Provinces were recently targeted by resource agencies and other interested parties for conservation efforts. Ongoing activities include research and monitoring of extant populations in Illinois (Allerton Park and Ryerson Conservation Area), Missouri (Squaw Creek NWR), New York (Cicero and Bergen-Bryon swamps), and Ontario (Georgian Bay National Park and Bruce Peninsula).

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Appendices

Figure 1: Distribution of *Sistrurus catenatus*

Redrawn from Conant and Collins (1991)

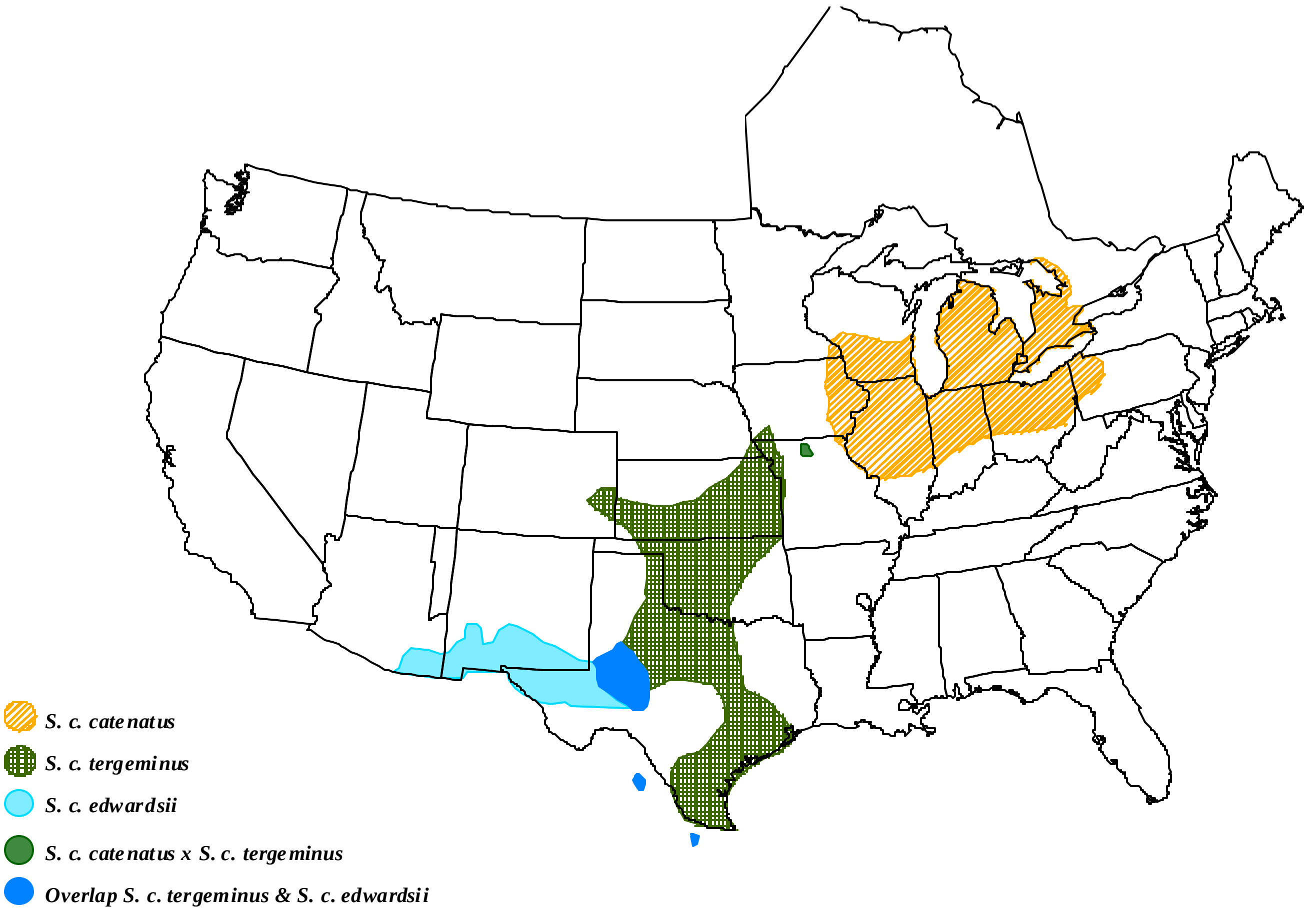
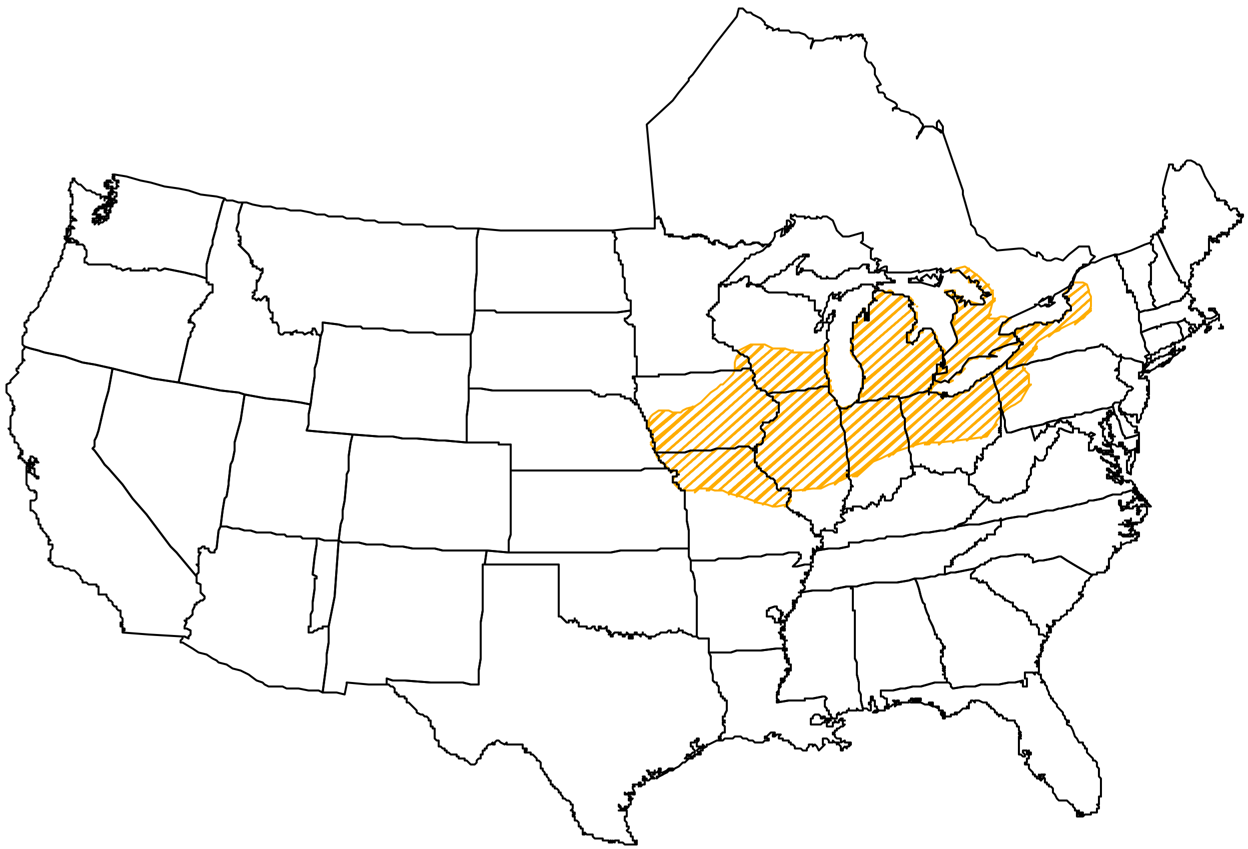


Figure 2: Approximate Range of the Eastern Distinct Population Segment of *Sistrurus catenatus*



A3

Figure 3. Counties with extant and extirpated populations of eastern massasauga.

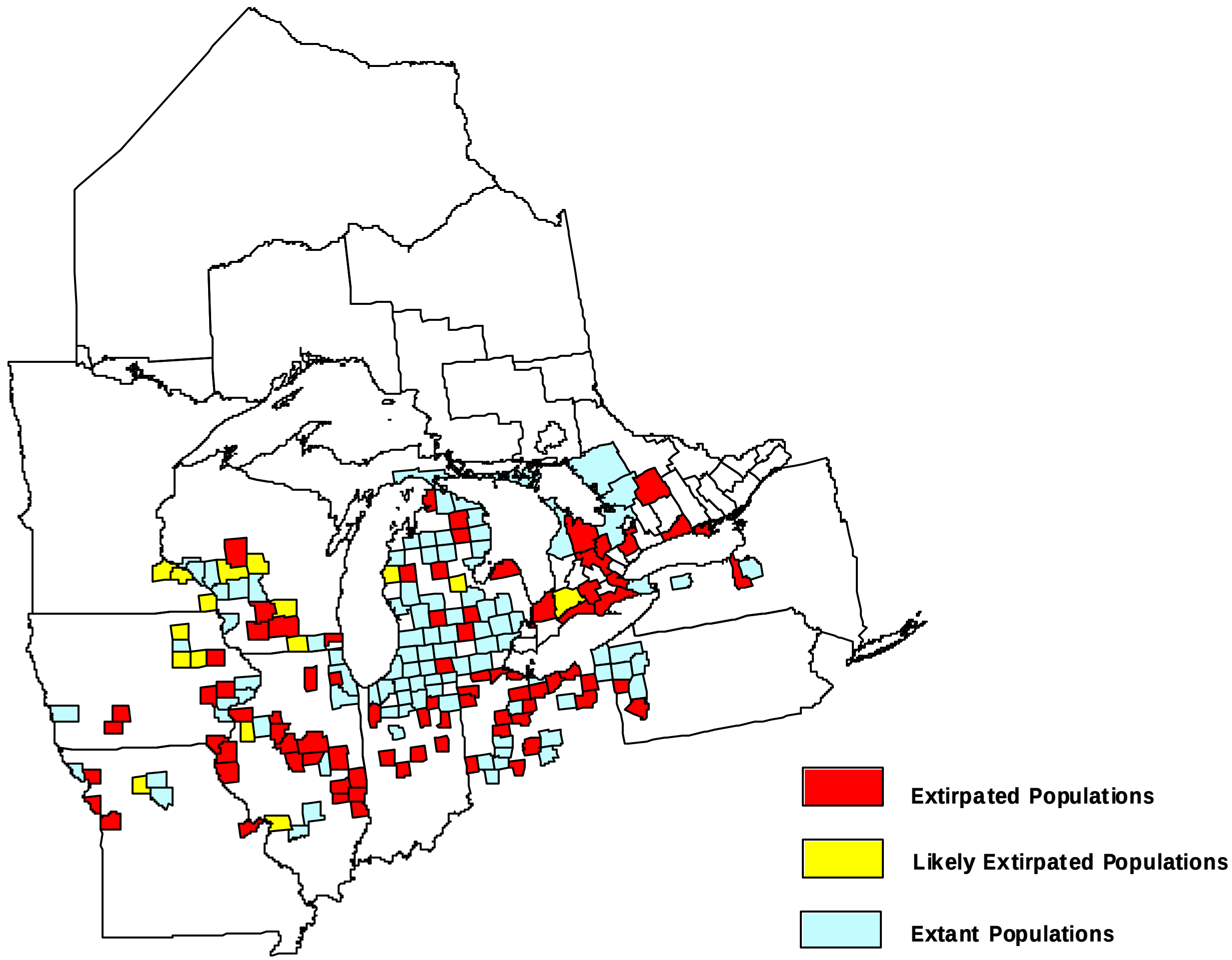


Figure 4: The Number of Extant, Extirpated, and Likely Extirpated Counties/ Districts by State/ Province

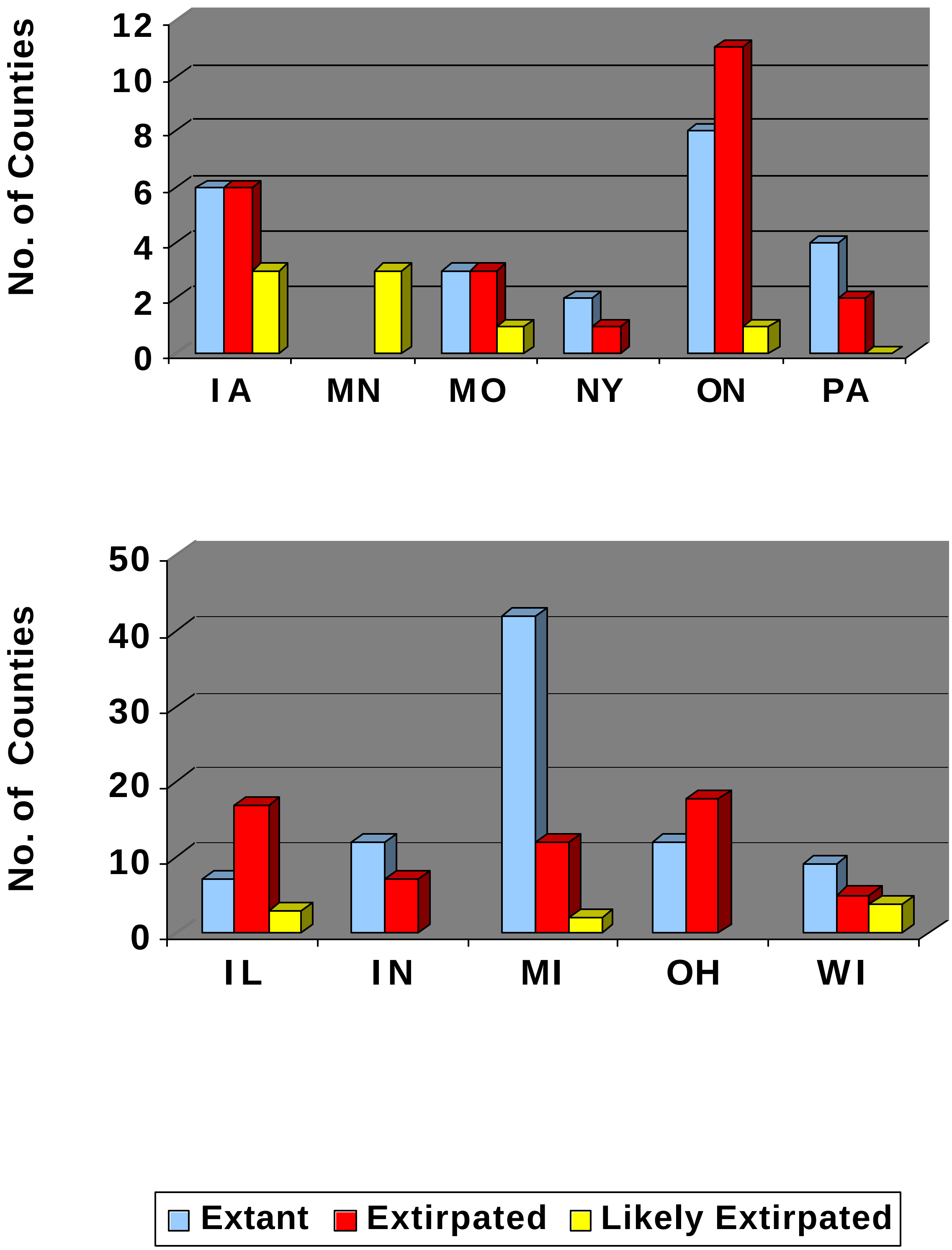
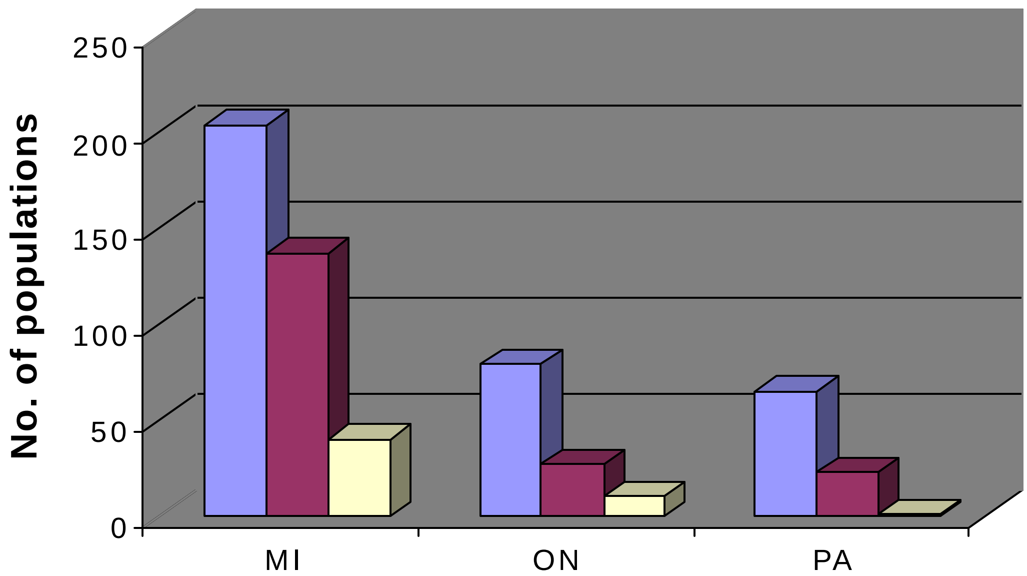
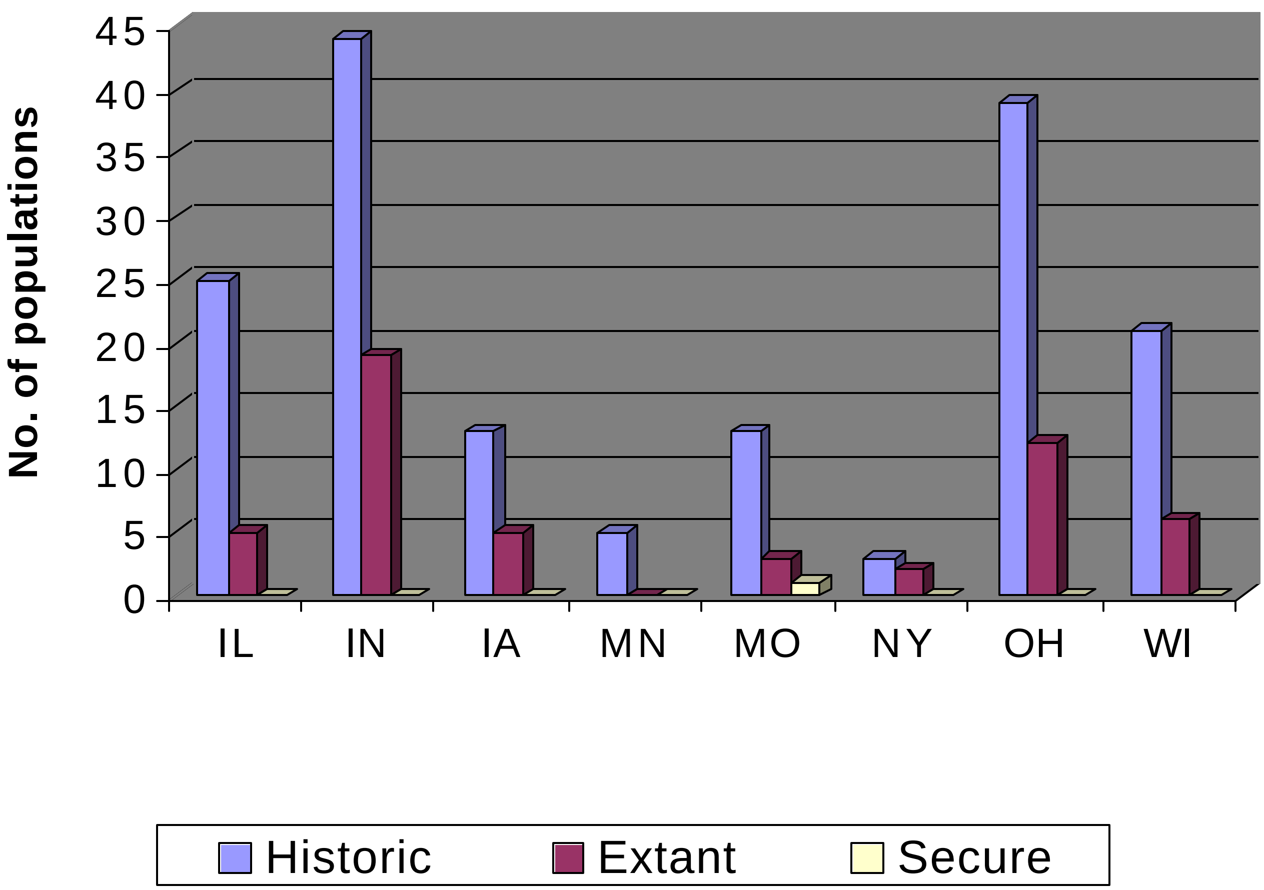


Figure 5: The Number of Historic, Extant, and Secure Populations by State/ Province





Definitions and Ranking Criteria

Occurrences are considered valid if the localities are documented by a specimen, photo, or verified reports by recognized scientists. Only those populations that are valid, unless otherwise noted, are considered in the analysis. Note: Michigan's EO database includes sightings from field biologists and managers, wildlife nuisance control workers, and other consultants. Most of these records were further analyzed to ascertain the validity of the records. Similarly, Ontario's database includes sightings that are considered valid but have not been specimen or photo documented.

Status refers to the species occurrence at a site, i.e., extant, extirpated, likely extirpated, or unknown. See rules below for further explanation.

Trend refers the population's long-term viability. Populations are classified as secure, presumed secure, declining, presumed declining, or unknown. See rules below for further clarification.

Ranking Criteria

STATUS:

Extant (E) if LDO >1987 unless data indicates otherwise (e.g., habitat loss)

Extirpated (X) if LDO <1967 (30 years);

- if LDO <1977 and surveys or habitat analysis completed with negative results; OR
- if, regardless of LDO, habitat is no longer available

Likely Extirpated (LX)=status information incomplete but **VERY** likely X

- if LDO <1987 and surveys completed with negative results but habitat is available and not confident it is extirpated;
- if LDO <1987 and occurs on public land or nature preserve (The assumption is that even if surveys have not been completed, massasauga presence would likely have been documented if present. However, since there is suitable habitat researchers are hesitant to assign extirpated status); OR
- if H[1] ranked in Ontario and LDO >1967 or suitable habitat remains

Unknown (UK)= status information is lacking but could be X

- if LDO<1987 and no other information available; OR
- if E[1] ranked in Ontario

TREND: Unlike other states, WI has historical data for comparison. Hence, WI trend can be assigned more definitively. Note, although there is evidence of reproduction (a criteria that supports Secure or Presumed Secure), the populations are believed to be declining. This indicates that assignment of Secure based on evidence of reproduction is a very conservative decision. In other words, this analysis overestimates the security of Massasauga populations.

Secure (S) = longterm viability appears secure

- Evidence of reproduction (presence of gravid females, neonates or juveniles), large quantity of suitable habitat available, adults relative easy to locate, and threats manageable; **OR**
- A-AB ranked in Ontario[1]

A-BC ranked populations in Michigan[2] that meet all four criteria specified above

Presumed Secure (PS) = Data inconclusive but longterm viability may be secure

Minimal sightings or lacking evidence of reproduction but large quantities of suitable habitat available, threats manageable, and relatively low human activity; **OR**

B-BC ranked in Ontario

Michigan - A-BC ranked populations that meet all but the reproduction criteria specified above

Vulnerable (V) = longterm viability tenuous but evidence of decline not apparent

Some evidence of reproduction but limited habitat or presence of threats; **OR**

C-CD ranked in Ontario[1] or Michigan[2]

Declining (D) = longterm viability is tenuous

Small population sizes relative to past observations, shrinking habitat, or very limited habitat; **OR**

D ranked in Ontario[1] or Michigan[2]

Presumed Declining (PD) = Data inconclusive but evidence of decline

Habitat available but numbers fewer than past observations or no evidence of reproduction **OR**

H ranked in Ontario[1]

U ranked in Michigan[2] (assigned PD if there is only a few sightings <1987 and other sites in the county X)

Unknown (UK) = Data lacking or very limited

No information available; **OR**

E ranked in Ontario[1]

U ranked in Michigan[2]

[1]Ontario trends were assigned based on the Nature Conservancy's Element Global Ranking Criteria: A ranked occurrences are considered secure; B ranked presumed secure; C ranked vulnerable; D ranked declining; H ranked presumed declining; and E ranked unknown. "A" ranked sites are assigned to populations that have large patch of high quality habitat; element is relatively easy to find; threats appear to be manageable. "B" ranked refer to sites with moderately large patch of habitat of at least good quality; element relatively is to find; and threats appear to be manageable. "C" ranked sites have adequate quality but relatively small; or element is somewhat difficult to find, reflecting moderate population density; or threats may be difficult to manage. "D" ranked refer to sites with habitat patch is so small and isolated that population persistence is questionable; or threats are very difficult to manage (e.g., urbanizing areas with many roads and/or extensive development); or element is very difficult to find, reflecting low population density or vagrant occurrences. Historic (H) occurrences are ones where the species has not been reported for more than 20 years, but there is reasonable expectation that it may still be there (i.e. habitat still exists, and it may be that no one has looked recently). Extant (E) occurrences have relatively recent record(s) (<20 years), but no information at all on abundance or amount of habitat.

[2]Michigan trends for the southern populations (Oceana County east to Bay County) were assigned based on the ranking criteria similar to Ontario Element Global Ranking Criteria. The northern populations follow Ontario's criteria with the EXCEPTION of not requiring multiple sightings over several years for populations with large areas of suitable habitat and located in areas with relatively low

human impact (Legge *in litt*. 1998). Thus, secure (S) trend is assigned to those populations ranked A and that meet all the criteria listed for secure trend ; those A and B ranked populations occupying large areas of suitable habitat, have manageable threats, and have relatively low human activity are considered presumed secure (PS); C-CD ranked sites are considered vulnerable (V); D ranked sites are considered declining (D); and Unrankable ranked sites either unknown or presumed declining (UK or PD).

Table 1. Legal State Status and Population Status of *Sistrurus c. catenatus*

STATE	LEGAL STATUS	POPULATION STATUS
Illinois	Endangered	Extant
Indiana	Endangered	Extant
Iowa	Endangered	Extant
Michigan	Special Concern	Extant
Minnesota	Endangered	Likely Extirpated
Missouri	Endangered	Extant
New York	Endangered	Extant
Ohio	Endangered	Extant
Pennsylvania	Endangered	Extant
Wisconsin	Endangered	Extant
Ontario	Threatened	Extant

Table 2. *Sistrurus c. catenatus*: Illinois Locality Information

POPULATION	COUNTY	DLO	STATUS	TREND	THREAT
Quincy	Adam	<1938	X	NA	NA
Spoon River	Champaign	1907	X	NA	NA
Casey	Clark	<1947	X	NA	NA
Charleston	Coles	<1917	X	NA	NA
-	Crawford	<1961	X	NA	NA
Diona	Cumberland	1938	X	NA	NA
Cortland	DeKalb	<1871	X	NA	NA
Farmer City	De Witt	1879	X	NA	NA
Wood Dale	DuPage	1980	X	NA	NA
Paris/Hume	Edgar	1914	X	NA	NA
Vandalia/ Kaskaskia Rvr	Fayette/ Clinton	1956	X	NA	NA
-	Hancock	<1961	X	NA	NA
Broadwell	Logan	1941	X	NA	NA
Normal	McLean	<1892	X	NA	NA
Aledo	Mercer	1884	X	NA	NA
Peoria	Peoria	<1892	X	NA	NA
Stark	Stark	<1858	X	NA	NA
Tazewell	Tazewell	1873	X	NA	NA
American Bott.	Madison	1986	LX	D	Habitat loss & fragmentation
Massasauga Prairie	Warren	1973	LX	D	Veg. succession & habitat degradation
Carlyle Lake	Clinton/ Fayette	1995	E	V	Intentional killing, hwy mortality, & potential, major habitat loss.
Plum Creek	Cook/Will	1995	E	V	Habitat loss due to development, hwy mortality, small population size, & intentional killing
Des Plaines	Cook/Lake	1994	E	PD	Habitat loss, veg .succession, collection, hwy mortality, & intentional killing
DeLong	Knox	1993	E	UK	Veg. succession, habitat degradation & intentional killing
Allerton Park	Piatt	1992	E	UK	

Table 3. *Sistrurus c. catenatus*: Indiana Locality Information

DLO=Date Last Observed; Status= X (Extirpated), E (Extant), UK (Unknown), LX (Likely Extirpated); Trend= NA (Not applicable), S (Secure), PS(Presumed Secure), V (Vulnerable), D (Declining), PD (Presumed Declining), UK (Unknown);

Sources: Smith (1961), Beltz (1992, *in litt*. 1996), Anton (*in litt*. 1998, pers. comm. 1996), Ballard (Pers. comm. 1996), Mierwza (1993, *in litt*. 1996), Mauger (Pers. comm. 1996), Phillips(Pers. comm. 1996).

POPULATION	COUNTY	DLO	STATUS	TREND	THREATS
Gaston	Delaware	1943	X	NA	NA
Hamilton	Hamilton	1892	X	NA	NA
Lizton	Hendricks	1892	X	NA	NA
Jasper Pulaski-FWA	Jasper	1938	X	NA	NA
Winona Lake/Warsaw	Kosciusko	1936 1941	X	NA	NA
Lily Lake	LaPorte	1930	X	NA	NA
Lk. Maxinkuckee	Marshall	1900	X	NA	NA
Linden	Montgomery	1957	X	NA	NA
New Carlisle	St. Joseph	1935	X	NA	NA
Laketon Bog	Wabash	1952	X	NA	NA
Churubusco	Whitley	1903	X	NA	NA
Oabache SP	Wells	1908	X	NA	NA
Baer Field	Allen	1973	LX	D	Limited , poor habitat
Fort Wayne Co. Club	Allen	1974	LX	D	Limited, poor habitat
Elizabeth Hanna NP	Steuben	1990	LX	D	Small population size & vegetative succession
Silver Lake	Fulton	1970	UK	UK	
Fawn River	Lagrange	1986	UK	UK	Small population size
Massasauga Marsh	Lagrange	1986	UK	PD	Habitat modification
Fish Creek Fen/Stillwell	La Porte	1981	UK	UK	
Cree Lake	Noble	1985	UK	UK	Isolated
NB Elkhart	Noble	1983	UK	UK	
Buckbean/Martin Fen	Lagrange	1985	UK	UK	
Lakeville	St. Joseph	1986	UK	UK	Isolated
Crooked Cr.	Steuben	1983	UK	UK	
Ropchan NP	Steuben	1978	UK	UK	

POPULATION	COUNTY	DLO	STATUS	TREND	THREATS
Delphi Swamp	Carroll	1994	E	PD	Small population size, limited habitat & vegetative succession
Tri-County FWA,Pisgah, Backwaters Fen	Kosciuscko	1988	E	PD	Habitat modification
Nasby Fen Sawmill/ Trinity	Lagrange	1997	E	PD	
Fox Island	Allen	1997	E	D	Vegetative succession, isolated & collection
Moore Lake	Marshall	1993	E	D	Habitat destruction & indiscriminate persecution.
Tamarack Lk/Tam. Cr	Noble	1996	E	D	Vegetative succession
IN Dune NP	Porter	1997	E	D	Habitat fragmentation & highway mortality
KSM	Pulaski	1987	E	D	Small population size & isolated
Simonton Lk/ Mud Lk/Malaxis Bog	Elkhart	1995	E	UK	
Lt. Chapman	Kosciusko	1988	E	UK	
Cline Fen	LaGrange	1997	E	UK	
Turkey Creek Fen/E. Mongo/Tam. Bog	Lagrange	1994	E	UK	Vegetative succession
The Spreads	Lagrange/ Noble	1992	E	UK	
Springfield Fen	La Porte	1992	E	UK	Isolated
Needham Lake	Noble	1992	E	UK	Isolated
Wolflk-Merry Lea	Noble	1987	E	UK	
Bender Woods	Noble	1995	E	UK	
Pokagon SP	Steuben	1997	E	UK	
Seven Sis./Marsh Lk	Steuben	1993	E	UK	Habitat loss due to flooding

DLO=Date Last Observed; Status= X (Extirpated), E (Extant), UK (Unknown), LX (Likely Extirpated)
Trend= NA (Not applicable), S (Secure), PS(Presumed Secure), V (Vulnerable), D (Declining), PD (Presumed Declining), UK (Unknown)
Sources: Kingsbury (*in press*, pers. comm. 1996, *in litt*.1998), Resetar (1993, 1994, pers. comm. 1996), Hellmich (Division of Nature Preserves, *in litt*. 1996)

Table 4. *Sistrurus c. catenatus*: Iowa Locality Information

POPULATION	COUNTY	DLO	STATUS	TREND	THREATS
Cedar River	Cedar/Johnson	30-40 years ago	X	NA	NA
Delaware	Delaware	> 50 years	X	NA	NA
-	Johnson	30-40 years ago	X	NA	NA
Des Moines River	Lee	50 yrs or >	X	NA	NA
-	Madison	No Date	X	NA	NA
Afton	Union	1945	X	NA	NA
UWR-so. of Sweet Marsh	Bl. Hawk/ Buchanan/ Bremer	30-40 years ago	LX	D	Habitat loss due to golf course development
UWR-no. of Sweet Marsh	Chickasaw/ Bremer	1992	LX	D	Limited habitat
UWR-Sweet Marsh	Bremer	1993	E	D	Incompatible landuse, collection
LWR-Sherman Park West	Clinton/ Scott	1992	E	D	Intentional killing, habitat loss
LWR-East	Clinton/ Scott	1992	E	D	Intentional killing, habitat loss
Cedar River	Muscatine/ Louisa	1993	E	D	Intentional killing, habitat loss
Willow Slough	Pottawat-tamie	1993	E	D	Incompatible landuse, collection

UWR=Upper Wapsipinicon River; DLO=Date Last Observed; Status= X (Extirpated), E (Extant), UK (Unknown), LX (Likely Extirpated); Trend= NA (Not applicable), S (Secure), PS(Presumed Secure), V (Vulnerable), D (Declining), PD (Presumed Declining), UK (Unknown)
Source: James Christiansen (1993, *in litt*. 1996, *in litt*. 1998)

Table 5. *Sistrurus c. catenatus*: Michigan Locality Information

POPULATION	COUNTY	DLO	STATUS	TREND	THREATS
Allegan Dam	Allegan	1965	X	NA	NA
Peach Orchard Ck	Allegan	1938	X	NA	NA
Wilds Road	Alpena	1967	X	NA	NA
US-23 Wetland	Alpena	1957	X	NA	NA
Charity Island	Arenac	1910	X	NA	NA
New Buff. Twp	Berrien	1861	X	NA	NA
Gilead	Branch	1917	X	NA	NA
Tabacco River	Clare	1932	X	NA	NA
Duck Lake N	Crawford	1950	X	NA	NA
Smith’s Bridge	Crawford	1924	X	NA	NA
Wakeley Cr.	Crawford	1924	X	NA	NA
Crooked Lake	Emmet	1955	X	NA	NA
Camp Kiwanis	Genesee	1932	X	NA	NA
Heisterman Isl.	Huron	1908	X	NA	NA
Sand Pt	Huron	1908	X	NA	NA
North Island	Huron	1908	X	NA	NA
Chandler’s Swp	Ingham	1960	X	NA	NA
Ionia Area	Ionia	1965	X	NA	NA
Crawford Rd	Jackson	1967	X	NA	NA
Concord NE	Jackson	1966	X	NA	NA
Blue Ridge Rd	Jackson	1962	X	NA	NA
S. St. Jackson	Jackson	1958	X	NA	NA
Stony Lake	Jackson	1928	X	NA	NA
Waterloo	Jackson	1920	X	NA	NA
Wintergreen LK	Kalamazoo	1963	X	NA	NA
Driftwood Valley	Lake	1963	X	NA	NA
Ore Lake	Livingston	1951	X	NA	NA
Oak Grove SGA	Livingston	1947	X	NA	NA
Chase LK Rd	Livingston	1934	X	NA	NA
Green Oak	Livingston	1927	X	NA	NA
Manistee Rvr	Mason	1958	X	NA	NA

Table 5. *Sistrurus c. catenatus*: Michigan Locality Information

POPULATION	COUNTY	DLO	STATUS	TREND	THREATS
Rainy River Flood	Montmorency	1953	X	NA	NA
Canada Cr	Montmorency	1958	X	NA	NA
East Mona Lk	Muskegon	1937	X	NA	NA
Baker Bridge	Oscoda	1964	X	NA	NA
Chesaning N	Saginaw	1934	X	NA	NA
Cranberry Cr	Shiawasee	1928	X	NA	NA
Mud Lk	Washtenaw	1959	X	NA	NA
Cassidy Lk	Washtenaw	1958	X	NA	NA
Grosse Ile	Wayne	1858	X	NA	NA
Shaw Lake Fen	Barry	1980	LX	D	Intentional killing
Bath	Clinton	No Date	LX	D	
Race Road Marsh	Jackson	1977	LX	D	
Haehnle Sanct.	Jackson	1970s	LX	D	
Wabisis Lake	Kent	1973	LX	D	
Costello Creek	Mason	1982	LX	D	
Midland	Midland	1976	LX	D	
Gratiot/Saginaw GSA	Saginaw	1985	LX	D	
Coloma	Van Buren	1975	LX	D	
Pikeral Lake	Washtenaw	1978	LX	D	
Turtle Lake Club	Alpena	1978	UK	UK	
Grayling	Crawford	1982	UK	UK	
Goose Creek	Hillsdale	1979	UK	UK	
Spring Arbor LK	Jackson	1980	UK	UK	
Portage Cr-W.Fk	Kalamazoo	1983	UK	UK	
Pinckney	Livingston	1978	UK	UK	
Twin Lake	Muskegon	1980	UK	UK	
34th St. Wetlands	Van Buren	1983	UK	UK	
Whelan LK	Washtenaw	1982	UK	UK	
Whitmore Lk	Washtenaw	1986	UK	UK	

Table 5. *Sistrurus c. catenatus*: Michigan Locality Information

POPULATION	COUNTY	DLO	STATUS	TREND	THREATS
Cheshire	Allegan	1986	UK	UK	
Ward RdWetlands	Arenac	1986	UK	UK	
Filer Twp.	Manistee	1982	UK	PD	
Duck Lake	Calhoun	1980	UK	PD	
Burke Lake	Clinton	1986	UK	D	
Stoll Road	Clinton	1986	UK	D	
Olivet	Eaton	1986	UK	D	
Jackson LK Fen	Allegan	1995	E	S	
Allegan SGA	Allegan	1993	E	S	
SNC	Berrien	1995	E	S	
Portage Cr	Crawford/ Kalkaska	1994	E	S	
Swartz Cr	Genesee/ Oakland	1995	E	S	
Coppler Creek	Iosco	1992	E	S	
Augusta Creek	Kalamazoo	1995	E	S	
Kalamazoo NC	Kalamazoo	1995	E	S	
CCC Bridge Cpgd	Kalkaska	1990	E	S	
Skegemog LK Swp	Kalkaska	1994	E	S	
LSGA-Norway Lk Rd	Lapeer	1993	E	S	
Ives Rd Fen	Lenawee	1995	E	S	
Bois Blanc Island	Mackinac	1995	E	S	
Lt. Manistee River	Manistee	1992	E	S	
Proud Lk Rec. Ar.	Oakland	1995	E	S	
Indiana Springs Metro Park	Oakland	1995	E	S	
Seven LK SP	Oakland	1995	E	S	
Rattalee LK Fen	Oakland	1994	E	S	
Independence Oaks Park	Oakland	1994	E	S	
Moltke Swamp & Ridge	Presque Isle	1995	E	S	

Table 5. *Sistrurus c. catenatus*: Michigan Locality Information

POPULATION	COUNTY	DLO	STATUS	TREND	THREATS
Matthaei Gardens	Washtenaw	1993	E	S	
Roy Creek	Alcona	1995	E	PS	
Bucks Pond	Alcona	1995	E	PS	
MacDonald Cr	Alcona	1993	E	PS	
Alcona Dam Pond	Alcona	1989	E	PS	
West Alpina	Alpena	1995	E	PS	
Chippewa Hills	Alpena	1995	E	PS	
Greene Cr. S.	Cheboygan	1992	E	PS	
Hartwick Pines	Crawford	1990	E	PS	
Upper Manistee Rvr	Crawford/ Kalkaska	1994	E	PS	
Silver Creek	Iosco	1995	E	PS	
AuSable River	Iosco	1995	E	PS	
Sand Lake Area	Iosco	1995	E	PS	
Cooke's Dam Area	Iosco	1994	E	PS	
Indiana Rd Hill Cr	Iosco	1994	E	PS	
Lower AuSable R.	Iosco	1990	E	PS	
Baldwin River	Lake	1989	E	PS	
Muskegon River Oxbows	Missaukee/ Roscommon	1995	E	PS	
Evergreen Beach	Presque Isle	1995	E	PS	
Swan River	Presque Isle	1993	E	PS	Habitat loss due to calcite mining
Scott Creek Area	Allegan	1995	E	V	
142nd Ave.	Allegan	1995	E	V	
Dumont LK Cpgrd	Allegan	1995	E	V	
Emerson LK	Allegan	1994	E	V	
Rabbit River	Allegan	1993	E	V	
Spring Brook Cr.	Allegan	1993	E	V	
Mann Cr	Allegan	1990	E	V	
Kelly LK	Allegan	1989	E	V	

Table 5. *Sistrurus c. catenatus*: Michigan Locality Information

POPULATION	COUNTY	DLO	STATUS	TREND	THREATS
Mill Lake Area	Barry	1995	E	V	
McIlvain Farm	Barry	1993	E	V	
Perch LK Upl.	Barry	1993	E	V	
Bakertown Fen	Berrien	1993	E	V	
Indian Bowl	Berrien	1992	E	V	
Mud LK Bog	Berrien	1991	E	V	
LT Indian LK	Berrien	1988	E	V	
Dayton Wet Pr.	Berrien	1987	E	V	
Barnum Cr	Calhoun	1995	E	V	
Kalamazoo Rvr	Calhoun	1995	E	V	
Oakland Hills Golf Course	Calhoun	1995	E	V	
Battle Creek River	Calhoun	1993	E	V	
Jefferson Twp.	Cass	1995	E	V	
Long LK	Cass	1989	E	V	
Kirk LK Woods	Cass	1993	E	V	
Shavehead LK	Cass	1991	E	V	
Goodrich	Genesee	1994	E	V	
Bass LK Rd	Grand Traverse	1993	E	V	
Springport	Jackson	1995	E	V	
River Raisin	Jackson	1995	E	V	
Kimmel Road	Jackson	1995	E	V	
Vrooman Rd	Jackson	1994	E	V	
NE Albion Wetland	Jackson	1993	E	V	
Lyons Lake	Kalamazoo	1994	E	V	Intentional killing
Fulton State Game Area	Kalamazoo	1993	E	V	Habitat loss due to agriculture & urban development
Portage River	Kalamazoo	1992	E	V	
East Cooper	Kalamazoo	1991	E	V	
Paw Paw LK	Kalamazoo	1991	E	V	

Table 5. *Sistrurus c. catenatus*: Michigan Locality Information

POPULATION	COUNTY	DLO	STATUS	TREND	THREATS
Greenville	Kent/ Montcalm	1994	E	V	
Sutton Rd Wetland	Lapeer	1995	E	V	
S. Branch Flint Rvr	Lapeer	1993	E	V	
Tyrone	Livingston	1995	E	V	
Bass LK Area	Livingston	1993	E	V	
Logan Lakes	Livingston	1992	E	V	
Gregory	Livingston	1990	E	V	
Gregory SGA	Livingston	1988	E	V	
Stony Cr Metro Pk	Macomb	1995	E	V	
Big Cannon Cr	Missaukee	1991	E	V	
Clear LK	Muskegon	1995	E	V	
Green Cr. Rd	Muskegon	1987	E	V	
Highland State Rec. Area	Oakland	1995	E	V	Intentional killing
Lakeville Swamp	Oakland	1995	E	V	Intentional killing
Worden Rd	Oakland	1995	E	V	
Hensell Rd.	Oakland	1995	E	V	
Holly Rec Area-W	Oakland	1993	E	V	
Oakland Twp.	Oakland	1992	E	V	
Grand LK	Presque Isle	1995	E	V	Intentional killing
Pickerel Cr. Drain	Saginaw	1993	E	V	
Brandywine Cr	Van Buren	1994	E	V	
Lyle Lk Area	Van Buren	1994	E	V	
Melvin Cr. Wetld.	Van Buren	1994	E	V	
Jepththa LK Bog	Van Buren	1990	E	V	
Sharon Hollow	Washtenaw	1994	E	V	
Hudson Mills Metro Park	Washtenaw	1993	E	V	
Mill LK	Washtenaw	1993	E	V	
Portage-Silver Lk.	Washtenaw	1990	E	V	

Table 5. *Sistrurus c. catenatus*: Michigan Locality Information

POPULATION	COUNTY	DLO	STATUS	TREND	THREATS
Portage Creek/ Bicentenial Park	Kalamazoo	1995	E	D	Habitat loss due to development
Angling Road Sch.	Kalamazoo	1993	E	D	
Bald Mt. Rec. Area	Oakland	1994	E	D	
S. Townsend LK	Oakland	1994	E	D	Intentional killing
North Wixom	Oakland	1995	E	D	
Green/Union Lakes	Oakland	1988	E	D	Habitat loss due to development
Wixom	Oakland	1988	E	D	Habitat loss due to agriculture & highway construction
Cranberry LK /I-75	Oakland	1987	E	D	
Lake Erie Metro Pk	Wayne	1994	E	D	
Bassett LK Rd	Barry	1995	E	UK	Intentional killing
Cedar Cr	Barry	1995	E	UK	
Lawrence LK	Barry	1994	E	UK	
Cedar CR N	Barry	1993	E	UK	
Painter LK Area	Cass	1994	E	UK	
Mill Cr. Wetlands	Cass/St. Joseph	1994	E	UK	
Liberty Fen	Jackson	1995	E	UK	
Lime Lake Fen	Jackson	1993	E	UK	
Three Lakes	Kalamazoo	1995	E	UK	
Gourdneck SGA-S	Kalamazoo	1994	E	UK	Intentional killing
Gourdneck SGA-N	Kalamazoo	1994	E	UK	Intentional killing
Onsted SGA	Lenawee	1993	E	UK	
Brady RD Swamp	Livingston	1995	E	UK	
Brighton Rec. Area	Livingston	1994	E	UK	
Unadilla W/L Area	Livingston	1993	E	UK	
Grass Lake	Montcalm	1992	E	UK	
Benton Lake	Newaygo	1989	E	UK	
Styles Swamp	Newaygo	1994	E	UK	
Kensington Metro Park	Oakland	1995	E	UK	

Table 5. *Sistrurus c. catenatus*: Michigan Locality Information

POPULATION	COUNTY	DLO	STATUS	TREND	THREATS
Buckhorn LK area	Oakland	1995	E	UK	
Holly State Rec. Area	Oakland	1995	E	UK	
Bridge PSalley	Oakland	1995	E	UK	
Wolf Lk. Fish Hatchery	PSan Buren	1993	E	UK	
Pickney Prairie	Washtenaw	1993	E	UK	

Population=Number of populations within the county; DLO=Date Last Observed
Status= X (Extirpated), E (Extant), UK (Unknown), LX (Likely Extirpated)
Trend= NA (Not applicable), S (Securee), PS (Presumed Secure), V (Vulnerable), D (Declining), PD (Presumed Declining), UK (Unknown)
Source: Legge and Rabe (1994); Legge (1996, *in litt.* 1996, 1997); Rabe (*in litt.* 1997); Legge (*in litt*. 1998)

Table 6. *Sistrurus c. catenatus*: Minnesota Locality Information

POPULATION	COUNTY	DLO	STATUS	TREND	THREATS
Wabasha	Wabasha	1936-37	X	NA	Habitat fragmentation, collection, small population size
Zumbro River	Wabasha	1969	X	NA	Habitat fragmentation, collection, small population size
Whitewater River	Wabasha	1982-1984	LX	D	Habitat fragmentation, collection, small population size#
Root River	Houston	1986	LX	D	Habitat fragmentation, collection, small population size
Cannon River Bottoms	Goodhue	No Date	LX	D	Habitat fragmentation, collection, small population size

DLO=Date Last Observed; Status= X (Extirpated), LX (Likely Extirpated), E (Extant), UK (Unknown)
Trend= NA (Not applicable), S (Secure), PS (Presumed Secure), D (Declining), PD (Presumed Declining), UK (Unknown)
Source= MCBS (1994), Baker (Pers. comm. 1996), Hall (Pers. comm. 1996)

Table 7. *Sistrurus c. catenatus*: Missouri Locality Information

POPULATION	COUNTY	DLO	STATUS	TREND	THREATS
Nodaway River	Andrew	-	X	NA	NA
Mound City	Holt	-	X	NA	NA
Swope Park	Jackson	-	X	NA	NA
Bean Lake	Platte	-	X	NA	NA
East Leavenworth	Platte	-	X	NA	NA
Dardenne Lake Duck Club	St. Charles	<1983	X	NA	Habitat loss
Silver Lake	St. Charles	-	X	NA	NA
St. Charles Marshes	St. Charles	1941	X	NA	NA
Bigelow Marsh	Holt	1992	LX	D	Limited, marginal habitat
Fountain Grove	Linn/ Livingston	1981	LX	D	
Squaw Creek	Holt	1995	E	S	
Swan Lake	Chariton	1990	E	V	Limited habitat
Pershing SP	Linn	1995	E	V	

DLO= Date Last Observed; Status= Extant (E); Extirpated (X); Likely Extirpated (LX), Unknown (UK)
Trend= Secure (S); PS (Presumed Secure); V (Vulnerable), Declining (D); Presumed Declining (PD), Unknown (UK); Not Applicable (NA)
Sources= Seigel (1986, pers. comm. 1996, *in litt*. 1997, *in litt*. 1998), Tom Johnson (MDOC, pers. comm. 1996), MDOC (*in litt*. 1996), Hultgren (*in litt*, 1997)

Table 8. *Sistrurus c. catenatus*: New York Locality Information

POPULATION	COUNTY	DLO	STATUS	TREND	THREATS
Featherbed Swamp	Cayuga	<1919	X	NA	NA
Bergen-Byron Swamp	Genesse	1995	E	V	Vegetative succession & collection
Cicero Swamp	Onondago	1995	E	V	Vegetative succession & collection

DLO=Date Last Observed; Status= X (Extirpated), E (Extant), LX (Likely Extirpated), UK (Unknown)
Trend= NA (Not applicable), S (Secure), PS, (Presumed Secure), V (Vulnerable), D (Declining), PD (Presumed Declining), UK (Unknown)
Sources= Johnson (1995, pers. comm. 1996), Breisch (Pers. comm. 1996)

Table 9. *Sistrurus c.catenatus*: Ohio Locality Information

POPULATION	COUNTY	DLO	STATUS	TREND	THREATS
Auburn Twp	Crawford	1932	X	NA	NA
Cranberry Twp	Crawford	1932	X	NA	NA
near Cleveland	Cuyahoga	<1938	X	NA	NA
Hicksville	Defiance	1971-72	X	NA	NA
Oxford Twp	Erie	<1938	X	NA	NA
Millersport	Fairfield	<1938	X	NA	NA
Rattlesnake Creek	Fayette	<1951	X	NA	Habitat loss due to agriculture & channelization
Westerville	Franklin	-	X	NA	NA
Swanton	Fulton	<1938	X	NA	NA
Mt Victory	Hardin/Marion	1964	X	NA	Vegetative succession & indiscriminate persecution
Mello Bog/Willard	Huron	1959	X	NA	NA
New Haven Marsh	Huron	<1938	X	NA	Habitat destruction
Lewisbury	Logan	1938	X	NA	NA
Pony Island	Logan	1931	X	NA	NA
Oberlin	Lorain	<1938	X	NA	NA
Several localities	Lucas/Fulton	<1951	X	NA	Habitat loss due to urban development
Ottawa	Ottawa	1968	X	NA	NA
Several localities	Paulding	<1951	X	NA	Habitat loss due to agriculture
Atwater	Portage	<1951	X	NA	NA
Camden	Preble	1967	X	NA	NA
Basler Run	Preble	1965	X	NA	NA
Woodland Trails Camp	Preble	1969	X	NA	NA
Two pops	Seneca	1932	X	NA	NA
Hartsville	Stark	<1938	X	NA	NA
Mifflin twp.	Wyandot	<1938	X	NA	Habitat modification
Countyline	Fairfield/ Licking	1971	UK	PD	Limitied habitat

Table 9. *Sistrurus c.catenatus*: Ohio Locality Information

POPULATION	COUNTY	DLO	STATUS	TREND	THREATS
Cedar Bog	Champaign	1995	E	V	Highway mortality & vegetative succession
Praire Road Fen	Clark	1995	E	V	Small population size
Spring Valley WA	Greene/Warren	1995	E	V	Collection & indiscriminate persecution
Pallister Woods Preserve/Rome Twp.	Ashtabula	1994	E	PD	
Orwell Twp	Ashtabula	1995	E	PD	Indiscriminate persecution
Wright-Patterson Air Base	Greene/Montg omery	1993	E	PD	Habitat modification
Buckeye Lake	Licking/ Fairfield	1996	E	PD	Habitat loss
Killbuck WA	Wayne	1990	E	PD	
Marseilles Twp/ Killdeer Plains	Wyandot	1997	E	D	Habitat modification
Resthaven WA	Erie	1993	E	UK	
Mecca Twp	Trumbull	1995	E	UK	
Mosquito Creek	Trumbull	1995	E	UK	Collection & incompatible management

DLO=Date Last Observed; Status= X (Extirpated), LX (Likely Extirpated), E (Extant), UK (Unknown)
Trend= NA (Not applicable), S (Secure), PS (Presumed Secure), V (Vulnerable), D (Declining), PD (Presumed Declining), UK (Unknown)
Sources= Davis et al. (1994and 1995); Davis and Menze (1996); Patricia Jones (ODNR, *in litt*. 1997); Doug Wynn (Pers. comm. 1998; *in litt* 1998)

Table 10. *Sistrurus c. catenatus*: Ontario Locality Information

POPULATION	DISTRICT	DLO	STATUS	TREND	THREATS
Red Bay	Bruce	1944	X	NA	
Sauble Beach	Bruce	1962	X	NA	
Purple Valley	Bruce	1960	X	NA	
Chesley	Bruce	1962	X	NA	
Hornings Mills	Dufferin	1963	X	NA	
Dunwich Marsh	Elgin	1930	X	NA	
Dexter	Elgin	1930	X	NA	Habitat loss due to agriculture
Aylmer	Elgin	1962	X	NA	
Amherstburg	Essex	1814	X	NA	Habitat loss due to agriculture & development
Harrow	Essex	1960	X	NA	Habitat loss due to agriculture
Kingsville	Essex	1930	X	NA	Habitat loss due to agriculture
Point Pelee	Essex	1893	X	NA	
Tilbury	Essex	1881	X	NA	Habitat loss due to agriculture
North Keppel	Grey	1977	X	NA	
Meaford	Grey	1975	X	NA	
Shelburne	Grey	1962	X	NA	
SW Simcoe	Haldimand-Norfolk	1963	X	NA	Habitat loss due to agriculture
Delhi	Haldimand-Norfolk	1962	X	NA	Habitat loss due to agriculture
W Simcoe	Haldimand-Norfolk	1961	X	NA	Habitat loss due to agriculture
Lowbanks	Haliburton	1955	X	NA	
Hamilton	Hamilton Wentworth	1950	X	NA	
Sarnia	Lambton	1962	X	NA	Habitat loss due to agriculture, urban & industrial developments
Club Island	Manitoulin Distr.	1963	X	NA	
Bayard Island	Manitoulin Distr.	1968	X	NA	
WSW Strathroy	Middlesex	1895	X	NA	
Glencoe	Middlesex	1851	X	NA	
Arthurs Island	Muskoka Distr.	1942	X	NA	
Gognashene Pt.	Muskoka Dist.	1962	X	NA	
Tillsonburg	Oxford	1962	X	NA	Habitat loss due to agriculture

Table 10. *Sistrurus c. catenatus*: Ontario Locality Information

POPULATION	DISTRICT	DLO	STATUS	TREND	THREATS
Midland Area	Simcoe	1969	X	NA	
SW Midland	Simcoe	1967	X	NA	
NE Angus	Simcoe	1963	X	NA	
Harriston	Wellington	1962	X	NA	
Jacksons Point	York R.M.	1962	X	NA	
Gould Lake	Bruce	1962	X	NA	
South Bay Mouth	Manitoulin Distr.	1972	LX	D	
Skunks Misery	Middlesex	1965	LX	D	
S. Muskoka Falls	Muskoka Dist.	1979	LX	D	
S Wiarton	Bruce	1981	UK	D	
N Mar	Bruce	1975	UK	D	
Charles Lake	Grey	1980	UK	D	
Restoule Lake	Parry Sound Distr.	1978	UK	D	
Lions Head	Bruce	1984	UK	UK	
Oliphant	Bruce	1986	UK	UK	Cottage development
Cruikshank	Grey	1980	UK	UK	
Vidal Island, West Point	Manitoulin Distr.	1977	UK	UK	
Cockburn Isl.	Manitoulin Distr.	1984	UK	UK	
E Bala	Muskoka Distr.	1984	UK	UK	
Oastler Lake	Parry Sound Distr.	1984	UK	UK	
Coldwater	Simcoe	1983	UK	UK	
Millerd Lake	Sudbury	1985	UK	UK	
Bigwood	Sudbury	1985	UK	UK	
N. Bruce P.	Bruce	1996	E	S	
Pike Bay	Bruce	1986	E	S	
Beausoleil Island	Muskoka Distr.	1991	E	S	
Six Mile Lake	Muskoka Distr.	1994	E	S	
Killbear	Parry Sound Distr.	1994	E	S	

Table 10. *Sistrurus c. catenatus*: Ontario Locality Information

POPULATION	DISTRICT	DLO	STATUS	TREND	THREATS
Lyal Island	Bruce	1987	E	PS	
Cove Island	Bruce	1996	E	PS	
Go Home	Muskoka Distr.	1994	E	PS	
Nine Mile Lake	Muskoka Distr.	1994	E	PS	
Healey Lake	Parry Sound Distr.	1993	E	PS	
E Mar	Bruce	1983	E	V	
Isaac Lake	Bruce	1983	E	V	
Cape Croker IR	Bruce	1984	E	V	
Fitzwilliam Island	Manitoulin Distr.	1985	E	V	
Bone Island	Muskoka Distr.	1995	E	V	
Wainfleet Bog	Niagara R.M.	1998	E	PD	Small population size, isolated & habitat loss
Ojibway Prairie	Essex	1994	E	D	Habitat loss due to development
Killarney PP	Manitoulin Distr.	1987	E	D	
S Maceys Bay	Muskoka Distr.	1984	E	D	
Key Harbour	Parry Sound Distr.	1987	E	UK	
Grundy Lake Provincial Park	Parry Sound Distr.	1985	E	UK	
Big Burnt Isl.	Parry Sound Distr.	1993	E	UK	
Clear Lake	Parry Sound Distr.	1993	E	UK	
Shawanaga	Parry Sound Distr.	1993	E	UK	
Hessner Lake	Muskoka Distr.	1992	E	UK	
Collingwood	Simco	1994	E	UK	
Long Lake	Sudbury	1987	E	UK	

DLO= date last observed; Status= X (Extirpated), LX (Likely Extirpated), E (Extant), UK (Unknown)
Trend= NA (Not applicable), S (Stable), PS (Presumed Secure), V (Vulnerable), D (Declining), PD (Presumed Declining), Uk (Unknown))
Sources:Mike Oldham (*in litt*. 1997)

Table 11. *Sistrurus c. catenatus*: Pennsylvania Locality Information

POPULATION	COUNTY	Sites[1]	DLO	STATUS	TREND	THREATS
Bakerstown	Allegheny	1	1899	X	NA	NA
Crider's Corners	Butler	2	1920(2)	2-X	NA	NA
Hartstown-Adamsville/Half-moon Swamp	Crawford/ Mercer	4	1906-26(3) 1967	4-X	NA	
Plain Grove	Lawrence	2	1937 1950s	2-X	NA	
Sandy Lake Area	Mercer	9	1900s (4) 1974 1980 1988(3)	4-X 2- LX 3-E	2-D 3-UK	Impoundment - loss of habitat
Clintonville	Venanago /Bulter	7	1931-42 (6) 1995	6-X LX	D	Road mortality and limited habitat
Greece City-Boydstown	Butler	5	1970s 1987(3) 1988	1-X 4-E	4-PD	Very limited habitat
Muddy Creek-Swamp Run City-	Butler	2	1940s 1962	2-X	NA	Habitat modification due to dam construction
Boyers-Glades, Jennings	Butler	5	1977 1984 1986 1990 1997	1-LX 4-E	1-S 3-D 1-UK	Major habitat loss due to strip mining & vegetative succession
Grove City-Perrine Corners-Henderson	Mercer	6	1971 1970s(2) 1980(2) 1995	3-LX 2-UK 1-E	3-UK 3-D	Major habitat loss due to strip mining
Fenelton	Butler	5	1946 1987 (2) 1988 1997	1-X 4-E	4-UK	Habitat loss due to strip mining
Rattlesnake Swamp/Coolspring	Mercer	3	1940s 1984 1986	1-X 2-E	1-PD 1-UK	Vegetative succession, major habitat loss
Tippery	Venango	14	1970s 1976 1977 1984 1985 1986 1987 (3) 1988	2- LX 8-UK 4-E	3-D 11-UK	Substantial habitat loss, intentional killing

DLO= date last observed; Status= X (Extirpated), LX (Likely Extirpated), E (Extant), UK (Unknown)
Trend= NA (Not applicable), S (Stable), V, (Vulnerable), D (Declining), PD (Presumed Declining), UK (Unknown)
Sources: Reinert (1978, 1990 and *in litt*. 1998), Reinert and Bushar (1993), Shields (PA Dept. of Fish and Boat Commission, *in litt*. 1998)

Table 12. *Sistrurus c. catenatus*: Wisconsin Locality Information

POPULATION	COUNTY	DLO	STATUS	TREND	THREAT
-	Clark	1955	X	NA	NA
-	Dane	1962	X	NA	NA
-	Iowa	1871	X	NA	NA
S. Fork Halls Cr.	Jackson	1947	X	NA	NA
-	Racine	No Date	X	NA	NA
Turtle Creek	Rock	No Date	X	NA	Habitat Loss
-	Sauk	1962	X	NA	NA
Honey & Sugar Creeks	Walworth	1890	X	NA	Habitat loss & persecution
Dike 17	Jackson	1989	LX	D	Habitat modification & indiscriminate persecution
East of Brodhead	Rock	1991	LX	D	
Portage Marsh	Columbia	1977	LX	D	Small population size due to collection
Rocky Run Creek	Wood	1993	LX	D	Unsuitable habitat
14th Ave. Swamp	Juneau	1983	UK	D	Habitat modification & collection
Miss. Rvr	Crawford	1979	UK	UK	
Plum Creek Bottoms	Pepin	1987	UK	UK	
Nelson-Trevino Bottoms	Buffalo/ Pepin	1993	E	D	Small population size due to collection & highway mortality
Yellow Rvr Bottoms	Juneau	1995	E	D	Habitat Modification, small population size due to collection & highway mortality
Black Rvr Bottoms	LaCrosse/ Trempealea	1993	E	D	Small population size due to collection & highway mortality
Warrens	Monroe	1994	E	D	Limited habitat, predation & highway mortality
Turtle Creek	Walworth	1988	E	D	Habitat fragmentation
Paradise Valley, BRF	Monroe	1993	E	UK	

DLO=Date Last Observed; Status= X (Extirpated), LX (Likely Extirpated), E (Extant), Uk (Unknown)
Trend= NA (Not applicable), S (Secure), PS (Presumed Secure), V (Vulnerable), D (Declining), PD (Presumed Declining), UK (Unknown)
Sources: Hay and Kopitzke (1993), Casper (1993, *in litt.* 1996), Hay (*in litt.* 1996, pers. comm. 1996), BER (*in litt.* 1996), King (pers. comm. 1996)

Table 13: Number of known extant & known secure sites within *S. c. catenatus* range

STATE	NO. OF EXTANT SITES [1]	NO. OF SECURE SITES [2]
Illinois	5 (20%)	0
Indiana	19 (43%)	0
Iowa	5 (38%)	0
Michigan	137 (67%)	40 (29%)
Minnesota	0	0
Missouri	3 (31%)	1 (33%)
New York	2 (67%)	0
Ohio	12 (32%)	0
Pennsylvania	19 (29%)	1 (1%)
Wisconsin	6 (29%)	0
Ontario	28 (35%)	10 (35%)

[1]Numbers in parentheses are the percentage of historical populations that remain
[2]Numbers in parentheses are the percentage of extant populations that are secure

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