Effects of Mowing and Summer Burning on the Massasauga (Sistrurus catenatus)

FRANCIS E. DURBIAN
United States Fish and Wildlife Service, Squaw Creek National Wildlife Refuge, P.O. Box 158, Mound City, Missouri 64470

ABSTRACT.—Prescribed fire is used to reduce coverage of woody vegetation in early successional habitats, but burning may also result in direct and indirect mortality of reptiles inhabiting the burn site. Mowing prior to burning has been hypothesized to render grassland habitats unsuitable for the massasauga (Sistrurus catenatus), thereby reducing the number of individuals that may be affected in the management unit at the time of burning. I evaluated the impact of mowing prior to summer burning on massasaugas at Squaw Creek National Wildlife Refuge, in northwestern Missouri, during the summer of 2003 using radiomarked snakes. Pre-burn mowing resulted in the direct mortality of three (43%) of seven radio-marked massasaugas present in the treatment area. Prescribed fire resulted in a mortality of one of two remaining individuals. Pre-burn mowing did not reduce mortalities as hypothesized and likely added to the overall snake mortality rate. Management alternatives other than mowing and prescribed fire when snakes are active should be considered when managing massasauga habitat.

INTRODUCTION

The massasauga (Sistrurus catenatus) is a state endangered species in Missouri (Missouri Natural Heritage Program, 2005) and populations of both subspecies, Sistrurus c. catenatus and Sistrurus c. tergeminus, that occur north and east of the Missouri river are candidates for listing under the United States Endangered Species Act (Szymanski, 1998; 64 FR 57534). The general ecology of this small rattlesnake species is well summarized in Johnson et al. (2000). Massasaugas in Missouri utilize wet prairie and, to a lesser extent, upland prairie habitat with minimal shrub and tree cover (Seigel, 1986; Johnson et al., 2000). Preservation of early successional habitats is imperative for the continued survival of the species in Missouri (Johnson et al., 2000).

A common problem for land managers responsible for maintaining early successional habitats is encroachment of woody vegetation. An effective tool for controlling this problem is the utilization of prescribed fire during the summer months which kills or temporarily retards woody vegetation (Adams et al., 1982; Anderson, 1997). Other, but less efficacious, means of controlling woody growth include herbicides and mechanical treatments such as hand cutting or mowing, although prescribed fire appears to be the most efficient and cost effective method.

Prescribed burning during summer (June through August), when fire is most effective at reducing woody vegetation, can result in direct mortality of massasaugas as this time frame coincides with the above ground activity period for this species. I observed the mortality of eight massasaugas on a 16.6 ha prairie after a spring burn conducted on 18 April, 2000 at Squaw Creek National Wildlife Refuge (SCNWR), and Frese (2003) reported that 85% of all snakes found after a fall burn on tallgrass prairie in southern Missouri were mortalities attributed to the fire. Mortality and injury to reptiles from seasonal fires has also been described by Babbitt and Babbitt (1951), Erwin and Stasiak (1979) and Heinrich and Kaufman (1985). The potential risk for direct mortality of massasaugas from summer burns creates a tenuous management situation when using prescribed fire as a management tool.
in the maintenance of grassland habitat. For this reason it is important to examine management techniques that reduce woody plant encroachment yet minimize or eliminate snake mortality caused by the treatments.

Results from a pilot study conducted on SCNWR during 2001 suggested mowing, prior to conducting summer prescribed fires, may have reduced snake mortality (Durbian, 2004). This was attributed to the reduction of shading and insulative cover through mowing which resulted in unfavorable habitat conditions for massasaugas. Elevated temperatures were believed to have forced snakes to temporarily leave the area or seek refuge underground until habitat conditions were once again favorable. It was then postulated that burning the site after mowing may have prevented direct mortality from fire while achieving the desired treatment effect of reducing woody vegetation. The pilot study used presence/absence data before and after mowing and burning, and no data were gathered to document snake activity or mortality during mowing and burning operations. I conducted the present study to determine the impacts of mowing prior to summer burning on massasaugas.

**MATERIALS AND METHODS**

**Study area.**—This study was conducted on the 3012 ha SCNWR located within the Missouri River floodplain in Holt County, Missouri. Squaw Creek National Wildlife Refuge consists of six main habitat types including old field (24 ha); developed land consisting of roads, parking areas, levees and drainage ditches (102 ha); agricultural cropland (234 ha); forest (558 ha); prairie (643 ha); and wetland (1451 ha). The refuge currently harbors one of three extant populations of massasauga in Missouri (Johnson, 2000), with the main wet prairie (380 ha) in the center of the refuge supporting the largest portion of the population.

The study site encompassed a 16.6 ha portion of wet prairie located in the north-central portion of the refuge. This area, which is surrounded by agricultural fields, prairie, wetlands and bottomland forest, is characterized by saturated soil and is managed for native warm season grasses including Indian grass (*Sorghastrum nutans*), switch grass (*Panicum virgatum*), big bluestem (*Andropogon gerardi*) and eastern gamma grass (*Tripsacum dactyloides*). Reed canary grass (*Phalaris arundinacea*), dogwood (*Cornus* sp.) and honey locust (*Gleditsia triacanthos*) were encroaching on the site.

The 59.7 ha control site was adjacent to the south and west sides of the study site. This area is similar to the study site in vegetative structure but is dominated by reed canary grass, river bulrush (*Scirpus fluviatilis*) and smartweed (*Polygonum* sp.).

**Capturing snakes.**—Massasaugas were captured on the study site using 41 drift fences, patterned after Fitch (1960), arranged in a grid with 1 fence/2.47 ha. Each 0.6 m \( \times \) 7.3 m fence was constructed from 1.3 cm plywood and held in place by four 2.5 \( \times \) 5 \( \times \) 60 cm wood stakes hammered into the soil and attached to the plywood with screws. One funnel trap, constructed from 6 mm mesh size hardware cloth, was placed at either end of individual fences. The bottom of all fences was flush or slightly below the surface of the soil to prevent snakes from crawling under the fence. Trapping took place 4–5 d per week during the period of 4 April through 27 June 2003. Traps were checked daily, typically late morning, and twice daily when temperatures exceeded 32 C. Vegetation was placed over the traps to provide shade and reduce heat stress/mortality.

**Radiomarking snakes.**—Radio telemetry was used to monitor snake movement immediately prior, during and after mowing and burning and as part of a larger study evaluating the spatial ecology of this species on SCNWR. I removed captured snakes from traps and held them in captivity for 1–5 d following capture until they could be surgically implanted with a transmitter. I anesthetized snakes using isoflurane gas delivered through a medical
anesthesia machine and implanted cylindrical, 9 g transmitters (model SI-2, Holohil Systems, Inc., Carp, Ontario, Canada) using techniques similar to those described by Reinert and Cundall (1982) and Hardy and Greene (1999). Implanted transmitters never exceeded 5% of snake body mass. Incisions made for introducing the transmitter were sutured using 3.0 Polldioxanone (Vedco, St. Joseph, Missouri, USA). Enroflaxin (10 mg/kg) was intramuscularly injected immediately after completion of surgeries, followed by a subcutaneous injection (50 ml/kg) of 0.9% lactated Ringer’s solution to facilitate healing and reduce dehydration. Implantation surgeries were supervised by a licensed veterinarian and took place under sterile conditions in a small animal veterinary hospital surgery room. All individuals held in captivity were housed in cotton or nylon snake bags that were placed inside a ventilated 48-quart beverage cooler. Coolers were placed in a temperature controlled environment (~20 C) to reduce stress. Snakes were released at the point of capture 1 d following surgery.

Management treatments.—All drift fences and traps were removed from the study site on 28 June 2003 in preparation for mowing and burning. The entire site was mowed to a height of approximately 20 cm during the period 30 June through 1 July 2003 using a tractor and 4.6 m wide, bat-wing style, rotary mower. This height was chosen based on recommendations by Johnson et al. (2000:24) who suggested that mowing at heights greater than 10–15 cm will “... miss most massasaugas and other snakes.”

The controlled burn took place on 9 July 2003, 8 d post-mowing, and followed protocol within the refuge fire management plan (Speer, 2001). Although backing fires are the most effective firing pattern for maximizing woody mortality, safety and access considerations dictated the use of a combination of backing (25%), flanking (25%) and head (50%) fire to achieve a safe and effective burn.

Monitoring management impacts to snakes.—Radiomarked snakes located on the study site were monitored immediately before, during and immediately after mowing and burning, while radiomarked snakes located on the control site were monitored within 1 d prior to and after mowing and burning. Additionally, the burned area was searched by three refuge staff members immediately after completion of the burn. This search consisted of looking for dead or injured snakes while walking the entire burn area on 10 m wide grid intervals. The number and general location of injured or dead massasaugas was recorded during this search effort.

RESULTS

I captured and radiomarked 14 adult massasaugas (eight males and six females) during 2291 trap days of effort. No mortalities occurred during capture, handling, radio marking or transport. The last snake was radiomarked on 26 June, 2003, 4 d prior to the mowing treatment. Immediately prior to mowing there were seven radiomarked snakes (three males and four females) on the study site and seven radiomarked snakes, five males and two females, on the control site. Two mortalities, one male and one female, occurred during the first day of mowing. The female was crushed by a tractor tire and the male was killed by contact with the mower blades. An additional female mortality due to contact with mower blades was documented on the third day of mowing. This individual appeared to have been cut by the mower blades the previous day. One day after mowing a fourth individual, male, was depredated in the mowed area. This depredation was attributed to a raptor.

Seven days after mowing, the three remaining radiomarked snakes, one male and two females, were still within the mowed area. All three were located on the east half of the unit. Due to the location of these individuals and the high direct mortality rate (N = 3, 43%)
attributed to mowing the decision was made to only burn the east half of the unit (8 ha) in order to reduce potential mortality of any non-radiomarked massasaugas that may have been present on the site. This allowed assessment of the effect of the prescribed fire on the radiomarked snakes while reducing the total area affected and potential mortality of snakes present in the west half of the unit. In order to further reduce potential mortality of this rare species, one of the radiomarked females (#53271064) was captured, her capture location was marked using GPS, and she was temporarily moved to the holding facility at the refuge headquarters. This individual was returned to the capture site the following day and survived through hibernation in mid-October.

The controlled burn took approximately 2 h to complete and burned 100% of the east portion of the study site. The depth of the burn was patchy and varied across the burn site from a complete burn down to mineral soil to an incomplete burn leaving 1–5 cm of scorched litter. A post-fire inspection revealed that a majority of the standing woody vegetation was scorched or burned down to the soil surface by the fire.

Immediately after the fire both of the remaining radiomarked snakes, one male and one female, were located in crayfish burrows and could not be seen. During the transect search, which required 2 h to complete, refuge staff located three dead, unmarked massasaugas, that appeared to have died during the fire. No other snake species were located. One day post-burn, the radiomarked female that had been located in a crayfish burrow was found dead, although it had no apparent external injuries from the fire. The remaining radiomarked male was also located on the site 1 day post-burn and appeared to be unharmed. This individual was located on the control site 7 d after the burn and survived through hibernation in mid-October. The seven radiomarked snakes on the control site did not incur any injury or mortality during the mowing or burning treatments and all of them survived through hibernation in mid-October.

**Discussion**

Although the number of radiomarked snakes monitored was relatively small, the large proportion of eastern massasaugas injured and killed as a direct result of management activities is noteworthy. Four sources of mortality were identified during this study: direct mortality due to contact with mowing blades, crushing under implement tires, indirect mortality via avian predation associated with removal of cover and attraction of avian predators, and direct mortality attributed to burning. Each of these sources merits discussion.

The direct mortality of three (43%) of seven radiomarked snakes was higher than expected based on the premise that mowing at heights greater than 10–15 cm would prevent most snake mortality due to mowing (Johnson *et al.*, 2000). Since massasaugas are typically found on or within a few centimeters of the ground during the hot summer months (Durbian, unpubl. data) these mortalities suggest that massasaugas were likely subject to the slight vacuum that this type of mower can produce. Future mowing efforts on sites inhabited by massasaugas or other small snake species should include the use of alternative mower types, such as sickle bar or disk mowers, which do not create a vacuum during use. Mortality due to crushing under implement tires is likely a low probability event that was observed by chance. Nonetheless, using mowing implements with the widest wheel base possible will reduce the number of passes necessary to complete mowing and lower the probability of this mortality type. The single indirect mortality due to predation was not anticipated as 20 cm of residual cover remained on the site after mowing. The disturbance of mowing, which typically attracts avian predators, probably increased this individual’s vulnerability to predation. The controlled burn resulted in the mortality of one (50%) of the two
radiomarked snakes that remained on the site during the burn. Both of these snakes were located in crayfish burrows immediately after the burn. When these individuals were observed the following day neither of them exhibited any apparent burn marks suggesting that both of them were either already below ground or located crayfish burrows prior to the passage of fire. Although no autopsy was conducted, female #52525302 may have suffered fatal internal injuries due to the inhalation of hot or toxic gases produced by the fire.

The high mortality rate (50%) of radiomarked individuals on the burn site plus the mortality of three unmarked individuals located during the transect search demonstrates that a number of massasaugas did not leave the site after mowing as hypothesized by Durbian (2004). I have no estimate of the number of unmarked snakes that may have been present on the site and sought refuge under ground although the presence of snakes after mowing suggests that enough residual vegetation was left on the site to provide patches of cover containing suitable micro-climates.

Even if the previously described overall mortality of 5 (71%) out of seven individuals occurred due to chance, the results of these treatments are not acceptable in light of the potential sensitivity of change in adult survival relative to population viability. Using population viability analysis (PVA) and data from the SCNWR massasauga population, Seigel and Sheil (1998) suggested that annual adult mortality rates greater than 22%, combined with an average neonate mortality rate of 80%, may result in increased extinction rates for small populations of this species. Although caution must be exercised when interpreting PVA results it is important to note that population demography, especially density estimates, is not understood for a majority of existing populations (Johnson et al., 2000), most of which are considered fragmented and relatively small, therefore making it important to keep mortality due to management actions at a minimum.

This study suggests that mowing prior to burning results in additional mortality beyond that incurred by prescribed burning. Managers should use other means (e.g., chemical treatments) to control woody vegetation and conduct most burns while massasaugas are hibernating until methods that effectively reduce mortality while achieving the treatment objective are identified. Post-mowing depredation should also be taken into consideration prior to initiating this type of management action.

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LITERATURE CITED


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