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STATUS OF THE EASTERN MASSASAUGA, *SISTRURUS C. CATENATUS*, IN INDIANA WITH MANAGEMENT RECOMMENDATIONS FOR RECOVERY

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ABSTRACT: The eastern massasauga, *Sistrurus catenatus catenatus*, is a small rattlesnake currently listed as Endangered in Indiana and as a Candidate Species for listing as Threatened by the U.S. Fish and Wildlife Service. The status of massasauga populations in Indiana was examined to determine the species' past and present distribution, to evaluate threats to extant populations, and to provide recommendations for monitoring, protecting, and enhancing populations. The eastern massasauga was once widely distributed across northern Indiana and relatively abundant in certain localities. The rattlesnake's current range only extends half as far south as it did historically, and most viable populations are restricted to the extreme northeastern corner of the State. Current threats to its existence appear to be largely the same as the historic ones, with habitat loss still being the most critical. While outright habitat loss continues to be a problem, land management practices that allow plant succession may be of equal or greater concern. The most significant threat may be the stabilization of water levels within watersheds and the subsequent loss of the open canopy habitats that the snakes frequent.

KEYWORDS: Conservation, land management, massasauga, *Sistrurus catenatus catenatus,* snake.

INTRODUCTION

The massasauga, *Sistrurus catenatus*, is a small rattlesnake most closely related to the pygmy rattlesnake (*Sistrurus miliarius*). The eastern massasauga, *S. c. catenatus*, is found in the Midwestern United States south of the Great Lakes, in restricted, adjacent areas of Canada, and as far east as portions of New York and Pennsylvania (Minton, 1983; Conant and Collins, 1991). The occurrence of the massasauga in the Midwest and further east has been attributed to its expansion during the Wisconsin interglacial period, when it invaded as a prairie species (Cook, 1993).

The massasauga has been reported from well over twenty counties in Indiana, and Minton (1972) suggested a historical range covering much of the northern half of the State. While apparently once abundant, the massasauga now appears to be in serious decline over its entire range. This snake is currently list-

ed as Endangered in Indiana and is a Candidate Species for listing as Threatened by the U.S. Fish and Wildlife Service. A major cause for the decline of many populations has been the loss of habitat. Over the last hundred years, most prairie areas, as well as most wetlands, have been converted to agriculture. Much of the habitat previously occupied by the massasauga is now no longer available. These snakes are also poisonous, and though their small size reduces the relative risk they pose to people, they have been subject to more efforts at eradication than even the average unlucky snake.

In order to evaluate the extent and to document the reasons for the overall decline of the massasauga, a regional effort has been initiated by the U.S. Fish and Wildlife Service in cooperation with state agencies to establish the status and distribution of this snake in the Midwest. With the support of the U.S. Fish and Wildlife Service and the Indiana Department of Natural Resources, the author conducted the Indiana portion of that effort. In this paper, the natural history of the massasauga, its status in Indiana, the historic and existing threats to its populations, and recommendations for enhancing the security of remaining populations will be reviewed.

NATURAL HISTORY OF THE EASTERN MASSASAUGA

Based on habitat associations reported throughout the range of the animal (Minton, 1972; Reinert and Kodrich, 1982; Seigel, 1986; Weatherhead and Prior, 1992), the habitat used by massasaugas appears to be regionally variable and site dependent. However, the preferred habitats generally are the grassy margins of wetlands and open areas such as prairie. In Indiana, massasaugas are found in sedge fens, grassy meadows, and disturbed areas in the early stages of succession. While they may have occupied prairie habitats in the State in the past, little of this habitat remains today. Almost all the Indiana records link the massasauga to wetlands, which might lead one to presume a preference for such areas. However, *S. c. catenatus* tends to avoid permanently wet areas (Wright, 1941), and individuals are never found swimming, as would commonly occur with typical water snakes. Nevertheless, the snakes have been seen perched immediately adjacent to open water on tufts of sedges or grasses (T. Swinford and J. Hampshire, pers. comm.).

The snake's association with wetlands in Indiana is especially interesting, given that massasaugas are not even semi-aquatic. In fact, rattlesnakes as a taxon are generally associated with relatively xeric habitats. The snake's association with wetlands may be related to the vegetative characteristics of such sites, the type of prey available, the elevated water loss rates, or the massasauga's exclusion from preferred habitats (Atkinson and Netting, 1927; Klauber, 1956).

A characteristic common to all the sites where massasaugas persist in Indiana today is a generally open vegetative structure. Over most of their range, massasaugas tend to avoid heavily wooded areas (Wright, 1941; Bielema, 1973; Seigel, 1986), although Weatherhead and Prior (1992) did find them in openings in coniferous forests in Ontario, Canada. Typically, these sites also have a rela-

tively open shrub layer. This vegetative structure, where tree and shrubs are thinly distributed, allows sunlight to strike the underlying vegetation and the ground, providing places for basking. Prey (rodent) densities for the snakes may be enhanced by the successful growth of sedges, grasses, and herbs. In spite of their preference for largely open areas, the massasauga may show a preference for microsites near isolated trees or shrubs within the open area (Bielema, 1973). This choice may be related to the shade provided by the vegetation as well as to the protection afforded from aerial predators.

Rodents such as voles (*Microtus*) and deer mice (*Peromyscus*) are the predominant prey of adult massasaugas (Wright, 1941; Bielema, 1973; Seigel, 1986). Bielema (1973) found that jumping mice (*Zapus hudsonius*) elicited the most active search and pursuit behavior by massasaugas in captivity. He was unable to elicit attacks on anurans or house sparrows (*Passer domesticus*). Seigel (1986) examined the prey preference of 96 snakes and found that of the 22 that had prey in their stomachs, 84% of the prey was rodents, and 16% was snakes. Snake prey was found only in the stomachs of juvenile massasaugas. Keenlyne and Beer (1973) examined the stomach contents of several hundred sacrificed massasaugas and found that 86% of their prey were voles (*Microtus*). The remainder of the prey were other small mammals, snakes, and birds. No amphibians were found. Overall, adults apparently eat only small rodents, while juveniles accept a greater variety of prey, including small snakes. Some older references indicate that anurans were sometimes included in the diet (Atkinson and Netting, 1927; Curran, 1935).

Massasaugas often show seasonal shifts in habitat use. The typical usage pattern is wet prairie and meadow habitats in the spring and fall and higher, drier habitats in the summer (Bielema, 1973; Reinert and Kodrich, 1982; Seigel, 1986). Some populations do not show a seasonal shift in habitat use (Wright, 1941; Maple, 1964). Linked to the spring-fall habitat pattern is the snake's use of crayfish burrows to hibernate (Maple, 1964; Seigel, 1986), which may explain why massasaugas are often discovered immediately adjacent to water in the spring. Summer habitat use with its reliance on higher, drier sites might explain why roadkills peak in August — the snakes are up in elevated sites rather than down near the water.

PAST AND PRESENT DISTRIBUTIONS OF THE MASSASAUGA IN INDIANA

Methods. The historic distribution of the massasauga in Indiana was estimated using the Indiana Department of Natural Resources' Natural Heritage Database, museum records provided by Alan Resetar (Field Museum of Natural History), the publications of Minton (1972) as well as Whitaker and Gammon (1988), and conversations with regional herpetologists, state personnel, and local residents. Over forty sites were visited to assess the extent and quality of the available habitat, to evaluate potential or existing threats, and to search for snakes. The current distribution of massasaugas was estimated using only observations

since 1985 adjusted by the exclusion/inclusion of some sites based on habitat quality. If suitable habitat at a site was known to have been removed, then the population was assumed to be extirpated at that site. On the other hand, where suitable habitat had remained extensive and of high enough quality to retain a population, the massasauga was inferred to be present even if records from the last ten years did not exist. This assumption is reasonable given the secretive nature of these snakes. To discourage the misuse of site information from this report, specific details on most sites are omitted. Table 1 details the species' status in Indiana on a county by county basis, and Figure 1 shows its historical and current distributions in Indiana.

Historical Distribution. Massasaugas were much more abundant in the past and had a wider distribution in Indiana than they do today. Figure 1 depicts their distribution prior to the 1900s based on historical records within Indiana and the surrounding States. The distribution of massasaugas no doubt ran across the entire northern part of the State, but the extent of their range toward the south is not clear. Minton (1972) discounted the Sullivan County record and limited the southern margin of the massasauga's range to northern Hendricks and Marion Counties, a reasonable assumption given the disjunct nature of the species in Indiana. However, the site in Sullivan County is not far from sites, both confirmed and unconfirmed, having massasaugas in Edgar, Clark, and Crawford Counties in Illinois (Beltz, 1992). The massasauga's range may have continued into Indiana as an extension of these populations along the Wabash River, an extension suggested in Figure 1. Further investigation may clarify whether such an inclusion is warranted or suggest more accurate boundaries for the inclusion. In any case, this portion of the range should be viewed as an extension from Illinois rather than as a disjunct southern population, as a map of the Indiana distribution alone might suggest. Another southerly record recently emerged for Jackson County (Indiana Natural Heritage Database, 1986) but remains unconfirmed. This report was discounted based on the lack of confirmation and the site's distance from other records.

Historically, some of the largest massasauga populations appear to have been along the shores of Lake Michigan in the region of the Indiana Dunes National Lakeshore and throughout the Northern Lakes Natural Region (see Homoya, *et al.*, 1985) of northeastern Indiana. The number of massasauga specimens at the Field Museum in Chicago, which were collected from the Dunes area until the 1920s and 1930s, is quite high (A. Resetar, pers. comm.). To some extent, the number of specimens is due to the area's proximity to Chicago and its collectors. However, good habitat was apparently quite extensive at that time. The Northern Lakes Natural Region, as its name implies, has numerous kettle lakes. The area also had extensive, shallow, ephemeral wetlands and associated habitats, but many have now been drained. The availability of these wetlands, not the lakes, accounts for the historical abundance of the massasauga in this area.

Current Distribution. The present distribution is notably more restricted than the historical one (Figure 1). A southern boundary which encloses all but

Table 1. A summary of the status of the eastern massasauga, *Sistrurus c. catenatus*, in Indiana. Data are presented by county showing the year that the species was last reported from that county, the approximate minimum number of remaining locations for the species within the county, the last year that massasaugas were seen there, the source of the information, and the status (based on the best site in the county) and comments on the status for that county.

County	Sites	Year	Source[1]	Status[2] and Comments
Allen	1	1996	BAK	R; disjunct distribution
Carroll	1	1994	BAK	R; disjunct distribution
Cass	0	1963	SAM	X
Delaware	0	1944	SAM	X
Elkhart	2	1995	BAK	R; good habitat remains
Fulton	0	1970	SAM	X
Hamilton	0	NA	SAM	X; no date or location given
Hendricks	0	1887	SAM	X
Jackson	0	1986	INHD	U; well away from other sightings
Jasper	0	NA	SAM	U; suitable habitat present
Kosciusko	3 - 5	1990	INHD	R; may contain stable populations
Lagrange	5 - 10+	1996	JH	S; several robust population structures
Lake	1	1980s	AR	U; one possible population
La Porte	1	1992	AR	Resetar (1993)
Marshall	1	1993	BAK	R; habitat restricted, disturbed, and isolated
Montgomery	0	1957	SAM	X
Newton	0	1988	INHD	U; no suitable habitat
Noble	1	1995	BAK	R; may be more abundant than indicated
Porter	1	1987	AR	R; severe habitat loss via succession
Pulaski	2	1987	BB	R; small habitat fragments remain
Starke	0	1957	SAM	X; habitat eliminated
St. Joseph	1	1993	BAK	R; snakebite case
Steuben	5 - 10+	1996	FJW	S; several robust population structures
Sullivan	0	NA	SAM	X; disputed locality well south of other sites
Wabash	0	1951	INHD	X
Warren	0	NA	SAM	U; Lee Casebere (IDNR) comment to SAM
Wells	0	NA	SAM	X; no recent observations
Whitley	0	NA	SAM	X

[1] Sources: BB = Bill Bean (IDNR); BAK = Bruce A. Kingsbury (observed or confirmed); JH = Jeff Hampshire (Property Manager, Pigeon River Fish and Wildlife Area); INHD = Indiana Natural Heritage Database (to which I deferred when a source was not a professional scientist or biologist); SAM = Sherman A. Minton (Indiana-Purdue University Indianapolis); AR = Alan Resetar (Field Museum of Natural History); FJW = Fred J. Wooley (Pokagon State Park Naturalist).

[2] Status Codes: U = unconfirmed; X = extirpated; R = rare; and S = stable.

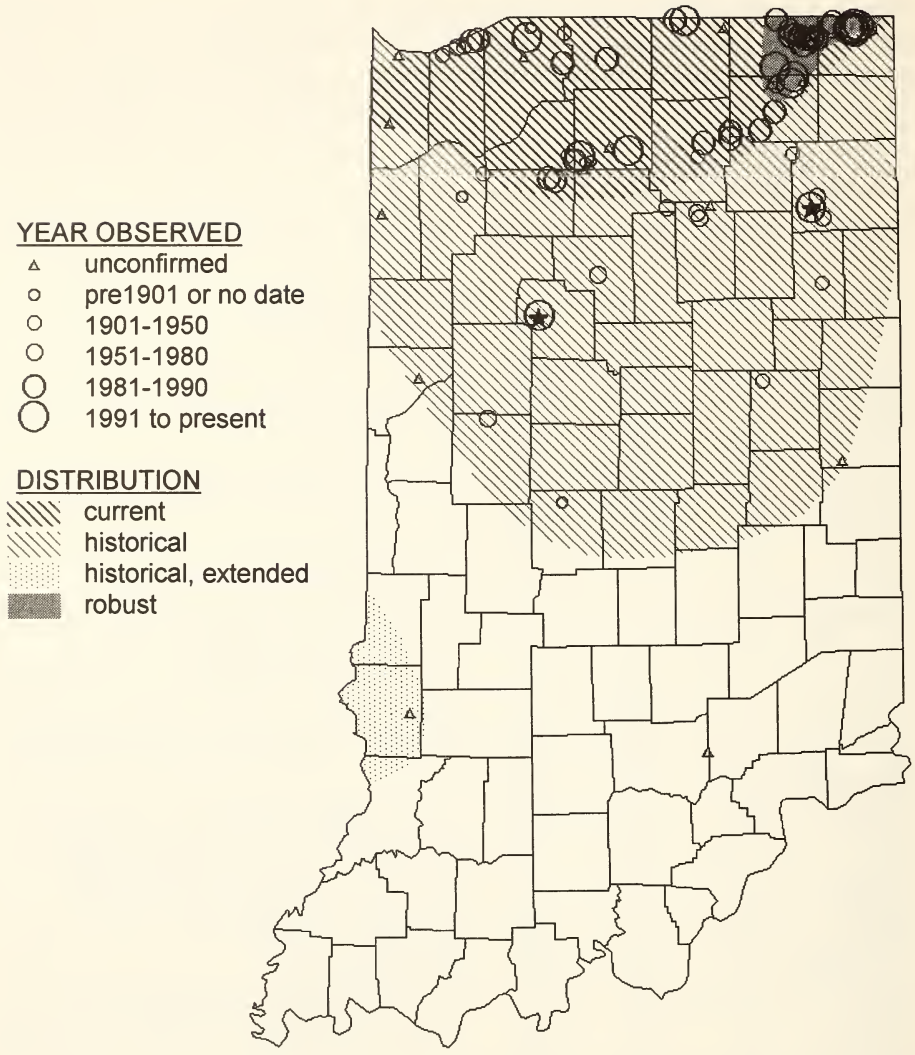

Figure 1. Distribution of the eastern massasauga, *Sistrurus c. catenatus*, in Indiana. The inclusion of the disjunct, southerly region is based on a single, questionable record, which is adjacent to established records in Illinois. Two isolated populations, one in western Carroll County and the other in southwestern Allen County, have been verified as remaining extant and are indicated by stars. Note the restricted size of the area in which most populations remain in the State (shown as the "robust" distribution).

two known populations appears to run only as far south as the northern edge of Cass, Miami, and Wabash Counties. Of the two confirmed populations that lie south of this boundary, the southernmost one is in western Carroll County in a large, but isolated, sedge meadow. The other population is found in southwestern Allen County in a series of moist old fields.

The most dramatic losses in range have occurred to the south and southwest, and most of the western populations have also been extirpated. The loss in range brings up an important point — the simple inspection of a distribution map for the massasauga in Indiana does not provide an accurate assessment of the status of this snake. Looming in the near future is the potential loss of the few remaining western populations in Lake, Porter, and La Porte Counties. Most of the sites in these Counties are small and have been isolated for decades. Succession has removed much of the habitat that has not already been put into agriculture or urbanized. Protecting populations within these Counties will be critical if the current distribution is not to contract even further in the immediate future.

Truly robust massasauga populations are restricted to a small region in the northeastern corner of the State (Figure 1). These populations are relatively large, connected to adjacent populations, and occur in protected habitat. As a result, these populations are at little risk of extirpation for the foreseeable future.

Two of the areas containing massasauga populations are worthy of special attention. The first is Pokagon State Park and its vicinity. This region is by no means uninfluenced by human activity — there are many roads, homes, and farms throughout the area. However, the entire region is interspersed with suitable habitat fragments, many of which are found in areas with protected habitat (e.g., Pokagon State Park and the Marsh Lake Fish and Wildlife Area). Interstate 69 does form an effective barrier just east of the park, but there are several ponds that pass beneath the highway that may allow occasional genetic interchange. The second area is the Pigeon River State Fish and Wildlife Area and the surrounding environs. This area is also interspersed with suitable habitat, much of it protected within the Fish and Wildlife Area. Fens and associated habitats are found along the Pigeon River and several of its tributaries. Many sites have records for massasaugas, including some reports during the time period of this study. Some of the largest suitable habitat fragments in the State are included in this area, and extensive marginal habitat also exists to act as corridors between these fragments.

FACTORS CAUSING THE DECLINE OF THE MASSASAUGA

To evaluate the factors which have led to the decline of massasaugas populations in the past and which may continue to do so in the future, I reviewed the available literature on the species, spoke with herpetologists, other authorities, property managers, and land owners, and visited selected sites. Knowing the factors which threaten massasaugas, recommendations for removing, or at least reducing, the identified threats can be made.

Habitat Loss. Without doubt, the most profound factor leading to the decline of massasaugas has been the conversion of their habitat into farmland. Almost all tillable land in Indiana has been put into agriculture. The prairie habitat is largely gone, and most wetlands have been successfully drained. Habitat loss due to agriculture no doubt continues to some extent, but the loss was more extensive in the past.

Currently, the most critical factor in habitat loss is succession. Massasaugas appear to be ecotonal specialists. The habitats that they use are often transitory in nature, requiring disturbances such as fires and floods to maintain them. The regulation of water levels in wetlands and watersheds has no doubt played a much more significant role in habitat loss than fire suppression. Seasonal variation in wetland water levels keeps an area open by inhibiting the encroachment of species such as cattails on the hydric side of the ecotone and brush and trees on the terrestrial side. Habitat losses due to succession are more extensive than might initially be realized, because the hydrology of entire areas is simultaneously impacted. Inspection of numerous lake complexes in northern Indiana reveals that miles of watershed may have virtually the same elevation and that shifts of less than a meter in water depth would dramatically change the shoreline over vast areas. Historically, seasonal flooding did just that—each year, many square miles of habitat might be flooded by shallow water. The flooding would also have a high degree of unpredictability. The result of flooding would be the maintenance of vast tracts of ephemeral wetlands, that are all but gone in northern Indiana. They have been converted to farmland, or, along channelized river banks, succeeded by forest.

Malicious Killing. Another problem for massasaugas is outright killing. Snakes as a taxon are unreasonably persecuted, and things are worse for massasaugas because they are venomous. Their killing is unfortunate, because, in addition to any moral or ethical notion that they have a right to co-exist with us, they are useful for rodent control. In addition, as poisonous animals are concerned, massasaugas are relatively non-threatening. Finally, most of them live in areas that relatively few people enter, and they rely on crypsis to avoid detection. They may live in an area for years without anyone knowing that they are there.

Even when encountered, massasaugas prefer not to bite. In my encounters with them, I have never observed the snakes to strike. Instead, the snakes try to remain undetected. When they are detected, they try to flee. Prior and Weatherhead (1994) evaluated the defensive behavior of massasaugas. These researchers either (1) stepped next to (within 0.5 m) and then continued on, (2) stopped for 30 seconds next to, or (3) stepped over massasaugas they knew were present (they were monitoring them with radiotelemetry). The snakes remained motionless 58% to 66% of the time, depending on the treatment; of those that responded in some way, 66% rattled and fled, while the rest simply rattled. Out of 174 trials using 21 snakes, no strikes were ever observed! In another study (appar-

ently on the same population), Hedgecock (1992) presumably stepped on the snakes; that is, the foot was actually placed on top of the snake, although it goes unstated. Only 7% of the snakes that were "stepped upon" in the study struck at the investigator's foot!

While massasaugas are venomous enough to warrant respect, their small size limits the dose that they can deliver. Even without recent medical advances, the bite of this snake has rarely proven to be fatal. Wright (1941) reviewed 24 cases of snakebite, with and without the availability of antivenin, and no fatalities were observed. Minton (1972) did mention that some fatalities had occurred. Generally, their bites result in regional inflammation and discomfort. Being bitten by them is thus not a trivial event.

Incidental mortality may be quite significant. Many locality records come as the result of roadkills. In Indiana, massasaugas are most mobile in August and are most susceptible to traffic at that time. Unfortunately, many of these casualties are gravid females. Agriculture also takes its share of these snakes. The tilling of fields, especially fallow fields where the snakes have taken up residence from neighboring areas, kills the snakes living there. Harvesting and baling feed crops also leads to fatalities. The author has listened to many stories about massasaugas being found not only under bales but in them as well!

A final problem for massasaugas is that they are sought out by some collectors. Because massasaugas are venomous, they are perceived by hobbyists as "exotic" or novel. Ineffectual State protective laws also minimize the legal risk of collecting. One factor which will help the massasauga at most sites is the fact that they are so hard to find. This reduces the attraction for many illegal collectors, as it takes too much time to find them for it to be profitable.

State and Federal Status of the Massasauga. The classification of the eastern massasauga as Endangered by Indiana and Threatened by the U.S. Fish and Wildlife Service is appropriate. The snake should not be Federally listed as Endangered, since it is not in imminent danger of being completely extirpated, either in this State or over its entire range. Indiana does not legally distinguish between Threatened and Endangered (C. Gremillion-Smith, Indiana Department of Natural Resources, pers. comm.). Thus, although the species is not in immediate peril of extirpation in the State, the massasauga is listed as Endangered here. The species has suffered a severe contraction in range in this State and others, and further losses are likely in the near future. Listing is thus appropriate, and massasaugas should be afforded a high priority when management decisions are being made in areas where they are suspected to occur.

MANAGEMENT RECOMMENDATIONS

While we might hope that sites containing massasaugas will be left undisturbed, this will not often be the case. Many populations reside on private property or in areas managed for other species, such as waterfowl. Given that most of the land on which these animals live is used in some way, land uses

which are compatible with population persistence should be promoted. Such activities may remove individuals, but they are less likely to threaten the existence of the entire population.

In those cases where managing habitat for massasaugas is an option, the following recommendations should be considered:

1. Habitat maintenance should be geared towards maintaining open habitat, especially at sites where there is some seasonal saturation of the soil, through burning, mowing, or selective herbicidal applications. However, a number of risks to the massasaugas are associated with all of these practices. Seigel (1986) noted the loss of individuals during burning, and Wright (1941) and various property managers noted losses during mowing. No doubt herbicides have their side effects as well. Many of the problems with habitat management can be mollified by correctly timing the practice to minimize losses—massasaugas are largely inactive prior to late April and after September. They also tend to stay underground on cold, overcast days. Perhaps crops could be harvested later in the year in areas occupied by massasaugas.
2. Permit natural water level fluctuations. Controlling water in impoundments is common in fish and wildlife areas and other managed situations. Maintenance at fixed levels leads to losses of suitable habitat (see above). Land managers are often concerned with keeping habitat open, and fluctuating water levels may promote such habitat.
3. Promote the development of safe, useable corridors. Providing safe corridors between adjacent habitat fragments enhances the usefulness of both fragments to the snakes. Land managers should keep this in mind when planning land use in a habitat mosaic. Some areas of human disturbance may act as corridors, if not actual habitat. For example, highway right-of-ways are essentially maintained as grassland, and they often have ephemerally wet areas. These right-of-ways often border habitat fragments which are suitable massasauga habitat. As such, they can act as linkages and as supplemental habitat, especially if the grasses growing there are suitable forage for rodents. The margins of railroad beds, bikeways, and local roadways may also act in the same way. Maximizing the benefits of such thoroughfares for massasaugas will preclude mowing the entire right-of-way during the activity season (the strip bordering the road could be mowed all year).
4. The public should be educated about the ecological role of the snake and the low risk that it imposes on people. Clarifying the snake's role will undoubtedly aid in its acceptance. Protecting any snake is challenging, given the common fear of such animals. Protection of a poisonous and potentially harmful animal is even more difficult. If people learn that, unless actually picked up, massasaugas pose little risk to them, perhaps they can be convinced to leave the massasauga alone.

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