Conservation Approach

for

Eastern Massasauga (Sistrurus C. Catenatus)

USDA Forest Service, Eastern Region
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This Conservation Approach was prepared to compile the published and unpublished information for the Eastern Massasauga. It does not represent a management decision by the U.S. Forest Service. Though the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. In the spirit of continuous learning and adaptive management, if you have information that will assist in conserving the subject taxon, please contact the Eastern Region of the Forest Service Threatened and Endangered Species Program at 310 Wisconsin Avenue, Suite 580 Milwaukee, Wisconsin 53203.

EXECUTIVE SUMMARY

The eastern massasauga rattlesnake, *Sistrurus c. catenatus*, is a Candidate for listing under the Endangered Species Act. The USDA Forest Service (Forest Service) has designated it as a Regional Forester's Sensitive Species on the Huron-Manistee National Forests. The imperiled status of the massasauga is largely the result of the loss or decline of populations and habitat, and take, either from direct persecution or as a side effect of habitat management efforts for other wildlife. It is suspected that most of the remaining populations in the United States are in Michigan, and that many of those are on public lands. Given the importance of Michigan's remaining massasauga populations for the conservation of the species, and the potential contributions of the Huron-Manistee National Forests to this effort, the Forest Service has pursued the development of a Conservation Approach for this species of snake.

The Conservation Approach was developed following the prescribed format established by the Forest Service Manual 2672.11.6.b. Key tasks were to review the current state of understanding of the eastern massasauga in terms of its ecology, life history, and distribution and status in Michigan, specifically within the Forests. This was achieved by extensive review of the existing literature on the species, examination of land cover data, and visits by B. Kingsbury to the Forests to gain a better understanding of available habitat and activities in and adjacent to that habitat. Findings were then used to 1) examine interactions between current Huron-Manistee National Forest Land and Resource Management Plan management practices and other human activities and the needs of the massasaugas, and 2) develop proactive measures to promote the health of massasauga populations on the Forests.

During visits to areas of the National Forests, no massasaugas were observed. Thus, no large populations were apparent. However, suitable habitat was often found near many of the historical records, and several metapopulations likely persist. Suitable habitat does not appear to be substantially as extensive as it once was, however, and this is impacting massasaugas. Several factors, each related to current land management practices, either clearly conflict with maintenance of massasauga habitat, or may do so. Hydroelectric dam construction flooded extensive areas of habitat, and pulsed discharges leading to repeated oscillations of wetland water levels destroyed or substantially degraded downstream habitat. Fire suppression has lead to the widespread loss of open canopy habitats such as meadow and savannah. Management for old growth forest may thus also lead to loss of habitat elements used by massasaugas if fire suppression precludes the maintenance of early successional habitat. Habitat modifications for cold water stream fish would also appear to be a conflict in several ways: tree planting in streamside meadows directly removes suitable habitat, and beaver suppression removes a primary mechanism for habitat maintenance. Management of areas along currently designated scenic rivers does not appear to pose a problem. Management prescriptions are compatible with massasauga conservation, and massasaugas are not currently known to occur in designated areas along the Manistee, Pere Marquette, and Au Sable Rivers.

Habitat management efforts should focus on maintaining and expanding a patchwork of open canopy habitat along riparian corridors. Areas to target first should be those watersheds with known records, followed by adjacent watersheds with similar physical features. Examples on the Manistee National Forest include the Little Manistee River corridor and wetland systems converging near Baldwin and White Cloud. On the Huron

National Forest, riparian corridors along streams draining into Lake Huron, including the lower watershed of the Au Sable River, are most important. Many of these streams are relatively small. In both Forests, massasaugas need not be considered in areas one kilometer or more from wetlands and streams. Such a distance would represent a relatively extreme move for snakes away from these habitats. Timber management plans, including old growth management, could thus be driven by other considerations outside of this buffer.

Maintenance of massasauga habitat has utility beyond benefiting the focal species. Wildlife communities dependent upon dynamic, early successional systems will directly benefit. Massasauga habitat also has other management benefits. For example, riparian corridors with open upland buffers could be interlaced with Kirtland's warbler habitat to provide firebreaks.

Future efforts regarding this species should focus on determining local habitat needs and clarifying its distribution more accurately. We only have a basic understanding of patterns of movement and habitat use by the massasauga in coniferous forests with sand substrate. A finer-grained assessment of the distribution of the snake would require substantial field time in May and August. Efforts to develop accurate population estimates would be extremely challenging and costly. However, it may be possible to develop indices of density to detect improvements or declines in populations and habitat over time.

Opportunities for collaboration on massasauga conservation are extensive. Potential cooperators in the form of government entities include elements of the USDI Fish and Wildlife Service, Michigan Department of Natural Resources (Forest Management Division, Wildlife Division, and Fish Division), Michigan Natural Features Inventory, and the Michigan Department of Military and Veterans Affairs. Native American tribal groups that may collaborate include bands of the Chippewa, Ottawa and Odawa. Collaboration with private landowners will also prove to be very important, as many areas of the Forests are not contiguous, but are intermixed with private in holdings.

ACKNOWLEDGEMENTS

Development of this Approach was primarily funded by the USDA-Forest Service. I appreciate the effort on the part of Kenneth Ennis and other Forest personnel to consider massasauga conservation as a part of the Forest management agenda. Logistic support was provided by the Center for Reptile and Amphibian Conservation and Management at Indiana-Purdue University. Editorial comments were coordinated by Kenneth Ennis. The following Huron-Manistee National Forests employees provided comments: Chris Schumacher, Wildlife Biologist, Cadillac/Manistee Ranger Districts; Joe Kelly, Wildlife Biologist, Baldwin/White Cloud Ranger Districts; Phil Huber, Wildlife Biologist, Mio Ranger District; Jeff Cook, Biological Technician, Huron Shores Ranger District; and Holly Jennings, Fisheries Biologist, Huron National Forest. I also thank Kenneth Ennis for facilitating interactions with other Forest Service personnel and providing useful hard copy and digital information. I was accompanied in the field by Dave Riegle, Wildlife Biologist, Huron Shores Ranger District; Carl Racchini, Wildlife Biologist, Huron Shores Ranger District; Joe Kelly, Wildlife Biologist, Baldwin/White Cloud Ranger Districts; Tom Walter, Biological Technician, Baldwin/White Cloud Ranger Districts, Jim Cline,

Biological Technician, Baldwin/White Cloud Ranger Districts, and Jennifer Biehl and Sarah Harvey, summer interns, Cadillac/ Manistee Ranger Districts. I thank Dave for his engaging style in the field that led to interesting discussions about massasaugas and forest management. The Michigan Natural Features Inventory provided data on confirmed observations for massasaugas in Michigan.

INTRODUCTION

The eastern massasauga (*Sistrurus catenatus catenatus*) is one of three subspecies of massasauga rattlesnake (cover page, Figure 1). Snakes of the genus *Sistrurus* (massasaugas and pigmy rattlers) are relatively small compared to most species of the more familiar rattler genus *Crotalus*. They differ as well in that the dorsal head scales of *Sistrurus* are enlarged, whereas the dorsal head scales of *Crotalus* are similar in size to those on the back of the body. Individuals typically have a series of dark dorsal blotches on a gray to brownish-tan ground color (Conant and Collins 1991). Melanistic (black) individuals also occur in some populations. As with most snakes, males have longer tails, but are otherwise quite similar in appearance to females. Experienced persons may reliably sex massasaugas by cloacal probing.

Figure 1. An Eastern Massasauga Rattlesnake

This snake, held by the author, is anaesthetized. Note the small size of the snake, even though it is an adult. Diagnostic features include the rattle and the heat sensitive pits, one of which can be seen on the face, just in front of and lower than the eye, and looking much like an extra nostril.

Several other species of snake from Michigan may be misidentified as massasaugas, two of which have ranges that extend onto the Forests. In the area of the Forests, the eastern hognose snake (*Heterodon platyrhinos*) is the species most commonly mistaken for massasaugas. The eastern milk snake (*Lampropeltis triangulum*) may also be mistaken for a massasauga.
For some time, biologists have been concerned about local extirpations of this species, as well as declines in the remaining populations. The U.S. Fish and Wildlife Service (FWS) designated the massasauga as a Category 2 candidate species in 1982 (Legge 1996), and after the restructuring of the candidate process, gave it Candidate status in 1999 (U.S. Fish and Wildlife Service, 1999). Candidate species are species for which the U.S. Fish and Wildlife Service has sufficient information on file to list the species as either Threatened or Endangered.

It has become apparent that many populations of massasauga are on managed lands, including the Huron-Manistee National Forests. Forest Service personnel recognized the potential of the Forests' populations to contribute to the persistence of the species and have sought to develop this Conservation Approach. The Approach was developed following the prescribed format established by the Forest Service Forest Service Manual

2672.11.6.b for Conservation Strategies. Key tasks were to review the current state of understanding of the eastern massasauga in terms of its ecology, life history, and distribution and status in Michigan, specifically within the Forests. This was achieved by a review of existing literature and visits to the Forests to gain a better understanding of available habitat and activities in and adjacent to that habitat. Findings were used to investigate interactions between management and other human activities and the species' needs to 1) identify how current Forest Plan management practices and other human activities affect massasaugas, and 2) develop proactive measures to promote the health of massasauga populations on the Forests.

Legge and Rabe (Legge and Rabe 1994, Legge 1996) reviewed the status of the massasauga in Michigan. That work, in conjunction with Szymanski's (1998) range-wide assessment, is considered to be the equivalent of the Conservation Assessment to precede this Conservation Approach. These two references, as well as Johnson et al. (2000), are recommended for any individual interested in becoming more familiar with what is known about the ecology and conservation of massasaugas. Appendix A shows the covers of these documents for easy reference.

LIFE HISTORY AND DEMOGRAPHICS

Snakes as a taxon have proven to be difficult to study because of their secretive nature (Parker and Plummer 1987), and massasaugas certainly epitomize this challenge. Nevertheless, there are several studies that provide information about the reproductive biology of this species. Correlations of snout-vent length to age of maturity suggest that female massasaugas attain sexual maturity at three or four years of age (Wright 1941, Keenlyne 1978, Seigel 1986). Age of maturity may be delayed for more northerly populations, however. Long-term research on snakes of known age in Killbear Provincial Park, Ontario indicates that most females do not begin to reproduce until they are at least five, and perhaps even six or seven years old (C. Parent unpublished data).

Massasaugas mate in the late summer or fall (late July to early September), depending on the latitude of the population. However, fertilization and development do not occur until the following spring. Massasaugas are ovoviviparous, that is, they do not lay eggs but give birth to fully developed young. During the summer, gravid females devote their time to maintaining constant, elevated body temperatures, which facilitates the development of the embryos. At more northerly latitudes, these females may congregate at sites that allow effective thermoregulation, such as open, rocky areas (Reinert 1981, Johnson 1995, C. Parent unpub. data).

Massasaugas typically give birth from mid-August to early September (Wright 1941, Keenlyne 1978, Reinert 1981 and 1985, Seigel 1986, Johnson 1995, C. Parent unpub. data), although yearly variation in weather patterns can influence this timing. However, parturition dates may be strongly influenced by climate. The sex ratio of offspring does not differ significantly from 1:1 (Klauber 1972, Parker and Plummer 1987). After the young are born, mother and young remain at the site of birth for several days, and then gradually disperse.

The brood size for massasaugas can vary dramatically. For example, the number of young observed by Seigel (1986) at one site in Missouri ranged from 3 to 19. Factors driving this variability are unclear, but brood size is positively correlated with female

snout-vent length (Seigel 1986, C. Parent personal communication). The frequency of female reproduction is also variable. In some populations, females appear to reproduce annually (Keenlyne 1978, Bielema 1973), while in others they do so every other year (Reinert 1981, Seigel 1986, Johnson 1995). Why this is the case remains to be clarified, but it probably relates to prey abundance and length of growing season.

HABITAT USE AND MOVEMENT

Range-Wide Patterns of Habitat Use and Movement

Across their range, massasaugas have been reported from a number of habitats, including wet prairie (Seigel 1986), fens and sedge meadows (Minton 1972; Johnson 1995; Kingsbury 1996, Kingsbury and Barlow 1999), peatlands (Johnson 1995, 2000), coniferous forest (Weatherhead and Prior 1992; C. Parent, personal communication), meadows and old fields (Reinert and Kodrich 1982, Wright 1941, Smith 1961). Careful inspection of the literature reveals that some of this diversity is a matter of semantics, as various authors and researchers use terms differently. However, it is also apparent that habitat use varies regionally, and is somewhat site dependent even within a particular region (Wright 1941, Minton 1972, Reinert and Kodrich 1982, Seigel 1986, Weatherhead and Prior 1992, Johnson 1995, Kingsbury 1996, Kingsbury and Barlow 1999).

Despite this variation, there are several common attributes of the habitats used by massasaugas. A notable feature is an open vegetative structure relative to surrounding areas. Over most of their range, massasaugas tend to avoid heavily wooded areas (Wright 1941,Bielema 1973,Reinert and Kodrich 1982, Seigel 1986, Kingsbury 1996, Kingsbury and Barlow 1999), although some investigators have associated them with gaps in bottomland hardwoods (Johnson 1995, King 1997) or coniferous woodlands (Weatherhead and Prior 1992, Johnson 1995, C. Parent 1998, personal communication). Even in wooded situations, the snakes generally use those areas with the most open canopy.

Sites also typically have an open shrub layer. These vegetative structures, where trees and shrubs are thinly distributed, may provide a desirable thermoregulatory mosaic. The openness of the habitat also increases prey (rodent) densities by enhancing the growth of sedges, grasses, and herbs. Within relatively open habitat, massasaugas often select microhabitat near isolated trees or shrubs (Bielema 1973, Johnson 1995). This may be related to the shade provided by the vegetation, as well as protection from aerial predators.

Another common aspect of massasauga habitat is the proximity to water. This attribute is observed across most of the species' range (Missouri: Seigel 1986, Wisconsin: King 1997, Indiana: Minton 1972, Kingsbury 1996, Kingsbury and Barlow 1999, Pennsylvania: Maple 1968, Reinert and Kodrich 1982, New York: Johnson, 1995). The association with wetlands is especially interesting, given that massasaugas are not even semi-aquatic. In fact, rattlesnakes as a taxon are generally associated with relatively xeric habitats. Massasaugas tend to avoid open water, and individuals are not regularly found swimming, as would commonly occur with typical water snakes.

Massasaugas often show seasonal shifts in habitat use. The typical pattern is the use of wet prairie and meadow habitats in spring and fall, and activity in higher, drier, habitats in summer (Bielema 1973, Reinert and Kodrich 1982, Seigel 1986, Johnson 1995). The

snakes then return to the wetter habitats in the fall. Other populations do not appear to show a seasonal shift in habitat use, with individuals remaining in wetlands all year (Wright 1941, Maple 1968, Kingsbury and Barlow 1999). In some populations, only the gravid females move (King 1997).

Arriving at wetlands in the fall seems to be a consistent trend for massasaugas, regardless of where the snakes were during the activity season. This aspect of habitat use relates to the selection of hibernation sites, which are typically in areas where the soil is saturated but not inundated. Over much of their range, massasaugas use crayfish burrows to hibernate (Maple 1968, Seigel 1986, Kingsbury and Barlow 1999). Sphagnum hummocks (Johnson 1995) are also used.

The date the snakes enter and exit hibernation depends upon the site, and snakes stay underground longer at more northerly sites. Information from other studies in northern climes suggests that massasaugas may emerge from hibernation throughout May, and retreat throughout September and early October.

As mentioned earlier, another factor influencing habitat use is the reproductive condition of females. Non-gravid females tend to behave similarly to males while gravid females often exhibit a tendency to select sites with a more open canopy (Johnson 1995, King 1997, C. Parent 1998, personal communication). Several females may be found together in such gestation sites (Reinert and Kodrich 1982, King 1997, C. Parent 1998, personal communication). The advantage to such sites is very likely tied to their thermal properties; they may facilitate the maintenance of temperatures advantageous for the development of young. Paralleling the use of more open sites is the tendency for gravid females to move very little until parturition (i.e., the time they bear young).

To summarize, massasaugas prefer habitat with open canopy and sedge or grass ground cover. Sphagnum is also often a significant component of the substrate. Massasauga habitat is typically associated with shallow wetland systems. While individuals may move to drier environs in the summer, they almost always return to wetlands to hibernate. Gravid females are the most likely to move to more exposed warmer sites for the summer until they bear their young

Another aspect of the ecology of massasaugas is their diet. Adult massasaugas eat primarily small mammals, although juveniles also eat small snakes (Keenlyne and Beer 1973, Seigel 1986, Johnson 1995). Species commonly listed as predominant mammal prey include voles (*Microtus*) and jumping mice (*Zapus*). Garter snakes are a common snake prey item.

Habitat Use in Michigan

In many ways, Michigan contains a relatively complete assemblage of possible massasauga habitats. Populations are distributed throughout the Lower Peninsula, and climatic, soil and vegetation features are widely variable across the state (Figure 2). In southern Michigan, habitat often appears much as it does in states such as northern Illinois, Indiana and Ohio. Populations are often associated with sedge fens and wet meadows along rivers and around lakes. If such areas are affiliated with savannah or old fields, the snakes may be found in these in the summer months. Habitat further north may be spottier, and our understanding of habitat use is less extensive. Late summer observations are often in dry upland forests (jack

pine and red pine) or even coniferous forests (cedar swamps). Activity in such areas requires further clarification. Historical observations are nevertheless typically associated with sedge or grassy habitat patches. Massasauga habitat on the northeastern edge of the Lower Peninsula has a number of attributes similar to habitat around the Georgian Bay in Ontario. In both areas, the substrate is rocky, rather than sandy or mucky. As a result, openings in the canopy are provided by continuous rock slabs, and the snakes use these for basking. Cap rocks in these openings also provide refugia for gravid females and basking individuals.

Habitat Use on the Huron-Manistee National Forests

Within the Forests, habitat use remains poorly understood. We can extrapolate that massasaugas may need sedge or grass dominated patches of habitat associated with wetlands. This certainly seems to be a part of their requirements, since inspections of historical observations often reveal sedge and grass patches interspersed with shrubs at most of the sites from where massasaugas have been found (Figure 3). However, observations are often made in areas containing a relatively dense canopy of coniferous species, and this does not represent "classic" habitat as described for sites to the south. Habitat associations are typically in close proximity to streams and areas that historically contained cedar swamp or mixed coniferous swamp. These associations are strongest when the surrounding uplands are jack or red pine on a sandy substrate, and weaken when the surrounding swamp shifts to hemlock, beech, and maple on a finer till.

Figure 3. Examples of massasauga habitat. Clockwise from upper left: a sedge meadow along the Little Manistee River, a sedge/tag alder gap in coniferous forest on Camp Grayling, and an old field meadow at the Thompson Farm site near the Au Sable River. Although the matrix in which suitable habitat exists can vary substantially, sedge/grassy meadows with a scattering of shrubs seem to consistently occur near massasauga observations. Photographs by B. Kingsbury.

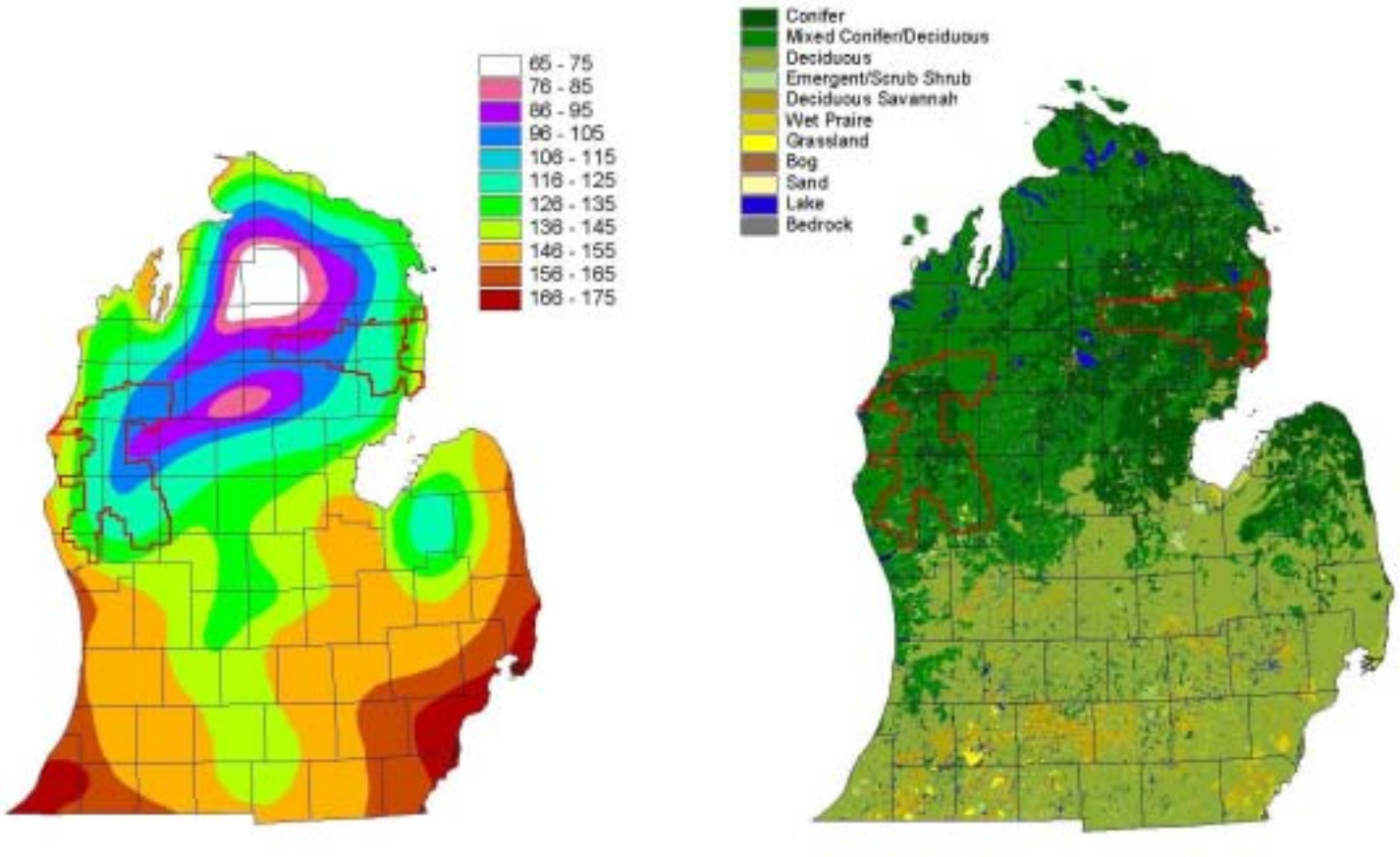

Figure A **Figure B**

Figure 2. Position of the Huron-Manistee National Forests relative to climate and vegetation cover of the Lower Peninsula of Michigan. A) Growing season data reveals that many portions of the Forests occur in areas with cooler climate, but not in the coldest areas of the Lower Peninsula. B) Presettlement vegetation in the Forests was predominantly coniferous or mixed coniferous forests.

STATUS AND DISTRIBUTION

Range-wide Population Status

The massasauga is essentially a mid-western species, ranging to the east as far as western New York and southern Ontario, through Ohio, Indiana, Michigan, and west to Iowa and Missouri (Conant and Collins 1991). Extensive anecdotal literature suggests that populations throughout the Midwest were once quite large. However, despite these apparently high historical densities, the massasauga has declined dramatically range-wide. Many populations have been extirpated, and most remaining populations are in habitat that is fragmented and isolated (Szymanski 1998). In some states such as Minnesota, all of the populations are believed to be extirpated. In other states such as Illinois, Indiana and Ohio, a few populations remain, typically isolated from neighboring populations by many miles. Even in Michigan, where most of the extant populations of massasaugas are believed to remain, a third or more of the historically known populations are gone (USFWS1998).

Status and Distribution in Michigan

Historically, massasaugas appear to have been distributed across much of the Lower Peninsula of Michigan (Figure 4). The farthest north they have been recorded in Michigan is on islands in the Mackinac Strait (Legge 1996). Their range only extends further north in Ontario on the east shore of the Georgian Bay of Lake Huron.

Currently, there is an ongoing effort to establish the status of the massasauga across the state of Michigan. As part of an effort to develop a Candidate Conservation Agreement (CCA), surveys were conducted across the state in 2001 (Kingsbury et al. in progress). While these surveys revealed evidence of only 10 massasaugas, we documented extensive habitat. Surveys will continue in 2002 and 2003. Prior to this work, the most recent substantive effort conducted to determine the status and distribution of massasaugas in Michigan was by Legge and Rabe (Legge and Rabe 1994, Legge 1996).

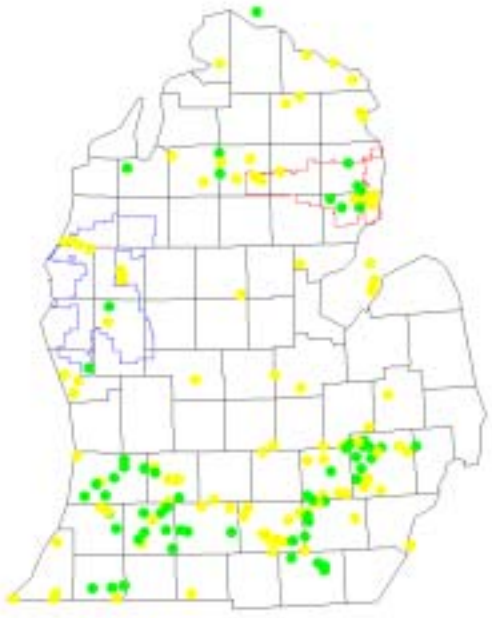

Figure 4. The Distribution of Eastern Massasauga Observations across Michigan. The yellow dots are confirmed observations from the MI Natural Features Inventory database (2000) reported during or before 1990, while the green dots are sightings more recent than that. The counties for the Lower Peninsula are shown in gray, the outer boundary of Huron National Forest is shown red, and the outer boundary of Manistee National Forest is shown in blue.

These investigators conducted an intensive mailing to solicit updates from land managers about recent observations and also conducted a series of site surveys. They also found ten snakes during their survey efforts.

Legge (1996) concluded that the listing of massasaugas in Michigan as Special Concern, but not as Threatened, was justifiable and should not be changed. However, he also noted additional information was needed to further clarify the status of the snake in the state. He suspected that populations in the northern Lower Peninsula were possibly more extensive than in the south. Although most observations of massasauga are in the southern third of the Lower Peninsula, the amount of rural countryside is far greater to the north, and Legge reasoned that chance encounters might be less frequent there given the lower human population. Kingsbury et al. (in progress) have not been able to substantiate large populations in the northern portion of the state, and we feel that further observations of snakes in a variety of areas are needed before concluding that the snakes are more abundant to the north.

Status and Distribution on the Huron-Manistee National Forests

The status of the massasauga on the Forests is not clear. As mentioned above, Legge (1996) felt that perhaps the massasauga was more abundant in the northern part of the Lower Peninsula, including parts of the Forests. However, the author's examination of historical records and several unsuccessful efforts to find individuals suggests that they are not abundant at any Forest location. Nevertheless, massasaugas continue to be found at several locations in both Forests. Records are not widely distributed, however. Counties of greatest importance include Alcona, Iosco, Manistee, Newaygo, and Lake. On the Huron National Forest, observations have been made along the Au Sable River and its tributaries, and in smaller watersheds near Lake Huron (Figure 5). On the Manistee National Forest, records cluster along the lower reaches of the Little Manistee River and around Baldwin and White Cloud (Figure 6). These distributions and how to view them using Forest mapping units are considered in more detail below.

Figure 5. Distribution of Massasauga Observations and Management Units on Huron National Forest. The green line represents the Forest boundary, the blue lines Management Units. Black dots represent confirmed massasauga observations since 1990, and gray dots confirmed observations during or before 1990.

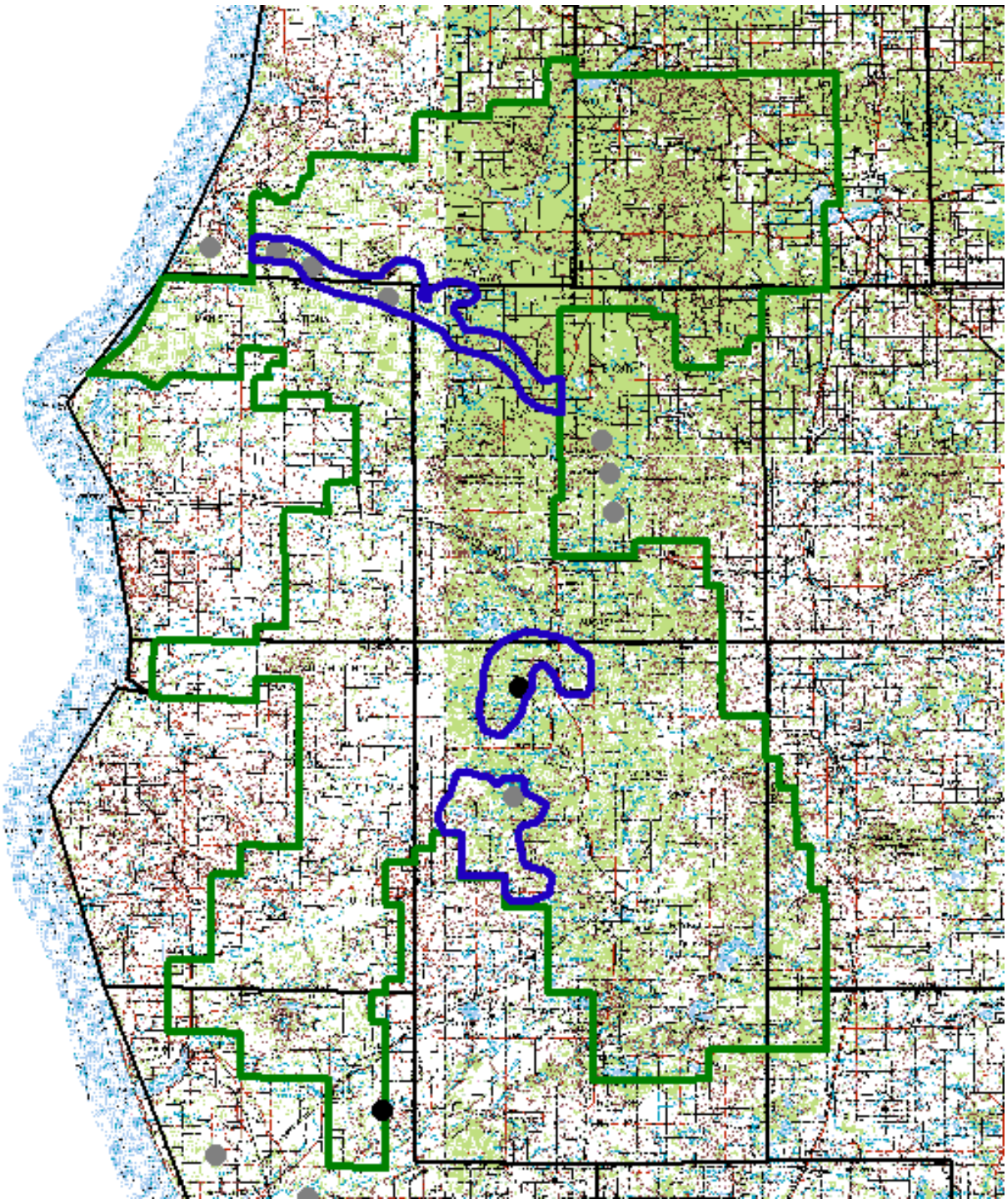

Figure 6. Distribution of Massasauga Observations and Management Units on Manistee National Forest. The green line represents the Forest boundary, the blue lines Management Units. Black dots represent confirmed massasauga observations after 1990, and gray dots confirmed observations during or before 1990.

Huron National Forest

Overview: All recent observations of massasaugas on the Huron National Forest are within 25 miles of Lake Huron. There are Forest records from over fifty years ago close to Grayling, and I suspect that the Au Sable River corridor may have been the route by which the species reached interior areas around Grayling. However, at this time, the main areas of concern are sites on the Tawas Ranger District and a small area in the southeasternmost portion of the Harrisville Ranger District in the Pine River drainage.

The complete lack of records in the interior wetland complexes away from the Au Sable River suggests that they have not been documented in those areas in recent history. Consideration of historic records and presettlement land cover suggests that massasaugas were primarily located in coniferous riparian systems (Land Type Association (LTA) 5 (Alluvial, Fluvial, and Organic)) imbedded in a surrounding matrix of red pine and jack pine (*Pinus banksiana*) uplands (LTA 1, Outwash Plains). Based on these associations and an upland buffer around them, Forest boundaries and the location of collateral roads, preliminary massasauga management unit boundaries are suggested for the Huron National Forest. Each proposed Management Unit is discussed below in a separate section and depicted in associated figures. Future consideration of Ecological Landtype Phases (ELTPs) may also reveal useful associations. Poorly drained ELTPs (60s, 70s and 80s) are of the greatest interest, particularly ELTPs 80 and 82. This is also consistent with the presence of sandy substrates. Records are generally lacking from areas of finer soils and land cover dominated by species such as beech, maple, and hemlock. As stated above, the Management Unit boundaries are preliminary. Further examination of ecological boundaries, coupled with an improved understanding of the ecological needs of the species, may lead to adjustments of the boundaries.

Au Sable River Management Unit: Historically, massasaugas probably ranged all along the Au Sable River up to its headwaters. They probably opportunistically utilized open areas along the stream that were dynamic over time as the river shifted its position in the floodplain or as beaver activity and fire created suitable habitat. Construction of the series of dams along the lower reaches of the river likely destroyed many populations of massasauga by flooding suitable habitat. If populations survived long enough to exploit created habitat from newly flooded areas, they may persist, but this does not seem to be the usual situation. There is at least one extant metapopulation structure above the Loud Dam reservoir in an area referred to as Thompson Farm (Figure 7). Recent observations suggest that the massasauga is still present in the area. Extensive sedge meadows interwoven with willow and dogwood shrubs run along the South Branch River as it nears the Au Sable. Historically, at least some portions of this complex were maintained as open canopy by farming. However, the persistence of the sedges indicates that the area is predisposed to support such habitat. The Au Sable River Management Unit is depicted in Figure 8, and is based on habitat extensions from the Thompson Farm. If further investigation reveals populations further upstream or downstream, the boundaries of this Unit would need to be modified.

Pine River Management Unit*:* On occasion, massasaugas have been observed along the small streams that feed into the Pine River. Extensive portions of the systems, perhaps the most important parts, are in the Au Sable State Forest or in private ownership to the

east of the Huron National Forest. This includes most areas that might serve to link different subpopulations along various stream corridors. It remains to be shown whether all of the streams in this area have suitable habitat and massasaugas. Perhaps only the largest streams, such as Roy and McDonald creeks, and the upper Pine River, have the snakes. An aerial view of riparian zones potentially containing massasaugas in this area is provided in Figure 9. Massasaugas have also been found along the northwest margin of the Forest adjacent to streams draining into Hubbard Lake. This area, largely outside of the Forest boundary, contains an extensive shallow wetland, and needs to be examined more carefully. The apparent similarity of habitat along a number of small streams in the area motivated the overall delineation of the Pine River Management Unit (Figure 10).

Much of the more southerly portions of the Pine River Massasauga Management Unit overlays Kirtland's Warbler Management Prescription Area 4.5. The interplay of management efforts for these two species thus needs to be examined. In discussions with Dave Riegle, Huron Shores Wildlife Biologist, the interaction may be largely complementary. Managing habitat for Kirtland's Warbler involves rotating large, uniform blocks (200+ acres) of jack pine through different age classes. Trees of approximately 8-20 years provide the most suitable habitat for the bird (Huron-Manistee National Forest Land and Resource Management Plan Management, 1986, pp. IV-139 through IV-144). The jack pine stands are maintained on outwash plains, and do not extend down into riparian areas. Also, maintenance of these stands in the desired stage requires control of the natural and human induced fires, and prescribed fire is a maintenance strategy (Huber 2001). The massasaugas occur along some of the streams in the area, and would benefit from a relatively open canopy in immediately adjacent uplands. Management efforts for massasaugas intended to maintain an open canopy in riparian corridors may thus provide fire breaks between extensive jack pine areas managed for the Kirtland's warbler, and not result in significant loss of habitat managed for the bird.

Silver/Loud Creeks Management Unit: Observations of massasaugas along Silver Creek (Figure 11) and Loud Creek indicate that riparian corridors of streams that largely drain into Tuttle Marsh also have massasaugas. Based on observations along Silver Creek and Loud Creek, and the extension of similar habitat along Silver Creek and other adjacent streams, the Silver Creek Management Unit is depicted in Figure 12.

Figure 7. Thompson Farm Habitat Complex. This site occurs near the confluence of the South Branch and Au Sable Rivers. Stream level and slightly elevated benches covered with sedge/shrub habitat, visible as light areas in this aerial photo from 1992, provide suitable areas for the massasauga.

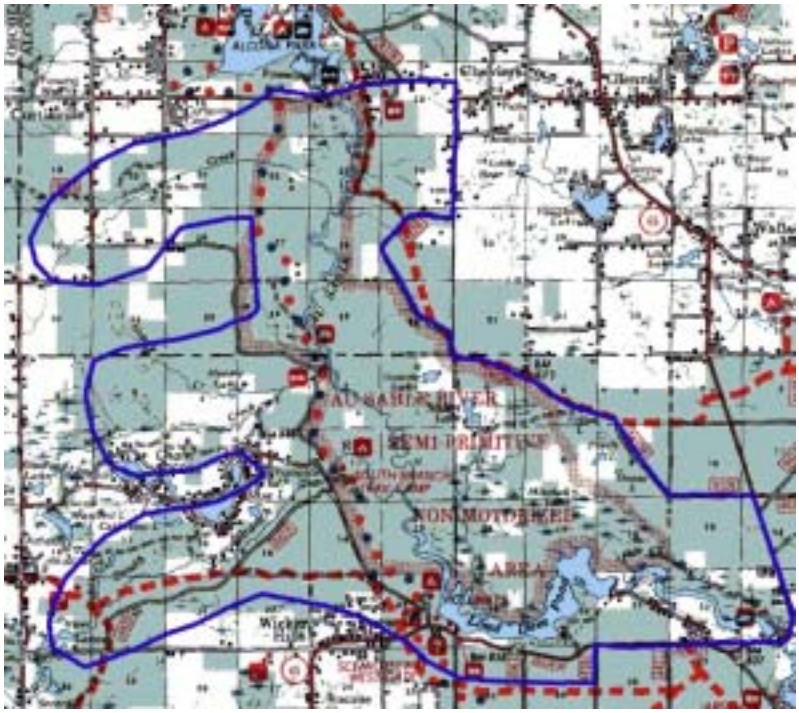

Figure 8. The Au Sable Management Unit. Massasaugas have been found in the vicinity of the South Branch Trail Camp. Suitable habitat has been identified to the east at Thompson Farm (Figure 7). In this figure and all such figures to follow, the Management Unit boundary is shown in blue, and is based on the extent of potentially suitable riparian zones, a one km buffer into surrounding outwash plain, and to some extent, surrounding roads and developed areas.

Figure 9. Aerial View of massasauga habitat along streams in Pine River Management Unit. Branches of Roy (below) and McDonald Creeks (above) are shown. Efforts to clear uplands for the purposes of Kirtland's warbler habitat management are evident in the center of the photograph.

Figure 10. Pine River Massasauga Management Unit. Riparian habitat along Roy and McDonald Creeks, as well as along the Pine River and tributaries feeding Hubbard Lake, may support massasaugas. To the south, this habitat inserts into the dry outwash plain being managed for Kirtland's warbler. Forest boundary not defined by the Management Unit boundary (blue), is shown in green.

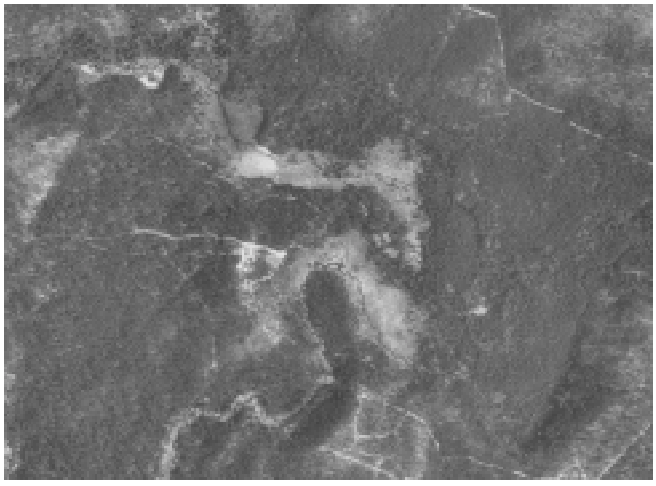

Figure 11. Silver Creek. Suitable habitat follows the bottoms of the riparian zone. Tag alders overtake this habitat unless periodically suppressed. Historically, this habitat was probably maintained by beaver activity along the stream, and fires in the adjoining uplands. Portions of these uplands are now managed as old growth.

Figure 12. Silver Creek Massasauga Management Unit.

Oscoda Management Unit: Massasaugas have been observed in wetlands along the Au Sable River in the vicinity of the closed Wurtsmith Air Force Base. It is not clear if they remain in this area, although the most recent confirmed observation for a massasauga in the MNFI database was in 1990. A brief visit to Clark's Marsh south of the old base did not reveal any suitable habitat. Perhaps construction of the base runways altered the hydrology of the area. Further exploration is warranted. Figure 13 depicts a possible management unit configuration for this area.

Extensive LTA 5 (Alluvial, Fluvial, and Organic) habitat also exists south of Oscoda, around Tuttle Marsh and to the east. There are no records of massasaugas in this area. I made a preliminary visit to Tuttle Marsh, and the habitat upstream and just below the levee was inappropriate for massasaugas. However, the area to the east is worthy of further exploration.

Figure 13. The Oscoda Massasauga Management Unit. This area is relatively small, constrained to the north by airport runways, and Oscoda to the east.

Manistee National Forest

Overview*:* Patterns of massasauga habitat and observations between the Huron and Manistee National Forests are similar. Most observations are associated with wetland habitats, and the areas have sedge or grass meadows as a component of the surrounding landscape. As on the Huron National Forest, riparian corridors also appear to be important, although some watersheds are occupied while others are apparently not. Why this is the case is not clear. A difference between the Forests is that massasaugas have "invaded" further into inland areas in Manistee National Forest, but not in Huron National Forest except along the Au Sable River. Massasaugas have been observed many miles from lake coastline around Baldwin (many of these observations are on State Forest property) and White Cloud, and these observations are not clearly based in riparian habitat.

Little Manistee River Management Unit: Historically massasaugas have been found along 30 miles of the Little Manistee River beginning at the mouth near Manistee, and recent observations have continued to occur on the first 15 miles or more of the river as it runs through the Forest. Fair to excellent habitat is extensive (Figure 14), though generally clearly limited to the riparian zone along the river. Although massasaugas have been observed in several locations, the habitat is largely unobstructed, and so, barring unforeseen barriers, the metapopulation is probably well defined by the habitat rather

than anthropomorphic barriers, Figure 15 depicts a preliminary delineation of the Little Manistee River Massasauga Management Unit.

It seems reasonable that the population along the Little Manistee could have extended up along the Manistee River as well, given the proximity of the river outlets and the apparently suitable habitat in the riparian corridor. However, there are no historical massasauga records in the lower portions of the Manistee River. Either this lack of records indicating that the massasauga may not have been present along the stream or that shifting water levels caused by regular releases of water from the hydroelectric dam upstream made habitat unsuitable. Even repeated changes in water level of a few inches might make extensive areas unusable by driving out the mammalian prey base. On the other hand, the lower reaches of other streams in the Manistee National Forest, such as the Sable, Pere Marquette and White Rivers, also lack records of massasaugas. It may well be that this species has only succeeded in invading a few watersheds in the Forest.

Figure 14. Aerial view of massasauga habitat along the Little Manistee River. The river undulates back and forth across the bottom of the riparian zone. Patches of sedge and shrub, as well as various mixtures of the two, are intermixed along the entirety of the bottoms. Six Mile Bridge Road crosses the river in this view.

Figure 15. Little Manistee River Massasauga Management Unit. Documented records within the Forest are all in Mason and Manistee Counties, though suitable habitat continues upstream to the boundary with Pere Marquette State Forest.

Figure 16. Baldwain-White Cloud Massasauga Management Unit.

Baldwin-White Cloud: Another cluster of massasauga observations lies further inland around Baldwin south beyond White Cloud (Figure 16). These observations are diffuse in their distribution, thus it is difficult to delineate a particular discrete management area. Habitat associations are also less narrowly defined, though again observations are proximal to the historical distribution of cedar or mixed conifer wetlands in a surrounding matrix of pine uplands.

All of the observations of massasaugas in the Michigan Natural Features Inventory database for this area are over ten years old. However, Joe Kelly, biologist on the Baldwin/White Cloud Districts of the Manistee National Forest, indicates that there are more recent observations, though largely from non-Forest Service biologists. Despite substantial human activity in this area, reliable observations are not frequent. Successional shifts in habitat as the result of fire suppression may be reducing the quality of the entire area for this snake.

THREATS IN THE FORESTS

By way of introduction to this section, readers are reminded of the impact of consistently removing even a few individuals from small populations with low recruitment and slow development rates, as with the massasauga. The loss of an adult now and then is probably not going to be a determining factor in the persistence of a population. However, if roadkills, negative human encounters, and other losses continue at a low rate in the same area year after year, the population may be extirpated.

Several aspects of massasauga biology may enhance their sensitivity to humans. Individuals encountered are often observed in one of two states. First, they are often easier to see just as they leave their hibernacula. This would likely occur in early May in the Forests. In many areas, massasaugas hibernate communally. In some localities further south, twenty to thirty or even more snakes may use crayfish burrows in a relatively small area (Kingsbury and Marshall 2001). Therefore, upon discovery, substantial proportions of a population may be vulnerable to disturbance or destruction. Observing a large number of snakes might also lead some to conclude that the snakes are “everywhere,”

and thus in need of control. However, once the snakes disperse for the active season, they may not be very dense in the area. Suitable hibernacula may be limiting. Thus, the area around known hibernacula should receive special consideration during the development of management strategies.

In the summer, gravid massasaugas are more likely to be found than other classes of snake. These pregnant females invest more effort in thermoregulation since elevated temperatures encourage embryo development. This focus on basking makes them more vulnerable to persecution. Because they may select open habitats and be slow to move away, they may be vulnerable to upland management activities such as mowing or disking, even when efforts are underway to protect nearby wetlands.

Persecution

Snakes in general, and massasaugas in particular, are subject to persecution. "The only good snake is a dead snake" is a common refrain in many areas. Compared to other poisonous snakes, the massasauga is not very threatening. Individual snakes prefer to rely on their cryptic coloration to keep them hidden, rather than aggressive attack, to protect them. It is my experience that individuals typically will not strike, rattle or even move until they are physically disturbed. The typical response then is to retreat deeper into any available refuge, rather than to attack.

Collection for the pet trade is another type of take. Massasaugas are popular in some circles, despite being poisonous. In fact, this is sometimes an added attraction. Collection of live snakes may occur on a casual basis by snake fanciers wanting one or more for themselves. More seriously, individuals may collect massasaugas for sale to others. Massasaugas often bring $50 or more to the collector who can sell them to pet dealers. The dealers can then sell them for $100-200 or more (Tony Wilson, Conservation Officer, Indiana Department of Natural Resources, pers. comm.).

Succession

In addition to outright habitat destruction, perhaps the most profound impact people have had on massasauga habitat is the promotion of succession. The species is reliant on earlier successional stages for satisfying much of its habitat needs. Blocking dynamic actions in the environment that promote early successional stages such as wildfires, beaver activity, and flooding thus harms these snakes. Massasaugas need open areas to bask. This is especially true for gravid females, and may be more critical at the northern extremes of the range of the massasauga where active periods are limited. Prey availability may also decline with succession as forage for rodents declines. Decreased prey density might cause snakes to abandon areas or travel farther to find prey. Changing vegetation communities may also impact hibernation opportunities as sphagnum hummocks are lost or crayfish discouraged.

Timber Management

The massasauga is essentially an early successional species. Barring unforeseen problems of general habitat destruction, the practice of logging is not considered to be a concern for the species in terms of habitat loss. In some cases, it may enhance available habitat by

opening the canopy. Perhaps the greatest challenge with timber management would be direct mortality due to harvest operations. This could largely be alleviated by placing processing operations away from riparian areas with harvesting of timber during the inactive period of the massasauga. In areas known to contain populations of massasaugas, timber harvesting should be constrained to before April and after October. Given that it would be very unusual to find massasaugas more than a kilometer away from wetlands and streams, timber management plans for areas further away than that need not incorporate consideration of this species. As we learn more, a smaller buffer zone may be just as protective. If areas are known to contain hibernacula, they should not be disturbed at all, especially by the movement of heavy machinery, which may destroy the underground characteristics of the site. This is also true for gestation sites. At the present time, no hibernacula or gestation sites have been identified.

Portions of the Au Sable River and Silver/Loud Creeks Massasauga Management Units are also designated as areas set aside for the development of old growth. It is conceivable that management for old growth might encourage successional losses of habitat in and near riparian corridors. However, the proposed old growth standards and guidelines allow for management that mimics the natural processes, or the permitting of the natural processes (USFS 2001). Thus the designation of an area as old growth does not constrain the maintenance of an open forest canopy in priority areas for the massasauga.

Manipulating Water Levels

Historically, changes in water levels within wetland systems probably helped to maintain early successional stages. The massasauga utilizes such habitat, and thus benefits. Scouring by stream flooding and the dynamic changes of the path of streams would help to provide massasauga habitat in broad riparian zones. Beavers also promote dynamic changes in the landscape, and thus the formation of appropriate habitat. As dams are formed, flooding kills shrubs and trees, opening the habitat and covering it with water. Dam failure or abandonment present new opportunities for plants to grow, and succession starts again.

However, changes in water levels under certain circumstances can have deadly effects on individual massasaugas if poorly timed or can result in permanent habitat loss. The lowering of water levels during hibernation may be the most serious. Massasaugas are typically underwater when hibernating, as they are in saturated soils. The water in the massasauga hibernacula protects the snakes from freezing. Desiccating the soil in the winter removes the heat sink capabilities of the water and weakens the thermal link to warmer areas farther in the ground. Dropping water levels in the winter may thus cause snakes and numerous other animals to freeze (Carpenter 1953, Maple 1968). Temporarily raising the water in the winter will probably not cause any problems. The metabolic rates of reptiles when their temperature is just above freezing is extremely low, and cutaneous gas exchange is adequate. This would not be the case for snakes trapped in warm water, however.

Dramatic rises in water levels are probably not as challenging for the snakes, provided that the duration is not more than a few days or perhaps weeks, and that all suitable habitat in an area is not simultaneously submerged. If elevated water levels are

maintained, it represents a loss of habitat, and any newly flooded areas at higher elevations would probably not provide suitable habitat for years and perhaps decades. At least in the short term, they would lack the vegetational features characteristic of the former habitat, and thus most likely not provide for the cover and prey needs of the massasaugas. Water level changes occurring downstream from hydroelectric dams are unnatural and no doubt harmful to resident massasaugas and other species not adapted to such variation. This would be especially true if water is released cyclically during periods of peak electric demands. Animals and plants residing in areas directly downstream no doubt may suffer obvious and immediate effects. However, impacts may occur for many miles downstream of dams in areas where levels change as little as a few inches.

Road Mortality and Roads as Barriers

Roads can impact the movements of snakes. Although single lane roads with little traffic might only present a minor barrier, roads with higher traffic or more lanes may form a relatively complete barrier. Many individuals may not be willing to crawl onto the road, thus preventing them from reaching resources on the other side, or from intermixing with other populations. In some cases, snakes will move onto paved roads to warm themselves in the evenings. This makes them vulnerable to being crushed by passing vehicles. Snakes that do endeavor to cross roads are also susceptible to such insults.

POPULATION VIABILITY GOALS

Ideally, we are striving for secure massasauga populations (numbering in the hundreds or thousands) in many areas across the Forests. However, without an extremely intensive effort, accurate assessment of the size of even one massasauga population is not possible. Certifying an area as devoid of massasaugas is also extremely challenging. With moderate effort, massasauga populations might be ranked on a scale with 3-4 levels ranging from common to rare/absent. The use of such an index would require frequent site visits and analysis of habitat quality and extent. Given the challenges of surveying for snakes, features that correlate with the viability of a population include the presence of extensive suitable habitat and the frequent observation of massasaugas, including a diverse array of size classes.

Most of the populations of massasauga on the Forests are distinct from one another, and should be managed separately. Genetic studies indicate that massasauga populations are naturally genetically distinct from one another (Gibbs et al. 1994, Gibbs et. al 1997, Gibbs et al. 1998), and thus likely can remain viable for an extended period with smaller population sizes and inbreeding. This may buy them time while we restore their degraded habitat. This same information suggests, however, that they are poor colonists, so we cannot assume that they will readily exploit newly available habitat.

Other genetic studies to date have found that three populations in Ontario and one each in New York and Ohio differed significantly in allele frequencies based on six DNA loci. This included two populations that are only 50 km apart and presumably part of a larger, continuous population. In addition to suggesting that massasauga populations are genetically distinct and should be treated as separate management units, these findings also suggest that each extant geographically-separated massasauga population should be

protected because of the unique genetic diversity found within them and its contibution to the species' total genetic diversity (from Johnson et al. 2000). These findings also suggest that massasauga populations may be genetically pre-adapted to population isolation and may be significantly impacted genetically by human-induced gene flow caused by introductions of individuals from one population to another. However, the findings and implications of these genetic studies should be considered preliminary since the sample size or number of replicates (i.e., only looked at 5 populations) for these genetic studies is still fairly small. The researchers of the genetic studies also have expressed they are not sure if the alleles they are looking at are associated with traits that influence or affect survival, fitness, or natural selection (i.e., whether the genetic difference between populations actually affect or have real implications for population viability) or whether they are simply associated with things like appearance. The currently known massasauga occurrences in the HMNF indicate potentially distinct populations within the Forests, but more surveys and radio-telemetry and/or genetic studies are needed to determine if all current populations are distinct.

MANAGEMENT RECOMMENDATIONS

Management Goals

The primary goal of this Conservation Approach is to maintain viable populations of massasauga throughout the historic range of the species within the Forests. Population maintenance should be achieved while minimizing conflicts with other management goals, notably maintenance of habitat for Kirtland's warble, cold-water stream fishes, and old growth.

Maintenance of viable populations throughout the historic range of the species on the Forests will require clarification of the distribution of populations, the definition and distribution of suitable habitat, and the maintenance or restoration of that habitat. Maintaining suitable and adequate habitat will require further clarification as to what represents the most beneficial for the massasauga on the Forests. Initial efforts aimed at restoring or maintaining suitable habitat can be driven by the existing body of knowledge gleaned from other sites.

The following objectives are based on the overall goals stated above. For each objective, actions are provided to reach the objective.

Objective A: Determine the distribution of massasauga populations throughout the Forests.

Our current understanding about the status and distribution of massasauga populations in the Forests is based on several brief visits to the area, conversations with wildlife biologists on the Forests, inspection of historic records, and evaluation of GIS information. Extensive work is needed to determine macrohabitat and microhabitat characteristics of sites where the snakes are currently known to occur.

Action 1: repeatedly survey all potential habitat under suitable conditions. Massasaugas are more likely found in cool, sunny conditions early in the spring. More visits to an area will help determine the health of the local population.

Action 2: solicit input on presence/absence of massasaugas in all apparently suitable wetlands.

While unsupported claims should be given some consideration, vouchering should be enforced. This does not require acquisition of sample specimens from all localities, but dead specimens should be investigated, photographs requested, and questions asked to establish reliability of accounts. The Michigan Department of Natural Resources maintains a report form at: http://www.MichiganDNR.com/wildlife/pubs/massasauga_obsreport.htm. For a copy of this page, see Appendix B. This page asks for specific details about observation to help confirm that a massasauga was actually seen, and also asks for contact details for follow-up.

Objective B: Maintain and expand suitable habitat available to all known populations while minimizing conflicts with other forest activities.

Action 1: Maintain sedge/shrub matrix in bottom of riparian zone along length of Little Manistee River

Action 2: Maintain and expand sedge and grass open canopy habitat around coniferous forest wetlands in the Baldwin/White Cloud area

Action 3: Rehydrate Thompson Farm meadows by blocking drainage ditches

Action 4: Retard successional habitat loss at Thompson Farm.

Action 5: Allow beavers to build dams and modify habitat in massasauga management areas. Beaver activities that are too disruptive may require management, but otherwise the beaver activity should be permitted.

Action 6: Mimic beaver flooding in areas where beavers have been extirpated.

Action 7: Streamside tree plantings in existing massasauga habitat should be evaluated before being implemented.
Streamside areas capable of supporting sedge or grass and shrub mixture should be maintained in early successional stages to promote massasauga habitat.

Objective C: Clarify ecological needs of Forest populations.

Action 1: Conduct research such as radio telemetry on resident snakes to clarify their micro and macro habitat, needs, as well as patterns of movement.

Objective D: Educate staff and public about massasaugas.

Action 1: Hold training sessions for Forest staff.

These training sessions should be directed at clarifying actual versus perceived risks from massasaugas, and explain habitat needs and how to manage for them.

Action 2: Develop outreach material for non-Forest personnel.

Objective E: Identify potential collaborators

Action 1: Develop collaborations with state and federal land management agencies

Action 2: Identify and include critical private landholders.

Objective F: Develop protocol for monitoring extent and quality of available massasauga habitat in Forests.

Objective G: Review Approach every five years to determine need for revision.

Management Tools for Inhibiting Succession

A major habitat management goal for massasaugas is the maintenance of grassy or sedgy areas with an open canopy. This type of habitat is often early successional in nature. Thus, existing tools used for inhibiting succession, explored from the perspective of massasauga management, can be applied to promote massasauga habitat. Land managers should also realize that hibernation sites are critical, as are corridors between habitats that snakes use seasonally.

The goal for habitat management is to create or maintain some areas completely or largely devoid of trees. Suitable habitat may extend along the bottoms of riparian zones or may be imbedded in surrounding coniferous swamp. Shrubs should be inhibited to the extent that they are diffuse throughout the area, and sites should be manipulated to favor smaller species such as shrubby cinquefoil (*Potentilla sp*). Complete removal of trees and shrubs is not necessary and efforts to achieve such a condition may be significantly more time consuming and expensive than just removing most of this vegetation.

Prescribed Burning. Fire has been used very effectively to control succession in wetlands and surrounding uplands. Given that a major problem for massasaugas on the Forests is the loss of habitat by the inhibition of fires, prescribed burns should be considered a likely tool for promoting suitable habitat on the Forests. Fire also has the potential to significantly impact populations of animals negatively that are desirable to retain, such as the massasauga. Restrictions on burns are intended to insure with relative certainty that massasaugas are underground when the burns occur. The only way to do this is to burn during hibernation, as massasaugas do not generally retire underground at any time during the active season, and would be vulnerable to burning during that period.

Wetland burns during massasauga hibernation do not need to be restricted. The challenge is to conservatively estimate when snakes may emerge from hibernation (egress), and when they will return (ingress). Massasaugas will not emerge from hibernation and leave hibernation areas until the risk of hard freezes has largely passed. In the northern Lower Peninsula, this is probably no sooner than early May, although this is an aspect of their biology that requires further study. A relatively reliable predictor of the timing of snake emergence is the period when ground temperatures begin to rise towards air temperatures

and frosts are unlikely or mild. Spring rains can help to warm the ground, as do series of warm days. Early emergers also stay close to their burrows and return to them at night.

Imposing thermal guidelines along with calendar restrictions may be the most effective means of protecting the snakes. Wetland burns after May 1 should be discouraged, and should only occur when the ambient temperatures are below 50 F (10 C). Wetlands should not be burned after May 15. Known hibernacula areas should be protected from burns or these burns should occur as early as possible. Virtually all massasaugas will be in the vicinity of hibernacula through mid-May.
Unusually dry conditions or the early onset of spring may lead to increased sensitivity on the part of the snakes. Burns in wetlands should be conducted earlier in the season during such years. Burns around wetlands in the spring should also be given priority in scheduling over burns in more terrestrial habitats. Burns are more favorable to massasaugas if the burns are incomplete, that is they leave a mosaic of burned and unburned habitat and provide cover from potential predators. Massasaugas do not prefer areas with no shrub layer, and the small mammal populations that they feed on may be impacted by burning as well. Fall burns are perhaps more problematic than spring burns, but guidelines based on those suggested for spring are probably correct. In northern Indiana, October is analogous to April, and burns after November 1st are safest for the massasauga.

Mowing

Mowing is commonly used as a management tool to discourage shrub growth and to maintain openings. Management decisions about mowing will depend on the goal of the effort, as areas mowed frequently to maintain a low-lying lawn should be treated differently than rank growth areas such as old fields. Massasaugas will exploit the edges of mowed lawns and other open habitats to bask under cool circumstances, but avoid these same areas when it is hot. Mowing of areas during the active season should be constrained to those times and conditions when the snakes will avoid those areas being mowed. Given the seasonality of movement in some populations, mowing may become more hazardous to massasaugas that have moved up out of wetlands and into drier habitats during the summer.

Areas within the wetland buffer that have been previously maintained in an open state by mowing throughout the year, as in park lawns, the tops of some levees, roadway borders, etc., can continue to be treated as such. However, attention should be given to when they are mowed. These areas may be mowed during the inactive season without constraint, and during the active season when the air temperature is less than 60^{o} F (15^{o} C) and overcast, or above 90^{o} F (32^{o} C). Snakes will not attempt to bask in an exposed site if it is too cold, and will not bask at all when hot. If areas are to be kept open by mowing, a commitment is needed to maintain the grass at a low height. If the grass is allowed to grow high enough that snakes perceive that they can hide in it, then the snakes will be vulnerable when a mower returns.

Non-wetland areas such as old fields that are within the wetland buffer and that are mowed or brush hogged for maintenance at an early successional stage should not be mowed during the summer (June – September). If such areas must be mowed, then the

mowing deck should be at least 20 cm (8 in.) above the ground. However, snakes may still be injured by tires passing over them. Thus, once again, if possible, areas should be mowed to a low height during the inactive season then maintained at a low height thereafter.

Disking. Disking is considered to be potentially more hazardous than burning or mowing, because it includes substrate disturbance. Disking may also permanently modify the soils of hibernacula, rendering them unusable or unattractive to the snakes. Areas that must be disked should be maintained in a disturbed state, rather than allowed to partially succeed. Otherwise, individuals may move into them and be vulnerable to further disking efforts at a later date. Disking in uplands within the wetland buffer should only be conducted during the inactive season. Disking may have a very detrimental effect on hibernacula, as well as upon as any snakes using the vicinity during the active season. Areas within 50 meters of known hibernacula should not be disked.

Water Level Manipulations. Massasaugas live in habitats that are often prone to small changes in water level, thus they are adapted to this phenomenon. Uncommon, short-term (= days) *elevation* of water levels in emergent systems should not harm the massasaugas at any time of the year, unless it forces snakes into hazardous areas. However, routine fluctuations in water level of more than a few inches are likely to be detrimental to massasaugas, and areas flooded regularly may not support them. Furthermore, long-term flooding of emergent wetlands will drive the snakes out and degrade the suitability of habitat. It would also very likely impact the small mammal prey base. The creation of deeper impoundments in areas containing potential massasauga habitat will result in the loss of that habitat, and perhaps the population of massasaugas.

Lowering water levels may be more serious, especially during the inactive season. Groundwater prevents the freezing of saturated substrates, and protects animals imbedded therein from freezing. The water increases the heat absorbance of the substrate and provides improved thermal connectivity with warmer areas farther underground. Draining wetlands during the winter has been demonstrated to be devastating to a variety of snakes and turtles, including massasaugas. Such activities are thus strongly discouraged.

COLLABORATIVE POTENTIAL

The Forests are imbedded in a landscape owned and managed by many parties. Forest Service System lands are not continuous, but intermixed with private inholdings. Thus individual private landowners represent an extensive potential pool for collaboration. Given the status of the massasauga, many federal and state agencies have a mandated interest in cooperating and collaborating on massasauga conservation efforts. Collaboration with private landowners may prove to be very important, as many areas of the Forests are not contiguous, but are intermixed with private in holdings.

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RESEARCH AND MONITORING NEEDS

Establishing Distribution and Status of Massasauga Populations

Our current understanding of the distribution of massasaugas on the Forests is relatively limited. Focused surveys to find massasaugas have not been carried out in a systematic fashion, thus encounters with massasaugas have been fortuitous. Locality information obtained in this fashion is informative, but potentially severely biased because of the probable lack of correlation in time and space of the snakes and humans. On the Huron National Forest, the Au Sable River also has populations along its length downstream from the Alcona Dam Pond, albeit apparently disjunct from one another as a result of reservoir construction and water management. The extent and status of the Thompson Farm population is unknown. Massasaugas occur in and around riparian corridors of several small streams leading into Lake Huron. How pervasive this occupation of such stream corridors actually may be is unknown, as is the extent of documented populations in areas such as Silver Creek.

On the Manistee National Forest, some population distributions may be relatively well defined, while others are not. It is clear that the Little Manistee River corridor has a metapopulation of massasaugas in it, and that they are constrained to the riparian zone and immediately adjacent uplands. However, the distribution pattern along the length of the river is unknown. Most problematic in terms of distribution and status is the Baldwin-White Cloud "metapopulation." Populations may have been sprinkled throughout this area historically, but human development, fire suppression, and other activities may be threatening the snake in this area.

The areas where massasaugas occur on Forest Service System lands are extensive and challenging at times to explore. The massasauga is also a very secretive animal. This makes it difficult to reliably find them when populations are low or the timing of searches is inappropriate. Intensive use of a geographical information system (GIS) modeling approach may be fruitful to help further define probable population distribution boundaries and survey sites.

To facilitate comparability of survey efforts, a protocol for surveys should be developed that is suitable for the Forests. Survey protocol prototypes are provided in Appendix C. One was developed and used by B. Kingsbury for work in Michigan, and another similar in form was developed by Casper et al. (2001), and distributed by US Fish and Wildlife Service.

Clarify Spatial Ecology in Forests

The massasauga has demonstrated regional and local variation in habitat use and behavior (reviewed in Szymanski 1998, Johnson et al. 2000). To date, the species has not been studied in the habitats exhibited in the Forests, coniferous forests on a sandy substrate. We are required currently to infer ecology and behavior from studies conducted in Ontario on a rocky substrate (Weatherhead and Prior 1992) and from Indiana and other states to the south in deciduous systems with muck or peat substrates (King 1997, Kingsbury and Barlow 1999, Kingsbury and Marshall 2001).

Quantitative study of the species in appropriate habitat is needed. A radio telemetric project monitoring snakes in the Forests or comparable habitat is recommended. Such a project is being initiated in the Grayling area. If more localized efforts do not occur, then inference from that study about massasauga ecology on the Forests will likely be more accurate than our current approach.

Monitoring Population and Habitat Health

Efforts to improve habitat for massasaugas should be coupled with some kind of monitoring program to see if the efforts are being successful. Given the challenges of surveying for massasaugas, evidence of success may in some cases be correlated with habitat improvement coupled with continued observations of massasaugas, especially juveniles. After a protocol for documenting the status of available habitat is developed (Objective F in Management Goals section), that habitat protocol can be coupled with the massasauga survey protocol and be used to monitor the status of populations and their habitat.

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APPENDIX A - Contributors to the Development of this Approach

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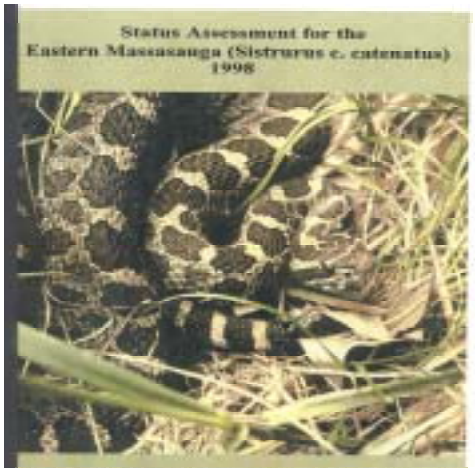
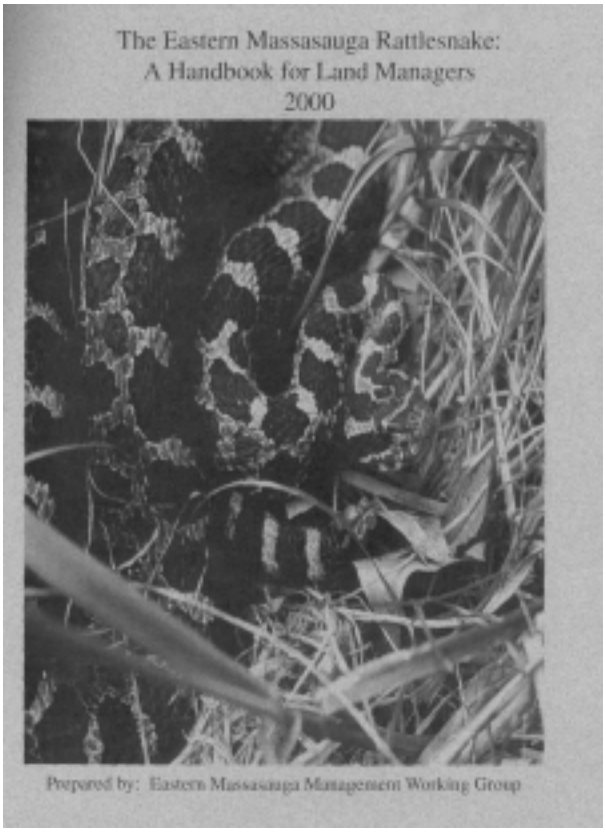
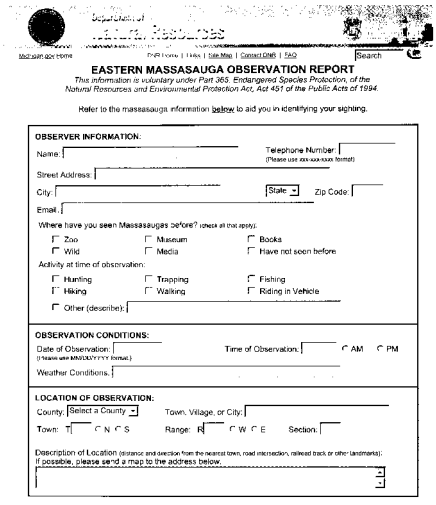
APPENDIX B-Cover Pages for Major Review and Status Documents on the Eastern Massasauga Rattlesnake





APPENDIX C - Michigan Department of Natural Resources' Eastern Massasauga Rattlesnake Observation Report



EASTERN MASSASAUGA OBSERVATION REPORT

This information is voluntary under Part 365, Endangered Species Protection, of the Natural Resources and Environmental Protection Act, Act 451 of the Public Acts of 1994.

Refer to the massasauga information below to aid you in identifying your sighting.

OBSERVER INFORMATION:

Name: | Telephone Number: (Please use xxx-xxx-xxxx format)

Street Address:

City: | State | Zip Code:

Email:

Where have you seen Massasaugas before? (check all that apply):

☐ Zoo ☐ Museum ☐ Books
☐ Wild ☐ Media ☐ Have not seen before

Activity at time of observation:

☐ Hunting ☐ Trapping ☐ Fishing
☐ Hiking ☐ Walking ☐ Riding in Vehicle
☐ Other (describe):

OBSERVATION CONDITIONS:

Date of Observation: (if future use MM/DD/YYYY format) | Time of Observation: ○ AM ○ PM

Weather Conditions:

LOCATION OF OBSERVATION:

County: Select a County | Town, Village, or City:

Town: T ○ N ○ S | Range: R ○ W ○ E | Section:

Description of Location (distance and direction from the nearest town, road intersection, railroad track or other landmarks):
If possible, please send a map to the address below.

APPENDIX D - Survey Protocols for the Eastern Massasauga Rattlesnake

Survey Considerations For The Eastern Massasauga (*Sistrurus C. Catenatus*) In Michigan

The following information is provided to increase the value and compatibility of surveys scheduled in 2001 for the massasauga in Michigan and surrounding areas. Given the secretive nature of massasaugas, it is important to optimize survey conditions, indicate when that has not occurred, and to take care in interpreting negative results. Also, given the potential for misidentification, individuals experienced with massasaugas should conduct critical surveys, and documentation such as a photograph is especially important. If surveyors are consistent in their approach, we may be able to apply more sophisticated analyses to the results that rely on snakes/survey effort. Adhering to such guidelines will also strengthen the implication of surveys where no massasaugas are observed. In presenting this protocol, it is presumed that the user is familiar with massasauga ecology.

Timing

Surveys conducted at inopportune times and that result in no observations of massasaugas are inconclusive. In southern Michigan, it is anticipated that late April and May, depending on the weather, will be the best time to find massasaugas. Spring surveys can be productive after freezes are unlikely and the ground has been warmed by an extended series of warm days or rains. Searches during the first week or two of emergence will be very productive if a hibernation site is encountered and the snakes have yet to disperse. Searches are also more successful before vegetation has grown too high, and after areas have been burned. We have also noted a correlation between high levels of garter snake activity and detectability of massasaugas. Another window of opportunity for finding massasaugas, especially further north, is late July and August, when gravid females are more noticeable while basking. Courting males may also sometimes be found nearby at this time.

To minimize the impact of environmental and seasonal conditions, surveys should be conducted on days and times that provide a moderate thermal challenge to the snake. This will encourage basking and give the surveyor a better chance at seeing snakes. Of course, if it is too cold or cloudy, the snakes will stay hidden. On sunny days, surveys could be conducted when air temperatures are above about 15 C (60 F). Partially sunny days may require slightly warmer temperatures, such as at least 18 C (65 F). Once temperatures get warmer, say around 27 C (80 F), then the snakes are not motivated to bask and become very difficult to see. Surveys should only be conducted when sunlight can strike the survey area, but not mid-day during warm weather, and not during windy conditions.

Habitat

The habitat of the massasauga will vary from region to region throughout the Lower Peninsula of Michigan. There would appear, however, to be two principal habitats exploited. In the south, wet meadows and fens, often associated with lakes, are where the snakes are found. To the north, massasaugas are not only affiliated with ephemeral wetlands but also wetland forests.

Despite variation in habitat use, several consistent features are associated with prime massasauga habitat. The canopy is open and the site is associated with ephemeral wetlands. In the spring, surveyors should focus their efforts on habitat with saturated soils or meadow-like habitats immediately adjacent to such areas. In the summer, surveys should be expanded to include more extensive searches of slightly elevated, drier, areas, as individuals from some populations have been shown to move into these areas during the summer.

I suspect that hibernacula tend to be associated with areas with moving underground water, though this remains to be fully substantiated. Thus, if I were to choose where to look in extensive, essentially homogeneous habitat, I would favor areas with evidence of inflow or outflow from a site.

In northern Lower Peninsula sites, the best time to survey for massasaugas may be mid-summer, such as the latter half of July. The surveyors will be looking for gravid snakes basking in the early morning and late afternoon. The best time will vary from site to site and year-to-year, depending on how early the activity season commenced at the site. Microhabitats that permit warming from the sun, such as open areas with exposed bedrock, are possibilities for gestation sites. Otherwise, searching should favor open canopy areas as described previously.

Interpretation of Findings

Detecting the massasauga under any but ideal circumstances represents a significant challenge. Thus, interpreting surveys wherein no snakes are found provides in itself an additional layer to that challenge. While the discovery of massasaugas at a site surely indicates their presence, the fact that they are not found after many hours of searching, even under good conditions, does not immediately demonstrate that they are not there.

It is the consensus of experts that, when abundant, massasaugas are often detected with several hours of searching under good conditions. The problem is how to interpret those numerous other circumstances when hours or days do not reveal any individuals. Discussion amongst experts supports the notion that even a full week of searching may not with certainty exclude the chance that massasaugas remain in an area. However, if an experienced massasauga surveyor under ideal conditions conducts such a search, then the population is certainly not robust. It may take several years of such searches, however, before it can be assumed with confidence that the massasauga has in fact been extirpated from the area.

Conducting Surveys

If the goal of surveys is simply to try to find massasaugas at a site, then a group of surveyors may be the most effective means of finding them. Each should operate somewhat independently to maximize the amount of habitat scrutinized. Surveyors should move slowly and carefully with frequent stops (pauses) to inspect the bases of all shrubs and grass/sedge hummocks as they go. If the intent is also to quantify observations so that findings can be compared between sites, especially where the differences between them are relatively subtle, then methodology will have to be more strictly defined. A quantifiable approach is to measure observations per survey effort, and the protocol described here may allow for comparison of findings from different surveyors.

All though the risk of death from a massasauga bite is rather small, the risk of misery and tissue necrosis is real and significant. Massasaugas should not be handled except as necessary for research. Individuals that are bitten should remain calm and have someone drive them to a hospital as soon as possible. Speak to your doctor or the American Red Cross about the latest approved approaches to minimizing risk and damage following poisonous snakebite.

Surveyors are also requested to respect property boundaries, both for legal reasons and because we are endeavoring to foster good relationships with people. Please make sure that land managers of survey sites have been contacted before entry. In many cases we will have already done this, but please help us keep these folks “in the loop.” Also, we do not condone accessing posted private property without permission.

Quantitative Surveys

Quantification requires keeping track of survey effort in the form of time expended and an estimate of the distance traveled during the search. Transect length will be approximated as accurately as possible using an aerial photograph or topographical map. The time will be recorded at the beginning and end of the transect, as well as each time the *Macrohabitat* type, as defined by the attached Habitat Classification, changes. Habitat shifts should be marked on the map as well.

A watch is needed for timing transects. Where available, a camera allows vouchering and habitat documentation. A GPS unit allows precise positioning information to be collected. Surveyors will also need to consider footwear. Hip or chest waders may keep you dry, but are tiring to wear for any length of time, and can get hot. Pull-on farm boots work okay as long as the water is not more than ankle deep. I generally just go ahead and get wet, wearing "Army" boots to protect my feet. Use pencil to keep your notes- pen will smear and run if it gets wet, erasing your data. Ziploc bags are good for keeping things dry.

Data Sheet Explanation

Header

At the top of the data sheet, *Date*, *Site*, Surveyor(s), and *Weather Summary* comments are filled out prior to beginning the survey. *TimeBeg* is entered when the survey actually begins. *TimeEnd* is entered when the survey is suspended. Times should be recorded in military time (1200 is 12 noon, 1400 is 2PM).

Weather Summary comments include air temperature, cloud cover, wind, etc. Air temperature (*Tair*) is taken with the thermometer held at about waist height with the bulb shaded (by your hand is fine). Availability of the sun as a heat source (*Sun?*) is Y for clear skies, mixed (M) for partially cloudy, or N for overcast. Substantive changes in the weather during surveys should be indicated on data rows between observations.
TransectL is an estimate of the total transect length. Length should be recorded in meters. Additionally, a section is provided to *summarize* your observations in terms of the number of snakes of several pertinent species observed.

Information Collected While Surveying

The codes for data entries are described in the survey code descriptions provided below. The last column is for brief or coded additional comments. In the field, comments can also be inserted on the data row(s) beneath the relevant observation. If habitat changes during the length of the transect, times and lengths of subtransects should be recorded by habitat. *Time* is when you start a new habitat classification; *Elapsed Time* is the time surveying the previous habitat. *Species* of snake is coded when possible. Your comments should include mention of other species observed. This column is also used to measure the subtransect length (*TransectL*) if you switch macrohabitats. *AgeClass* is the apparent age class of the snake [Y(earling), J(uvenile or subadult), A(dult)]. *Behav*ior is the activity of the snake at time of observation. If you have disturbed it and don't know, don't speculate.

*Macro*habitat and *Micro*habitat are coded as indicated in the attached habitat classification. The macrohabitat classification is based on a simplification and extension of Cowardin et al.'s wetland system. The code should be strictly adhered to, and deviation from the code should be well documented with comments.

Comment Code is space for symbol to link to comments made below. For example, "A" would relate to comments next to "A" in the comments area. Use the *Comments* section to make initial

notes on any details about the survey site. Additional comments can be made there as you go or on data rows between observations. Surveyor comments will be used to help establish habitat extent and quality throughout the range of the snake, so surveyors are encouraged to make detailed notes of their surroundings.

We strongly encourage carrying an aerial or topographic map of the survey site and marking the path of the survey as accurately as possible. The survey sheet included in this document is an imbedded Excel spreadsheet that can be used to directly enter data. It could then be e-mailed as an attachment. The datasheet is also available at the following web site: http://herps.ipfw.edu/surveys/massasauga.htm.

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Center for Reptile and Amphibian Conservation and Management
Science Building
Indiana-Purdue University, Fort Wayne, IN 46805-1499
(260) 481-5755, kingsbur@ipfw.edu, http://herpcenter.ipfw.edu

Survey Code Descriptions

Consider printing this guide on the back of your data sheet.

Macrohabitat

This classification was designed to be suitable for studying habitat use by the massasauga. It is therefore not intended to be an exhaustive classification scheme. Wetland components are intended to be relatively compatible with the National Wetlands Inventory (NWI) classification developed by Cowardin et al. (1979). "Macrohabitat" as used here is a large-scale measure. Distinct areas less than about 10 meters in diameter should just be incorporated into the surrounding habitat type. Microhabitat will be used to indicate finer levels of selection.

PFO Palustrine Forested Wetland: has standing water at least part of the year and tree canopy cover exceeding 30%. State type of forest using terminology you are comfortable with.
PSS Palustrine Scrub-Shrub Wetland: shrub cover exceeds 30%, but tree cover does not.
SDG Palustrine Emergent Wetland dominated by sedges.
CAT Palustrine Emergent Wetland dominated by cattails. (While marshes are not viewed as good massasauga habitat, note that we have found individuals routinely using *openings* in smaller cattail stands).
UFO Upland Forest: greater than 30% canopy cover by trees, elevated above any potential flooding by sloping topography. State type of forest using terminology you are comfortable with.
USS Upland Scrub-Shrub: extensive areas of berry bushes, willows, crab apples and hawthorns. In Michigan, this would typically be mid-successional area.
OLD Oldfield: fallow fields well covered with herbaceous or grassy cover. CRP lands would often be included here.

Behavioral Classification

Basking -at rest in tight or loose coil in sunny location
Resting -resting in non-basking position
Courting -male pursuing female, female, being pursued by male
Mating -actually copulating (much less likely than courting)
Foraging -moving slowly and methodically with inspection of potential prey refugia.
Traveling -moving continuously in linear path, with little investigative behavior along the way
Unknown -behavior ambiguous or snake disturbed before behavior observed: *something that happens all the time!*

Microhabitat

Microhabitat classification is somewhat similar to habitat, but on a smaller scale. Its use as a category allows the specific position (substrate) of the animal to vary to some degree from its general surroundings.

Shrub –under or in a bush
Sedge – in or on sedges
Grass -in a patch of grass
Rock -on a rock or rocks
Log –on or next to a log
Herb -in a patch of "nongrass" veg.
Bare -on bare soil
Island -on a small hummock in open water
Detritus -on leafy debris
Other – you tell us

Miscellaneous

Species- **MAS**- massasauga, **NWS**- northern water snake *(N. sipedeon*), **EGS**- eastern garter snake (*T. sirtalis*), **UNK**-unknown. Other species can just be written out.
Keep in mind that these surveys have multiple value. Please keep track of all herps seen, especially sensitive species (conservation and Herp Atlas value), the quality and extent of habitat (status assessment value).
Below is some example data: the page after this is a "clean" data sheet.

Date:	4/15/2001	Site:	Make Believe Point				
TimeBeg:	1030	Surveyor:	Kingsbury				
TimeEnd:	1315	Weather Summary		Beg Tair:	18	Sun? Y/M/N	Y
Duration:	165	minutes		End Tair:	20	Sun?	M
TransectL:	1200	Comments:	Oh what a beautiful day. No wind at all. No clouds at first, but a few here and there by finish.				
		SUMMARY: # of	MAS:	2	NWS:	1	
			EGS:	2	UNK:		

Time	New Macrohab	Elapsed Time	TransectL/ Species	AgeClass	Behav	Microhab	Comment Code
1030	PFO						
1035	PSS	5	50				
1037			EGS	J	B	Log	
1044	SDG	9	100				
1132			MAS	A	B	Sedge	1
	etc., etc….						
1315		23	400				
	(the end)						
	PFO, PSS, SDG, CAT, UFO, USS, OLD		MAS, NWS, EGS, or???	J,S,A	B, R, C, M, F, T, U	Shrub, Herb, Sdg, Bare, Grass, Isl, Rock, Detr, Log, ??	

COMMENT:

1) Two massas augas side by side!!!

MASSASAUGA SURVEY SHEET

Date:		Site:					
TimeBeg:		Surveyor:					
TimeEnd:		Weather Summary		Beg Tair:		Sun? Y/M/N	
Duration:		min.		End Tair:		Sun?	
TransectL:		Comments:					
	SUMMARY: # of	MAS:		NWS:			
		EGS:		UNK:			

Time	New Macrohab	Elapsed Time	TransectL/ Species	AgeClass	Behav	Microhab	Comment Code
	PFO, PSS, SDG, CAT, UFO, USS, OLD		MAS, NWS, EGS, or???	J,S,A	B, R, C, M, F, T, U	Shrub, Herb, Sdg, Bare, Grass, Isl, Rock, Detr, Log, ??	

COMMENTS:

Recommended Standard Survey Protocol for the Eastern Massasauga, *Sistrurus catenatus catenatus*

by Gary S. Casper [1*], Thomas G. Anton[2], Robert W. Hay[3], Andrew T. Holycross[4], Richard S. King[5],Bruce A. Kingsbury[6], David Mauger[7], Christopher Parent[8], Christopher A. Phillips[9], Alan Resetar[2],Richard A. Seigel[10], Thomas P. Wilson[11].

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Note to users: This is a pre-publication, draft manuscript (April, 2002), which is currently in review for the Milwaukee Public Museum Occasional Papers in Geology and Biology.

INTRODUCTION

The eastern massasauga, *Sistrurus catenatus catenatu*s, is a small crotaline rattlesnake with a United States range extending north and east from the Missouri River, to central Wisconsin, the northeastern shores of Georgian Bay in Ontario, Canada, and to New York state (Conant and Collins, 1991). It is widely recognized as having undergone significant population declines throughout its range, having been afforded endangered or threatened status in ten of the eleven states and provinces in which it occurs, and is currently classified by the United States Fish and Wildlife Service as a candidate species for listing under the United States Endangered Species Act (Szymanski, 1998; Federal Register, 1999). To properly assess population status and plan recovery efforts, a need exists for standardizing survey effort for comparison among sites, and for a consensus on data interpretation in order to assign recovery resources to those populations best able to benefit from them. For recovery and management recommendations see Johnson et al. (2000).

We address methods for surveying for this subspecies throughout the range defined above. It should be recognized that these techniques are not meant to be applied to populations south and west of the Missouri River (i.e. *Sistrurus catenatus tergeminus* or *S. c. edwards*i), where significant differences in ecology, habitat use, and behavioral response to temperature and precipitation exist.

In the range described here, the eastern massasauga *(Sistrurus c. catenatu*s) typically occurs in lowland (usually floodplain) forest, bogs and other wetlands, and mesic to wet-mesic prairies. *Sistrurus c. catenatus* also utilizes upland grassland, savanna, open woodland, prairie, and old fields adjacent to these wetland habitats. In the Georgian Bay area of Ontario, habitat varies from coniferous (Bruce Peninsula) to deciduous (Killbear Provincial Park) forest. Closed canopy is avoided, and in forested habitats canopy openings are preferentially used. For habitat descriptions see: Hutchinson et al. (1993), Johnson (1995), Johnson et al. (2000), King (1997), Kingsbury (1996), Reinert and Kodrich (1982), Maple (1968), Seigel (1986), Smith (1961), Weatherhead and Prior

(1992), and Wright (1941).

This recommended survey protocol is a consensus of opinion based on published life history accounts, radio telemetry studies, and the authors' collective field experiences conducting research.and surveys for this species. We have provided a sample data form, and an itemized protocol we believe will have utility across the geographic area defined above. We also suggest that prior to surveys, the investigator may find it useful to solicit information through a public notice, such as a newspaper article, with a massasauga photo and a number to call to report sightings. This may lead the investigator quickly to productive sites for snakes (even if not for *S. catenatu*s). Another way to obtain leads is to contact veterinarians and ask if they have treated pets for snake bite. This is something that they are not likely to forget, especially when the massasauga may be the only venomous snake in the area. When utilizing public outreach, however, the investigator should be careful not to give out information on massasauga sites to the public, due to poaching concerns.

Surveyor Qualifications

We recommend that persons conducting surveys have prior experience finding eastern massasaugas in the habitat type and region under investigation. Surveyors should be recognized as competent and qualified by regional peers, who often are persons under which the surveyor has trained. Recognizing that surveyors experienced with *S. catenatus* cannot always be found, we recommend that inexperienced surveyors at least have a reputation as a good field biologist, based on criteria including, but not limited to, letters of recommendation, affiliation with an educational or research institution, government agency, or relevant publication record. Experience and demonstrated competence with other snake species, and especially with state or federally listed amphibian and reptile species (the latter demonstrating trust placed in the individual by county, state or federal agencies), is also highly desirable. We recommend that the surveyor consult with experienced persons prior to and during surveys, and that the first *S. catenatus* specimens encountered by inexperienced surveyors be carefully documented to pass peer review. It is recommended that inexperienced surveyors, as well as seasoned herpetologists without specific experience with *S. catenatu*s, acquire some training in field survey techniques specific to *S. catenatu*s, by attending state or regional workshops.

Justification

There are two justifications for using highly experienced personnel to conduct surveys. First, the importance of observer skill and experience is illustrated by two examples. In Illinois, a study conducted to detect the presence of massasaugas at a Chicago area site in 1990 and 1991 yielded negative results and concluded that massasaugas were unlikely to be present (Strond, 1992). Yet surveys at the same site undertaken by different, more experienced, personnel in 1993 found numerous individuals (Mauger and Wilson, 2000; Wilson and Mauger, 2000). In Ontario, Black and Parent (1999) obtained capture success rates (snakes caught/person-hour of searching) of 0.017 with minimally experienced personnel (3 days field experience), 0.040 with moderately experienced personnel (at least 100 h field experience), and 0.075 from the highly experienced principle

investigator. These examples illustrate the disparity in results which can be attributable to differences in surveyors skills and experience.

Secondly, the eastern massasauga is one of the most often misidentified snake species within its range. Some of us (Anton, Casper, Hay, Parent, and others) estimate that over 80% of eastern massasauga reports from the public, wildlife biologists, and naturalists are misidentifications, based on the error rate of those reports where we were able to examine a specimen or photograph. Species frequently mistaken for eastern massasaugas include northern water snakes *(Nerodia sipedo*n),brown snakes *(Storeria dekay*i), milk snakes *(Lampropeltis triangulu*m), fox snakes *(Elaphe vulpina*ssp.) and eastern hognose snakes *(Heterodon platirhino*s).

RECOMMENDED METHODS

Techniques

The recommended survey method is visual searches (Karns, 1986; Heyer et al., 1994). Since
there appears to be wide variability in search success relative to habitat, weather and time of day, we
recommend that data on these parameters be collected for each search event, and that the following
conditions be used as general guidelines:

1. Habitat will vary regionally, but snakes are most often encountered in open to semi-open canopy habitats, in cryptic basking situations, where they are partially concealed under grass or sedge tussocks, or by shrubs. Searches should concentrate on openings in forests, and higher elevations within low wet areas. Most occurrences in the United States are known from habitats associated with fluvial systems, and *S. catenatus* range expansion has been hypothesized as occurring by the gradual colonization of marshes along water courses (Atkinson and Netting, 1927; Gloyd, 1940; Pentecost and Vogt, 1976; Campbell and Lamar, 1989; Johnson, 1993).
2. Weather conditions are best with >50% cloud cover, less than 15 mph breeze, and temperatures between 50 and 80 degrees Fahrenheit.
3. Preferred time is morning and evening.
4. During spring emergence, soil temperatures at a depth of 15 cm (6 inches) should exceed 10º C.
5. The most fruitful survey periods are during spring emergence for all age classes, and during mid-summer for gravid females.
6. If the opportunity arises, surveys should be conducted immediately after a burn.

Massasaugas may be active under very different environmental conditions across their United States range. In general, air temperatures < 60 F, winds > 15 mph, and cold winds depress activity.

It is essential that conditions be recorded for all surveys (especially those with negative results so that outside evaluators can determine whether surveys were conducted under appropriate conditions).

Effort

We recognize that effort expended on surveys is often a function of human resource availability. We caution that credible decisions on species or population management cannot be made in the absence of survey data, and that when in doubt one should always err on the side of conservatism, as if the species is present. Initial goals of surveys should be to determine whether or not the species is present at a site in detectable numbers. These data can form the basis of site recovery and management evaluations.

A minimum accumulation of forty person hours distributed over a standard (April-October) field season is recommended before any evaluations are made regarding the presence/absence of *S.catenatu*s. The majority of these hours should be expended in two time windows reflecting presumed maximum activity levels of the massasauga: 1) spring emergence, 2) mid- to late summer basking and birthing period. If massasaugas are found on a site, no further effort is necessary to determine species presence or absence. We recommend continuing this minimum effort for ten years before evaluating the likelihood of population extirpation (see Results and Interpretation).

To evaluate population size and demographics, we recommend mark-recapture studies. To evaluate habitat use and activity range at study sites, radio telemetry is recommended to map activity and movement. Standard statistical significance tests (Parker and Plummer, 1987; Sokal and Rohlf, 1981), and peer review, should be used to evaluate such studies.

Supplemental Technique

One of us (Resetar) has had success trapping *S. catenatus* in funnel traps. Since this technique has not been tried often, we recommend its use as optional and supplemental to visual searches at this time. If further tests of this technique prove fruitful, its use may become warranted as a standard technique. For this technique an aluminum drift fence with a funnel trap at each end is installed. The body of the trap and funnels can be constructed from aluminum window screen or other materials (Karns, 1986). A scythe or clippers should be used to trim vegetation down to about 8 - 12 cm in height, one meter on each side of the fence. Keep the vegetation at this level throughout the collecting period. In northwestern Indiana, Resetar was successful trapping *S. catenatus* with this method during late May, mid-June, and late September. Placement should be along natural habitat edges, which snakes might follow when moving, or randomly within a large contiguous habitat patch (Karns, 1986). Extreme care must be exercised in concealing the fence from human detection whenever possible to avoid poaching or vandalism, and in taking measures to avoid the possibility of snakes over-heating in traps through sun exposure.

Data Collection

In order to facilitate comparison of data among sites, which might be widely separated geographically, we recommend that the following minimum data be collected for each survey period:

1. Contact information for each surveyor
2. Date(s)
3. Survey site location(s)
4. Start and end times
5. Start and end temperature, relative humidity, wind strength, and percent cloud cover
6. Calculation of eastern massasauga rattlesnakes found per person hour

Estimation of crayfish burrow density may also be useful, including identification of burrowing crayfish by species and type (e.g., primary, secondary or tertiary burrower: Hobbs 1989).
These data may be helpful in evaluating hibernacula potential on the study site

Data collected for eastern massasauga rattlesnakes encountered may vary according to whether snake handling will occur.

If snakes are not to be handled, we recommend collecting the following minimum data:

1. exact location (GPS, compass distance and direction from a landmark, legal description, or topographic map mark-up)
2. photograph of animal (see below)
3. snout - vent length estimate
4. general health notes
5. micro and macro habitat descriptions
6. behavioral notes
7. snake detection method (sight, sound)

If the survey allows snake handling, the following additional minimum data should be collected for
each snake encountered:

1. 1. sex
2. 2. snout - vent length (SVL)
3. 3. weight
4. 4. reproductive condition
5. 5. collection of blood or tissue samples if possible

Other data may be collected as deemed necessary by the researcher/surveyor, or may be required as part of conditions specified by a contracting local, state, or federal agency. We have
provided a sample data form, which may be altered by users to suit their particular needs. The

decision to restrain snakes during surveys, in order to acquire more data, should be carefully weighed against potential stress to the animals, and the potential to increase the risk of injury to the snake and to the surveyor. Data on location, habitat use and behavior can be collected without restraint, and restraint may not necessarily improve photographs.

If the survey is part of long term monitoring, we also recommend marking with PIT tags (Jemison et al., 1995). If PIT-tagging is not possible, the application of a small amount of fast-drying, water-resistant paint on a basal rattle segment (UniPaint® oil-base paint markers, Sanford Corporation, Bellwood, Illinois), or fingernail polish, can be used. One drawback to this technique is that it may lead to inaccurate identification of an individual after numerous sheds, as position of the segments may change, or the segments may be eliminated altogether through natural wear and/or breakage. Disturbance of animals through frequent remarking should also be considered.

We recommend collection of blood samples regardless of whether or not these are required for the individual study. Blood samples should be provided to researchers or institutions involved with molecular and parasite studies. Sampling kits can usually be obtained from these same parties.

Documentation

As noted above, we strongly recommend that specimen photographs be taken at all unvouchered localities. Voucher photographs should be made of the first individual snakes discovered at each survey site. Photographs of snakes as encountered *in sit*u, as well as habitat photos, are strongly recommended. One copy of each photograph should be provided with the survey report, and a second set deposited into a permanent museum collection for verification. Observations of massasaugas lacking a photographic voucher must be viewed with skepticism, unless the observation was made by an expert on the species, or until a voucher in some form is procured (e.g. photo, shed skin, specimen). Photos of head/neck and full body, the latter being most effective for identification purposes, should be taken from above. We also recommend that all specimen carcasses discovered during surveys be preserved and deposited at a museum collection. Shed skins (from which identifications by individual pattern can be made) and prey items should also be salvaged when possible. Once a site has been vouchered, challenges to opinions on species presence should become moot, and subsequent (or prior) sight reports from qualified personnel are supported by the voucher.

Because of the danger of persecution from collectors and hunters, we strongly recommend that any publication of locality data be non-specific, with a resolution no greater than to county or province. Specific locality data may be provided on a need-to-know basis by the museum institution where the voucher was deposited, or by agencies responsible for disseminating information for environmental reviews, research, and management planning. Reports prepared for government agencies are often considered public information, and authors should discuss this issue with the agency beforehand, so that sensitive information can be deposited where it can be protected from abuse. We recommend omitting specific locality data from public reports, and providing these data separately to agency personnel on a need-to-know, case by case, basis.

Results and Interpretation

We recommend the following data interpretation for surveys performed within the geographic range given above. We recognize that massasauga populations can persist at low densities for long periods of time, and during those periods be very difficult to detect. Instances of massasaugas going undetected for over ten years before resurfacing are known (Casper). Put another way, absence of evidence is not evidence of absence for cryptic, secretive species. Therefore, we recommend that detection thresholds for the purpose of allocating management and recovery resources, be less stringent than thresholds applied to decisions on actual population extirpation, since extirpation determinations will have consequences for protection of a population and its habitat. We also recommend that management resources be applied only to detectable populations, and that non-detectable populations (with demonstrable historic presence) be the subject of long-term, periodic surveys and habitat assessments, before extirpation is assumed. Negative survey results at sites where there are prior records for eastern massasaugas should be a catalyst for ecosystem restoration, with follow-up surveys to detect recovery.

Recommended Data Interpretation and Hierarchy

A. Positive search results should be interpreted as an "extant population." We recommend that extant populations merit four responses:

    1. Immediate steps to protect habitat through acquisition and easements;
    2. Evaluation of illegal taking and persecution, with subsequent implementation of law enforcement and education programs as needed;
    3. Initiation of long term demographic and ecological studies to estimate population size, population trend, and to define population activity range and habitat needs (Parker and Plummer, 1987; Dodd, 1987);
    4. Initiation of habitat management based on the results of step 3. Habitat management should consider both vegetation (usually control of woody growth), and hydrology (usually avoidance of winter water level manipulations).

    In sum, extant populations merit the most stringent and urgent of recovery, monitoring and research efforts, and the highest resource allocation priority.

B. Negative results for a single survey period should be interpreted to mean that the population was undetected during the survey period, due to either low numbers, climatic factors, extirpation, or chance. We recommend that the appropriate management response is continuing surveys.

C. Continuing negative results after five survey years (with a minimum effort of 40 person hours per year, appropriately spread throughout the field season of April-October) should be interpreted to mean that the population is "of questionable viability" or "potentially extirpated", with recovery probably dependent upon intensive management to reduce mortality and/or enhance habitat. We recommend

that the appropriate management response is to convene a panel of experts to assess habitat quality and any other factors which may be relevant to population declines (such as poaching), and assessment and implementation of appropriate habitat improvement actions, with continuing periodic surveys to detect response to habitat improvements.

D. Continuing negative results after ten survey years should be interpreted to mean that the population can be considered "extirpated for management purposes", and that no management response is recommended.

E. Interpretation of continuing negative results after fifteen survey years should be made by a panel of experts. We recommend that a determination of permanent population extirpation, with its potential consequences for removing site protection, should require either a minimum of fifteen years of negative survey data, or unequivocal evidence and consensus that habitat losses (complete habitat estruction/development) at the site have been so great that a population could not persist.

A final note of caution

Sistrurus catenatus is a pit viper and must be handled, both in the field and laboratory, with.
care and respect. Unnecessary handling of adult and juvenile massasaugas should be avoided
whenever possible. Russell (1980) reported treating nine bites by *S. catenatu*s. Although two patients
were not envenomated, all of those that were experienced severe pain, with some additional nausea.
Swelling and bleb (fluid-filled blister) formation was noted. All patients took several days to recover,
and 4 of the 9 had to receive antivenin. Poticha (1971) also reported on massasauga envenomation
in northern Illinois.

A bite involving a field researcher is a serious matter for another reason. Any publicity of such an event is usually sensationalistic, and may have unforeseen consequences. Public concern,
often exacerbated by media attention to a snakebite, may hamper or even curtail local efforts to
protect massasaugas. Public support for protection of a venomous animal may be tenuous at best,
and ramifications of a snakebite accident should be considered by those working with such animals,
especially in semi-urban areas.

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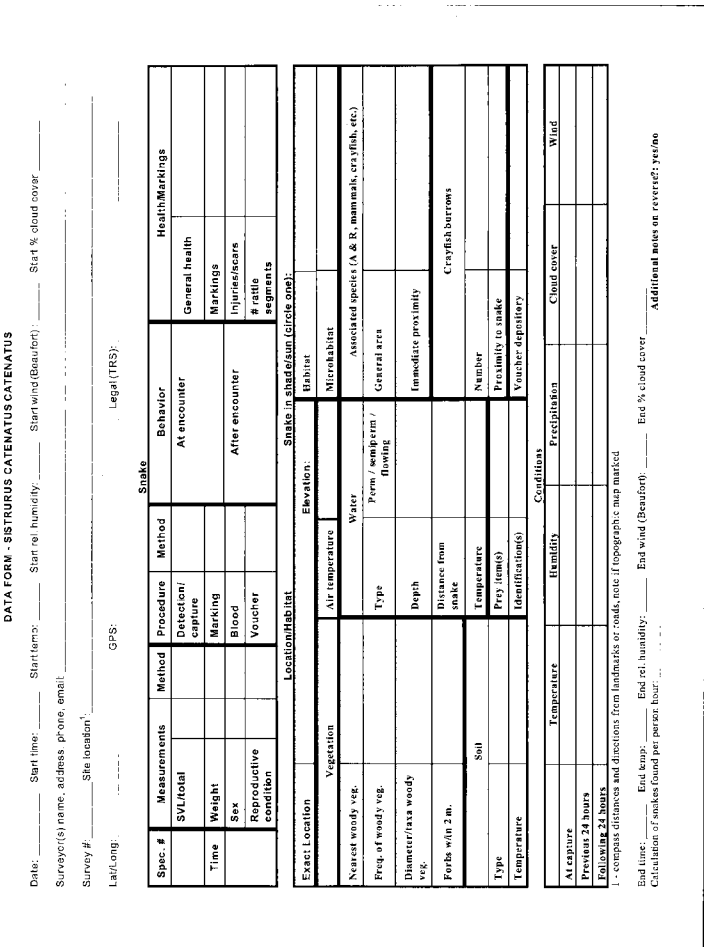

DATA FORM - SISTRURUS CATENATUS CATENATUS

Date: _____ Start time: _____ Start temp: _____ Start rel. humidity: _____ Start wind (Beaufort): _____ Start % cloud cover: _____

Surveyor(s) name, address, phone, email: _____

Survey #: _____ Site location[1]: _____

Lat/Long: _____ GPS: _____ Legal (TRS): _____

Snake

Spec. #	Measurements	Method	Procedure	Method	Behavior		Health/Markings	
	SVL/total		Detection/ capture		At encounter		General health	
Time	Weight		Marking				Markings	
	Sex		Blood		After encounter		Injuries/scars	
	Reproductive condition		Voucher				# rattle segments	

Location/Habitat — **Elevation:** — **Snake in shade/sun (circle one):**

Exact Location				Habitat	
Vegetation		Air temperature		Microhabitat	
Nearest woody veg.		Water		Associated species (A & R, mammals, crayfish, etc.)	
Freq. of woody veg.		Type	Perm / semiperm / flowing	General area	
Diameter/taxa woody veg.		Depth		Immediate proximity	
Forbs w/in 2 m.		Distance from snake		Crayfish burrows	
Soil		Temperature		Number	
Type		Prey item(s)		Proximity to snake	
Temperature		Identification(s)		Voucher depository	

Conditions

	Temperature	Humidity	Precipitation	Cloud cover	Wind
At capture					
Previous 24 hours					
Following 24 hours					

1 – compass distances and directions from landmarks or roads, note if topographic map marked

End time: _____ End temp: _____ End rel. humidity: _____ End wind (Beaufort): _____ End % cloud cover: _____

Calculation of snakes found per person hour: _____ **Additional notes on reverse?: yes/no**