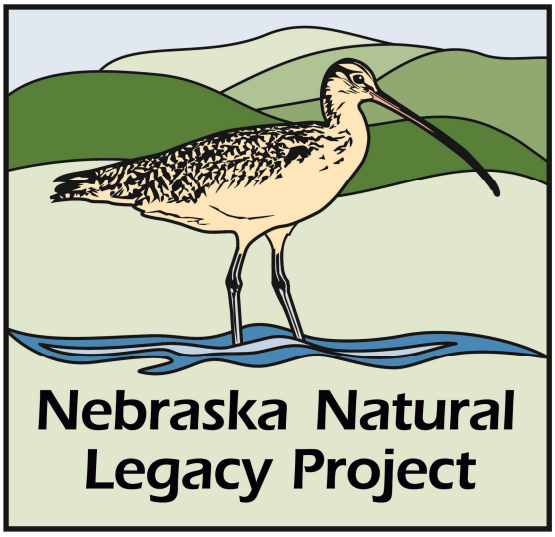
Western Massasauga
(*Sistrurus tergeminus*)

A Species Conservation Assessment
for
The Nebraska Natural Legacy Project



Prepared by Melissa J. Panella
and Brent D. Johnson
for
Nebraska Game and Parks Commission
Wildlife Division
Lincoln, Nebraska
June 2014

The mission of the Nebraska Natural Legacy Project is to implement a blueprint for conserving Nebraska's flora, fauna and natural habitats through the proactive, voluntary conservation actions of partners, communities and individuals.

Purpose

The primary goal in development of at-risk species conservation assessments is to compile biological and ecological information that may assist conservation practitioners in making decisions regarding the conservation of species of interest. The Nebraska Natural Legacy Project recognizes the Western Massasauga (*Sistrurus tergeminus*) as a Tier I at-risk species. Provided are some general management recommendations regarding Western Massasaugas. Conservation practitioners will need to use professional judgment to make specific management decisions based on objectives, location, and a multitude of variables. This resource was designed to share available knowledge of this at-risk species that will aid in the decision-making process or in identifying research needs to benefit the species. Species conservation assessments will need to be updated as relevant scientific information becomes available and/or conditions change. Though the Nebraska Natural Legacy Project focuses efforts in the state's Biologically Unique Landscapes, it is recommended that whenever possible, practitioners make considerations for a species throughout its range in order to increase the outcome of successful conservation efforts. And in the case of conservation for massasaugas, it is particularly necessary to take into account the seasonal needs of the species and conserve both wintering and summer foraging habitat.

Common Name	Western Massasauga
Scientific Name	*Sistrurus tergeminus*
Order	Squamata
Family	Viperidae
G-Rank	G3G4T3T4Q
S-Rank	S1
Goal	10
Distribution	Widespread
Criteria for selection as Tier I	State listed, G3T3
Trends since 2005 in NE	Stable
Range in NE	Very southeast portion of state
Habitat	Wet mesic tallgrass prairie, wet meadow/marsh/wet prairie, lower-middle tallgrass prairie, cordgrass wet prairie, crayfish burrows
Threats	Loss/degradation of tallgrass prairie habitat, woody invasion, tilling for agriculture, prescribed fires, haying, vehicle mortality, persecution by humans Climate Change Vulnerability Index: Highly Vulnerable (NatureServe 2013)
Research/Inventory	Determine size/extent of Colfax County population; conduct surveys to assess distribution and abundance; conduct population monitoring and population viability assessment
Landscapes	Lower Platte River, Sandstone Prairies, Southeast Prairies

Status

According to the last review in 2005, the Western Massasauga has a state Heritage status rank of S1, U.S. national status of N3N4, and global conservation rank of G3G4T3T4Q (NatureServe 2009). Previously, three subspecies of the massasauga were recognized, including the Eastern Massasauga (*Sistrurus catenatus catenatus*), Western Massasuga (*S. c. tergeminus*), and Desert Massasauga (*S. c. edwardsii*); however, recent taxonomic evidence has led to recognition of the Eastern Massasauga as a species distinct from the other two (*S. catenatus*; Kubatko et al. 2011). Although the Eastern Massasauga is currently a candidate for federal listing under the Endangered Species Act because of isolation of many of its populations (U.S. Fish and Wildlife Service 2011), the Western Massasauga does not receive such recognition and experiences more continuous habitat and less genetic differentiation among its populations (Murphy 2009). Only populations of the Western Massasauga are found in Nebraska (Fogell 2005). Western Massasaugas have threatened status in the state of Nebraska and are afforded all protections that designation provides. After careful review, the Nebraska Natural Legacy Science Team set a goal of maintaining at least 10 populations in the state (Schneider et al. 2011).

Principal Risk Factors

Approximately one third of the world's rattlesnake species are vulnerable to extinction (Greene 1997). With receding tallgrass prairie, extant Western Massasaugas in Nebraska have been mostly cornered in the southeastern region of the state where they face multiple risks (Fogell 2007). The following are risk factors that have been identified as likely to have the greatest impacts on Western Massasaugas in Nebraska.

Predation

Predation is a major cause of mortality for Western Massasaugas that can be influenced by changes to the structure of habitats (Fogell 2005). For example as trees invade a prairie, there are more perches for raptors to use as they hunt snakes. Predators of massasaugas can include birds of prey, carnivorous mammals, and other snake species (Szymanski 1998, Mackessy 2005). Predation of massasaugas is expected to be higher in edge or fragmented habitats (D. B. Shepard, pers. comm.).

Habitat alteration and loss

In Nebraska, an astounding amount (~98%) of native tallgrass prairies has been lost (Sampson and Knopf 1994), yet grasslands are needed as the primary habitat of resident massasaugas (Patten 2006). Direct loss of habitat often occurs because of the conversion of prairie to agricultural lands (Fogell 2005, Patten 2006). Western Massasaugas in the state may be negatively impacted by habitat modifications, such as haying practices and wetland alterations (i.e., creating farm ponds from wetland ditches, compaction of wetland soil, or any other alteration that would reduce or eliminate crayfish that build burrows; T. J. Coleman, pers. comm.). Indiscriminate haying could be disastrous to massasaugas (B. A. Kingsbury, pers. comm.). Massasaugas are known to seek cover in rows of mowed vegetation that are to be baled, and the snakes are then more vulnerable to mortality from hay baling equipment (Minton 1972, Kingsbury 1996, Fogell 2007). Encroachment of woody vegetation into grasslands is problematic, but even prescribed fire that may be used to reduce shrubs and trees may cause significant mortality of massasaugas if timing and intensity are not predicated by the species' annual seasonal ecology (Fogell 2005, Patten 2006). Mowing before burning does not limit mortality, and in fact, increases losses while snakes are active (Durbian 2006).

Mowing is detrimental to snakes in gestation areas (B. A. Kingsbury, pers. comm.). Habitat fragmentation can also impact massasaugas (Hobert et al. 2004).

Grazing

Direct mortality of Western Massasaugas resulting from cattle has not been documented (Fogell 2007). However, grazing may cause some indirect effects on the snakes, such as reduced small mammal populations (Fleischner 1994, Hayward et al. 1997) that would normally serve as prey on grazed lands (Fogell 2007).

Road mortality

Massasaugas can also be susceptible to road mortality, especially during peak times of migration associated with mating or movement to and from hibernation sites in the spring (Apr–May) and fall (Aug–October) (Fogell 2005, Shepard et al. 2008, Patten et al. 2009). Fogell (2005) states that dead massasaugas can be found on roads near one population site in Nebraska with some predictability each year.

Illegal harassment by humans

Purposeful collection or killing of Western Massasaugas occurs within the state based on limited reports (Fogell 2005, Patten 2006). Snakes, venomous and non-venomous, are taken as captives and do not survive, or they are targeted by humans who fear them.

Climate change

A climate change vulnerability assessment of Western Massasaugas indicated that they are highly vulnerable to impacts from changing climatic conditions (NatureServe 2013). Without a clear understanding of how climate change will impact massasaugas (and the crayfish they depend on for burrow creation), there is not yet a plan in place to help offset the risks to them. Fogell (2005) found that death of snakes within hibernation sites may be a result of excessive exposure to cold temperatures, which could result from changes to subsurface water levels.

Description

The Western Massasauga is a medium-sized pit viper with a gray to light-brown dorsal base color, a row of 21–50 dark-brown to black dorsal blotches, and three rows of small brown to black blotches on each side of its body (Ernst 1992). Western Massasaugas typically have a whitish or cream-colored belly with dark lateral blotches. This subspecies is, on average, slightly smaller than the Eastern Massasauga (Patten 2006) but larger than the Desert Massasauga (Holycross 2003). Western Massasaugas have an adult snout-vent length (SVL) usually between 45–65 cm (~18–26 in). In Nebraska, Patten (2006) measured most females to be shorter in length than males, which is a general trend among rattlesnake species (Klauber 1956).

FIGURE 1. Western Massasaugas have a grayish-brown base and dark blotches. Picture copyright NEBRASKAland, Nebraska Game and Parks Commission.

Habitat and Range

Western Massasaugas prefer mesic (moist) grasslands and are often associated with wetlands throughout their range (Seigel 1986, Patten 2006). Massasaugas require habitat for foraging during the warm months and habitat for brumation (hibernation of reptiles) during the cool months of the year (Fogell 2005, Patten 2006). Populations of the subspecies are found in Iowa, Nebraska, Missouri, Kansas, Oklahoma, and Texas (Mackessy 2005). In Nebraska, individual massasaugas have been shown to occupy areas of grass or forb vegetation with moderate to high ground canopy cover and moderate leaf litter during the summer and fall seasons (Patten 2006). Upland tallgrass prairie may be the most preferred habitat type, but massasaugas also spend limited amounts of time in shrublands, woodlands, cattail marshes, and other habitats (Fogell 2005). T. J. Coleman (pers. comm.) reports massasaugas using lowland prairie and shorelines for an entire season. Greene and Oliver (1965) suggest that Western Massasaugas in Kansas and Texas are largely nocturnal [during hotter weather] and often found on roads a little before and a few hours after dusk; however, daytime surveys in the spring and fall, during cooler weather, resulted in many sightings of Western Massasaugas in Nebraska (Patten 2006) and Missouri (Seigel 1986).

Observations indicate that massasaugas in Pawnee County, Nebraska brumate solely in crayfish burrows, and brumation extends from September–October to March–April (Fogell 2005, Patten 2006). Multiple Western Massasaugas may be found brumating in a single burrow, and other snakes such as Common Gartersnakes (*Thamnophis sirtalis*), Lined Snakes (*Tropidoclonion lineatum*), and Dekay's Brownsnakes (*Storeria dekayi*) may also be found in the same burrow as massasaugas (Fogell 2005). For the first 2 months after spring emergence, Western Massasaugas use mostly lowland prairie habitats containing loose, loamy soils with

many small mammal burrows and sparse vegetation, likely because of the foraging opportunities provided (Fogell 2005).

Prior to human alterations to tallgrass prairies, Western Massasaugas may have resided throughout much of eastern and southeastern Nebraska (Patten 2006). Past sightings and reports exist for eleven counties in the state — Colfax, Dodge, Douglas, Filmore, Gage, Jefferson, Lancaster, Nemaha, Pawnee, Saline, and Sarpy — but there are museum vouchers only for Filmore, Gage, Jefferson, Lancaster, and Pawnee counties (Taylor 1891, Hudson 1941, Mike Fritz pers. comm., Patten 2006, Fogell 2010). Additionally, there have been recent but unverified reports of Western Massasaugas in Cass, Saunders, and Webster counties (Fogell 2005). In September 2002 in Lancaster County, a landowner saw a snake that was likely a massasauga based on his description and historic records (Fogell 2003). Despite being the place of most historic sightings, Lancaster County's Western Massasaugas may now be near-extirpated. Current populations are known to exist only in Jefferson, Gage and Pawnee counties (Patten 2006). The subspecies was also reported in 1991 in Colfax County (Nebraska Natural Heritage, unpubl. data) and also in the same county in 2004 when a landowner found two dead massasaugas in a hay bale, but no other information is currently known about a population in the area (Patten 2006).

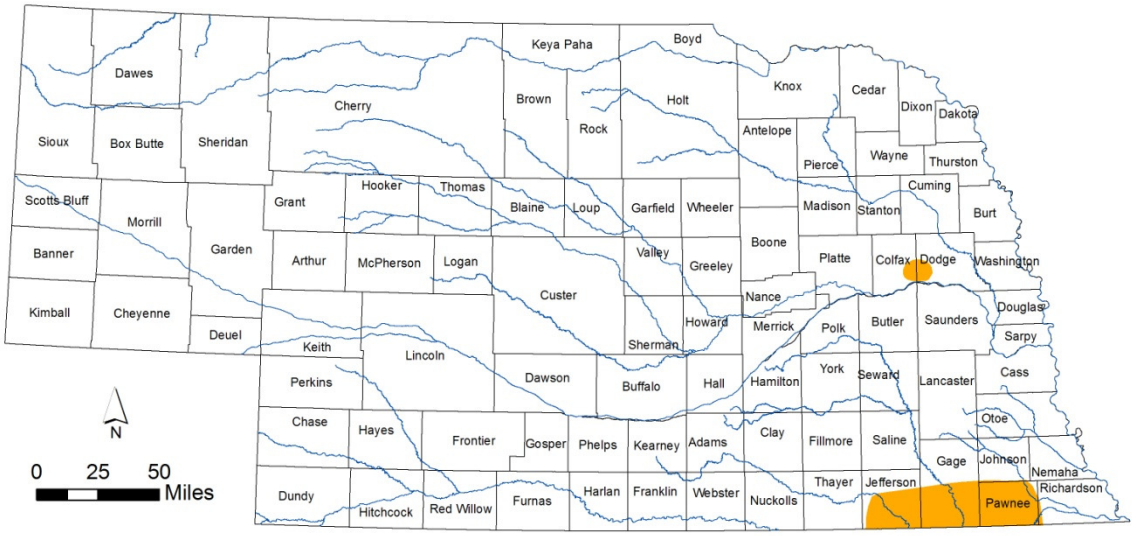


FIGURE 2. Current range of Western Massasaugas in Nebraska based on field observations, museum specimens, and expert knowledge. Map courtesy of Nebraska Natural Heritage Program, Nebraska Game and Parks Commission.

Area Requirements

Massasaugas tend to exhibit seasonal variation in their habitat use that includes long-distance, directional movements from hibernation sites to summer foraging or gestation areas each spring (Patten 2006, Reinert and Kodrich 1982, Seigel 1986, Hobert et al. 2004, Wastell and Mackessy 2011). In Nebraska, this migration begins in May and ends by early July (Patten 2006). Shorter movements within a more concentrated area are then made throughout the summer. After females give birth in August and possibly early September, Western Massasaugas begin a slow migration back to hibernation sites, and individuals do not always return to their previous hibernacula (Patten 2006). Patten (2006) found a mean distance of 181 ± 161 m between spring emergence crayfish burrows and those used in the fall. Some snakes

may move among different burrows during October and November if temperatures are warmer. Communal denning throughout the winter season appears to be a common occurrence among Western Massasaugas (Fogell 2005, Patten 2006).

Female massasaugas tend to occupy a smaller core area than males during each active season (Patten 2006, Durbian et al. 2008, Wastell and Mackessy 2011), although they make similar daily and seasonal movements in Nebraska (Patten 2006). Additionally, no difference exists in the minimum home range of males and females in the state, which averages ~9.4 ha (Patten 2006). After conducting surveys for massasaugas on two properties in Nebraska managed by the state, Fogell (2005) estimated their density to be 0.96 snakes/ha at Burchard Lake Wildlife Management Area (WMA) and 1.3 snakes/ha at Pawnee Prairie WMA. Because estimated density of massasaugas for each of the Pawnee County populations is low, being close to 1 snake/ha (Fogell 2005), and each state-owned property is considerably larger than the suggested minimum amount of habitat for supporting any massasauga population (100 ha; Durbian et al. 2008), this small estimated average home range size may not be problematic for the persistence of these populations. More important to the conservation of massasasaugas than total area is likely protection of critical habitat areas such as hibernacula and gestation sites (D. B. Shepard, pers. comm.).

Foraging Habits

Western Massasaugas are sit-and-wait predators that typically prey on small, terrestrial vertebrates (Greene and Oliver 1965) associated with mesic habitats (Holycross and Mackessy 2002). Adult massasaugas feed mostly on small mammals and occasionally on lizards, snakes, and birds (Greene and Oliver 1965, Anton 1992, Holycross and Mackessy 2002, Patten 2006). Juvenile massasaugas have a similar diet but may feed on small-sized snakes as often as they consume small mammals (Patten 2006).

Reproduction

The follicles of fertile females become enlarged during the winter and continue to grow in the spring and summer (R. A. Seigel, pers. comm.). In Nebraska, Western Massasaugas are known to mate opportunistically in April and May while still near their overwintering sites but have a second season of breeding activity during late summer (Fogell 2005, Patten 2006). Courtship can last for more than 6 hours and involves cycles of chin rubbing and tail stroking by the male (Chiszar et al. 1976). As a live-bearing snake, female Western Massasaugas gestate throughout the summer and give birth in August or September. Brood sizes recently recorded in Nebraska included 6, 7, and 11 neonates (Patten 2006). Comparable brood sizes were observed by Seigel (1986) in northwest Missouri and have also been observed for populations of Desert Massasaugas and Eastern Massasaugas (Anton 1992, Goldberg and Holycross 1999, Holycross 2003, Hobert et al. 2004). Females in Nebraska appear to reach sexual maturity at 3–5 years of age and at an SVL >50 cm (Fogell 2005). Similar to many other massasauga populations (Anton 1992, Goldberg and Holycross 1999, Reinert 1981, Hobert et al. 2004), these females generally reproduce biennially (every other year). After parturition, neonates can be found within a radius of ~1.0 m around the female and in pre-shedding condition (Greene and Oliver 1965). Within 1–2 weeks, the neonates will shed and disperse and may or may not forage before brumation (Patten 2006).

Survival

Estimates of survival for Western Massasaugas are unknown in Nebraska, but Jones and others (2012) estimated a range-wide trend in annual survival of 0.67 (range = 0.35–0.95) for the Eastern Massasauga. Populations of massasaugas in warmer climates tend to have higher annual mortality, likely because of increased exposure to threats during the active-

season, such as predation. A population viability assessment (PVA) for the eastern subspecies of massasauga used a maximum of 10 years as the lifespan for wild individuals (Middleton and Yan 2004). PVA (using data from Ontario, Canada) conducted by Middleton and Yan (2004) found that demographic parameters alone showed little to no risk of extinction until values fell way below what would normally be expected, but incidental mortality (e.g., roadkills, persecution) had the most detriment on populations. However, Seigel and Sheil (1999) conducted a PVA that suggested populations of Eastern Massasaugas in Missouri are very sensitive to changes in numbers of surviving adults and juveniles, especially when adult mortality exceeds 22% per year or neonate mortality exceeds 80% per year. Seigel and others (1998) found that sex ratio, population structure, and body condition differed significantly after an extreme flood event in Missouri during the summer of 1993. Captive massasaugas are known to live 20 years or more (NatureServe 2009).

Research and Conservation Strategies

A multitude of factors should be considered before implementing any conservation actions for species. Within the guidelines of state and federal law, the Nebraska Natural Legacy Project recommends: 1) consider, but do not limit options to, scenarios that benefit both the species of interest and property owners, 2) consider species dispersal and landscape context, 3) plan for multiple years, and 4) do no harm.

In Nebraska, Western Massasaugas have used habitat that is part of three Biologically Unique Landscapes recognized under the Nebraska Natural Legacy Project. Those areas are the Lower Platte River, Sandstone Prairies, and Southeast Prairies. The Nebraska Natural Legacy Project identified these landscapes as places that offer the best opportunities for conservation of the species in the state based on current knowledge. Given the principal threats identified, research and conservation efforts for Western Massasaugas (summarized in Table 1) may want to employ the following management strategies:

1. Prescribed fires can reduce woody vegetation and control canopy cover to help maintain the structure of habitat for Western Massasaugas. Mortality of massasaugas can be reduced by conducting burning prior to their spring emergence (Fogell 2005, Patten 2006). Fires in early spring on cool days early in the day are least likely to negatively impact massasaugas (Fogell 2007). Prescribed fires are conducted presently in 3-, 4-, and 5-year rotations during March and into April at population sites in Pawnee County, Nebraska, and dedicated efforts should continue to ensure they occur before massasaugas leave their hibernation sites (typically prior to the second week of March; T. J. Coleman, pers. comm.). Additionally, fires could be used to produce a patchy mosaic of thermoregulation, retreat, and foraging sites rather than being implemented on a larger scale. Be aware that larger-scale fires may potentially reduce abundance of the snakes' small mammal food source in grasslands for an entire season or more (Fogell 2005).

2. Haying is a habitat management tool used for similar purposes as prescribed fires but can also result in unintentional mortality of massasaugas, especially because it occurs in August and September, which overlaps the time of parturition for the snakes (Patten 2006). Better timing for massasaugas would be October through March for mowing, with mower blade heights set no lower than 15 cm (~6 in; Moser 2005). Gravid females in Pawnee County have been observed using lowland grassland or shoreline habitats, possibly as a means to avoid areas being hayed. Therefore, the exclusion of haying from lowland grassland areas and along lakeshores, where gravid females prefer to gestate, could minimize its impact (Fogell 2005, Patten 2006). Midslope grasslands are also

frequented by Western Massasaugas throughout each active season, so haying should be minimized in these areas as well. Leaving patches of un-mowed grassland that shift location annually can help to maintain proper refugia, corridors, and foraging opportunities for massasaugas while reducing the chance of predators learning to hunt along specific mowed paths (Fogell 2005). A possible mowing strategy would be to mow from the interior of a site to the outer edge to allow snakes a better chance of escaping equipment, provided that the snakes do not have to move very far (B. A. Kingsbury, pers. comm.).

3. Haying (and prescribed fire) may be inadequate at reducing woody vegetation that encroaches on critical hibernation areas for Western Massasaugas. Consequently, low-impact management, such as pruning, can be used as a management strategy if conducted regularly (Fogell 2005). Use of tractors and other large machinery may have unintended impacts such as compaction of crayfish burrows used as hibernacula, and are best avoided. Haying in late fall when massasaugas are using other habitats is least likely to impact them (Fogell 2005). Controlled herbicide applications may also be used to reduce woody vegetation. K. Condict developed the 'bloody-glove-technique' (5% glyphosate applied to cut stem with an absorbent cotton glove while applicator has protective barrier between his/her skin and the glove; Tu 2001) as one method of further targeting vegetation to be eliminated rather than applying broadcast herbicide. Dye can be used to distinguish treated areas from untreated ones (Czarapata 2005).

4. As critical habitat for Western Massasaugas in Nebraska, hibernation sites should be regularly monitored to ensure they maintain proper water levels and an absence of invasive vegetation (e.g., purple loosestrife [*Lythrum salicaria* L.], common reed [*Phragmites australis*], narrowleaf cattail [*Typha angustifolia* L.]). Winter water drawdowns need to be avoided to prevent severe detriment to animals overwintering (B. A. Kingsbury, pers. comm.). Water levels and invasive plants may not only directly alter the quality of crayfish burrows as hibernacula for snakes, but may reduce the prevalence of crayfish, which would reduce the number of burrows available (Patten 2006). Modifications of lakeside impoundments, such as dredging or draining, should be carried out in a way that maintains hibernacula for massasaugas, and dredged materials should not be placed on top of crayfish burrows that may serve as hibernacula (Fogell 2005). Hibernation sites may be located in roadside ditches; therefore, construction and mowing activities should account for this possibility (Fogell 2005).

5. To reduce road mortality where it is a concern, superintendents on state-managed properties can consider closing portions of gravel roads during times of the day when the snakes are most active (possibly determined via telemetry or road kill data) on roadways during the months of migration and when probability of road-related mortality is highest, which include April–May and September (Fogell 2005). Signage warning of snakes crossing roads may be a better option where closing roads is not feasible. To reduce the disregard of signs, signage should be erected only seasonally to alert drivers. Construction should be avoided in important areas for the massasaugas during the same time frame of sensitivity listed above for them (B. A. Kingsbury, pers. comm.).

6. Signage and informative kiosks could also be used to increase general awareness of Western Massasauga presence and conservation measures at population sites (Fogell 2005, Patten 2006). Outreach campaigns could improve support for conservation of Western Massasaugas among landowners and the general public, as has already been

demonstrated in Wisconsin (Fogell 2005) and in Nebraska at Burchard Lake (T. J. Coleman, pers. comm.). Such efforts may help to reduce malicious killings and collection of the snakes, actions known to occur infrequently in Nebraska.

7. Continued monitoring of populations of Western Massasaugas will help to better understand threats and could be used to develop up-to-date demographic estimates. More extensive surveying may be useful in discovering additional habitats used by the snakes and finding new population sites. Efforts should be made to locate and survey habitat use by massasaugas in Jefferson and Colfax counties to better understand their distribution and density. Intensive survey efforts immediately after a fire event can aid in detection of snakes when they are typically easier to locate (Fogell 2005). Survey efforts should also take into account the health and clinical signs of disease in the rattlesnakes. Infections such as *Chrysosporium* spp. (fungal dermatitis) and ophidian paramyxovirus (OPMV) are highly contagious and most often fatal amongst massasauagas (Allender et al. 2008, 2013). If an infected individual is handled, disinfect all surfaces and wash hands thoroughly to avoid transmitting the disease to other snakes.

8. Numerous USDA-NRCS Farm Bill programs might be used to benefit Western Massasaugas, but each management practice should be scientifically evaluated before it is widely implemented for this purpose. Availability of programs may vary in any given year. Consider:

   CRP – CP 2 (Native Grasses), 4D (Permanent Wildlife Habitat), 9 (Shallow Water Areas for Wildlife), 10 (Existing Grasses and Legumes), 21 (Filter Strip-grass), 23 (Wetland Restoration-floodplain), 23A (Wetland Restoration- non-floodplain), 25 (Rare and Declining Habitat), 29 (Wildlife Habitat Buffer), 33 (Upland Bird Habitat Buffer), 38 (State Acres for Wildlife Enhancement), 42 (Permanent Wildflowers and Legumes)
   EQIP- 528 – Prescribed Grazing, 314 – Brush Management, 390 – Wetland Wildlife Habitat Management, 645 – Upland Wildlife Habitat Management, 657 – Wetland Restoration, 659 – Wetland Enhancement
   CPGL - Conservation of Private Grazing Land
   WRP - Wetland Reserve Program
   WHIP - Wildlife Habitat Improvement Program
   GRP - Grassland Reserve Program
   FRPP - Farm and Ranch Land Protection Program
   WILD Nebraska

Information Gaps

The distribution of western massasauga populations throughout Nebraska is not yet fully known and could be better understood through systematic survey efforts. In particular, surveys should occur in Jefferson County where there are vast areas of likely suitable habitat and in Colfax County where two massasaugas were recently found in a landowner's hay bale. To what extent conservation practices (i.e., Farm Bill programs) could benefit massasaugas has not been evaluated in detail. We do not have a clear understanding how massasaugas could survive using refugia during the haying process (i.e, how big should un-mowed patches be, how long should patches be left, and how should locations of patches shift over time?). The impacts of small impoundment construction on the quality of hibernation sites via changes in water

levels should be further investigated and monitored (Fogell 2005). Potential impacts of climate change on populations of Western Massasaugas in Nebraska should be elucidated through long-term monitoring, so that measures can be taken to assist the species in coping with changing conditions. The evaluation of how changing climate may impact the crayfish that create habitat for massasaugas may be equally important to the conservation of the rattlesnakes and the freshwater crustaceans.

TABLE 1. Suggested management for Western Massasaugas in Nebraska is summarized. The following should be interpreted as general guidelines based on the best available knowledge at the time of this publication. See Research and Conservation section of this document for more detail and Reference section for sources of additional information.

FOCUS	STRATEGIES	MITIGATION and CONSIDERATIONS
Timing and extent of prescribed fires	Perform prescribed fires prior to spring emergence (~March; transmitters on some individuals can help to determine if snakes have emergeed) on cool days early in the day to avoid unintentional mortality of massasaugas. Fires could be used to create a patchwork of habitat to maintain retreat and foraging opportunities.	Prescribed fires may make massasaugas more visible to predators in the short term and reduce abundance of small mammal prey in burned areas for at least one full season. Days post-fire are a good time to locate massasaugas and thus conduct surveys
Extent of haying	Haying of lowland and midslope grasslands in late summer should be avoided as these areas are frequented by gravid females around parturition time. Leaving patches of uncut habitat with connectivity through a site and along property boundaries could provide snakes a greater chance of avoiding mowing equipment. Snakes may seek out tall patches (at least 15 cm [6 in] tall).	Raising the height of mowers to at least 6–8 inches (~20 cm) may also help reduce mortality of snakes, but only if the mowers do not touch the ground.
Reduce encroachment of woody vegetation	Low-impact cutting methods, such as pruning, should be attempted before larger-scale operations. Avoid the use of large machinery over crayfish burrows if possible, especially outside of summer months when burrows are most likely to be occupied by massasaugas.	Pulling out plant root systems could disrupt hibernation sites and should be done carefully, if at all.

TABLE 1. (cont.)

FOCUS	STRATEGIES	MITIGATION and CONSIDERATIONS
Maintain hibernacula	Monitor hibernation areas for changes in water level (particularly in winter), prevalence of crayfish burrows, presence of dredged materials, and encroachment of woody vegetation. Develop monitoring plans or site-specific recommendations. Address changes through low-impact management actions.	Roadside ditches may contain crayfish burrows used as hibernacula.
Reduce road mortality	Consider closing roads that massasaugas are known to cross during spring or fall migration times. Use signage to inform drivers of possible snake presence.	Construction activities on roads may disrupt massasaugas brumating in or otherwise occupying roadside ditches.
Signage and public outreach	Informational signs or kiosks could notify visitors about presence of massasaugas and current conservation strategies. Public outreach campaigns could increase general public awareness of the snakes.	As necessary, signage should include positive statements in place of warnings to keep visitors from feeling defensive or fearful during their time at a property. Do not put signage directly at den sites to try to minimize poaching risk.
Monitor and inventory populations	Known populations of massasaugas should be regularly monitored to record their status and observe possible declines. Survey efforts should be used to locate any additional populations in the state. Develop PVA.	Days post-fire are a good time to locate massasaugas. Radio transmitters or PIT tags may be used for monitoring. Efforts to locate additional populations could include informing landowners on how to report possible sightings.
Monitor health and disease in populations	Document any clinical signs of disease during inventory work. Diseased massasaugas should not be exposed to healthy snakes.	Various assays can be used to analyze blood samples for infection, but be wary of cross-contamination and false positives.
Maintain sufficient population of small mammal prey base	Livestock exclosures may be used to prevent grazing in some areas to avoid impacts to small mammals	Livestock are likely to select riparian and wetland areas (important to wildlife) for grazing if given the opportunity

Considerations for Additional Species

At-risk species that share habitat with Western Massasaugas should be considered in management plans for the snake. Conservation of Western Massasaugas may affect or be influenced by at-risk species that can be found in the same Biologically Unique Landscapes as the snake. Provided is a sample of at-risk species (Table 2) you may want to consider while planning for quality habitat that may be used by Western Massasaugas. This list will not apply to all sites of occupancy for the rattlesnake nor is the list all-inclusive.

TABLE 2. Tier 1 at-risk species identified in the Nebraska Natural Legacy Project that inhabit biologically unique landscapes with Western Massasaugas (Schneider et al. 2011) may necessitate consideration in habitat management plans.

Animals

- Bell's Vireo (*Vireo bellii*)
- Greater Prairie-Chicken (*Tympanuchus cupido*)
- Henslow's Sparrow (*Ammodramus henslowii*)
- Interior Least Tern (*Sternula antillarum athalassos*)
- Loggerhead Shrike (*Lanius ludovicianus*)
- Piping Plover (*Charadrius melodus*)
- Wood Thrush (*Hylocichla mustelina*)
- Iowa Skipper (*Atrytone arogos iowa*)
- Married Underwing (*Catocala nuptialis*)
- Ottoe Skipper (*Hesperia ottoe*)
- Whitney Underwing (*Catolcala whitneyi*)
- Northern River Otter (*Lontra canadensis*)
- Plains Harvest Mouse (*Reithrodontomys montanus griseus*)
- Blanding's Turtle (*Emydoidea blandingii*)
- Timber Rattlesnake (*Crotalus horridus*)

Plants

- Missouri Sedge (*Carex missouriensis*)
- Western Prairie Fringed Orchid (*Platanthera praeclara*)

A Note on Safety

While massasaugas are venomous, a little bit of precaution can go a long way toward avoiding bites and injury. Nearly half of reported snake bites of humans occur when a person deliberately handles a snake (Minton 1987). There are only 9–15 deaths per year from venomous snake bites estimated for the entire United States (Conover et al. 1995). To prevent bites, it is much safer to try to avoid the snakes or call a wildlife professional for assistance when the animal poses an immediate safety concern.

Acknowledgments

We were fortunate to receive several reviews of this document by individuals very knowledgeable with the subject matter. We would like to thank Tracy J. Coleman, Daniel D. Fogell, Bruce A. Kingsbury, Richard A. Seigel, and Donald B. Shepard for providing helpful comments that improved this document and made it a more useful resource.

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