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Case Study

Informational signage increases awareness of a rattlesnake in a Canadian urban park system

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Abstract: Human–snake conflict results in negative outcomes for people and snakes, and if left unmanaged, could undermine conservation efforts. One approach to managing conflict between people and snakes is to use signage to inform members of the public on the presence of venomous snakes and measures to prevent snakebites. To be an effective tool, however, signs must first be noticed, then read and understood by the target audience. As part of conservation efforts targeting eastern massasauga rattlesnakes (*Sistrurus catenatus*) in southwestern Ontario, Canada, we tested the effectiveness of signage at increasing awareness of its presence, status and threats, and snakebite prevention. We installed 6 informational signs at trailheads in a park occupied by massasaugas and conducted a random questionnaire survey of visitors during a 3-week period before (n = 51) and after (n = 54) sign installation. Awareness of the presence of massasauga habitat increased significantly after sign installation, whereas awareness of status, threats, and snakebite prevention methods did not change. Our results suggest that informational signs were effective, to some degree, at short-term information sharing with recreationists in the context of venomous snake conservation. This cost-effective approach warrants consideration as part of an overall strategy to mitigate human–snake conflict.

Key words: human–rattlesnake conflict, pit viper, public outreach, snakebite, venomous

The potential for human–snake conflict (HSC) is high where venomous snakes persist in close proximity to humans (e.g., in urban or suburban park systems). These conflicts can result in undesirable outcomes for people, pets, and snakes, including: snakebites (Sing et al.1994, Andrus 2010), snake death or injury (Shine and Koenig 2001, Ontario Ministry of Natural Resources and Forestry [OMNRF] 2016), ineffective snake translocations (Nowak et al. 2002, Brown et al. 2009), or simply "nuisance" encounters (Sealy 1997, Shine and Koenig 2001). Furthermore, human perceptions of snakes (e.g., fear, perceived risk of snakebite, etc.) can influence the rate of HSC; people with negative, fearful, ignorant, or ambivalent views toward snakes are more likely to want to harm or kill them (Pandey et al. 2016), which in turn increases the risk of snakebites (Pandey 2015). If left unmanaged, HSC could undermine conservation efforts targeting endangered species, particularly when such incidents attract sensationalistic media attention (Hayes and Mackessy 2010).

Greater knowledge of biology and behavior and less belief in myths are associated with positive attitudes toward controversial animals (bats: Prokop et al. 2009; snakes: Liordos et al. 2018); therefore, providing people with factual information on snakes may reduce HSC. Information sharing has been used as an indirect means to mitigate human–wildlife conflict in general (e.g., Treves et al. 2009) and HSC more specifically (e.g., Gramza and Temple 2010) and has been recommended to mitigate HSC with rattlesnakes in particular (Sullivan et al. 2014, Corbit 2015). In a park setting, information sharing with recreationists can be achieved cost-effectively via the use of informational signage (Winter and Cialdini

1998). In the case of HSC mitigation, signage could be used to present park users with information about snakes and encourage behaviors that would minimize the likelihood of HSC situations.

The elaboration likelihood model presents 2 potential pathways of persuasion from signage, direct messages and periphery messages (Van Lange et al. 2011). Direct messages influence behavior via sign evaluation, reading, and critical thinking about the messages presented therein (O'Keefe 2008). Periphery messages, in contrast, influence behavior via judgment or perception of the periphery variables of the sign (e.g., logos or design) as opposed to elaborate evaluation of the messages presented therein. Some people are persuaded by a sign's messaging while others are influenced by the credibility or authority the signage portrays. Regardless, to be an effective tool to mitigate HSC, signs must first be noticed, then read and understood, and accepted by the target audience (Winter and Cialdini 1998). Questionnaire surveys are a commonly used tool to evaluate sign effectiveness (Ismail 2008, Ballantyne et al. 2011, Davis and Thompson 2011) and can be used to determine if information sharing (and by extension, a contribution to HSC mitigation) has occurred.

As part of a multifaceted recovery program targeting an urban population of endangered eastern massasauga rattlesnakes (*Sistrurus catenatus*; OMNRF 2016), and to address previous recommendations regarding mitigation of HSC (e.g., expanding outreach and education initiatives, offering short distance translocations, and installing snake barrier fencing [J. D. Choquette, Wildlife Preservation Canada, unpublished re-port]), we installed informational signage at a park occupied by the target species. Our goal was to evaluate whether signage installed at major trailheads was effective at increasing the awareness of: (1) the species' presence, (2) the conservation and legal status of the species, (3) the major threats to the species, and (4) proper snakebite prevention and response. If the signage was effective, then awareness of the species' presence, its conservation and legal status, major threats to the species, and proper snakebite prevention methods would all increase among members of the target population after installation. We also sought to estimate level of support for massasauga recovery efforts.

Study area and species

Our study was conducted at the Ojibway Prairie Complex and Greater Park Ecosystem (OPCGPE), a 24-km^2 area in the city of Windsor and town of Lasalle, Ontario, Canada, which contains an urban park complex and supports a remnant tallgrass prairie ecosystem (42.2570°N, -83.0670°W; Choquette and Hecnar 2016). The park system is fragmented by residential, agricultural, commercial, and industrial land uses as well as an extensive road network. The OPCGPE includes 8 distinct day use nature parks, each defined by a unique geographical boundary and name. This project took place between August and October 2016 at an ~90-ha park within the OPCGPE (the exact name and location of the park is omitted to protect the location of a species at risk). This park is mostly managed as a natural area, dominated by lowland deciduous forest with patches of upland forest, shrub thicket, savannah, old field, and tallgrass prairie vegetation types (Oldham 1983), and is bound by roads, residential dwellings, and agricultural land. Recreationists use the park's trail network for walking, running, and biking.

The park was chosen for our study because it was occupied by eastern massasaugas and there was no snake-related signage already in the park (note: massasauga-related signs were present in a separate park ~4.5 km away). Also, incidents of HSC were documented in and near the park over the previous decade. For example, 2 snakebites were reported in the local media (2009 and 2013), 2 rattlesnakes were confirmed killed in nearby residential yards (2006 and 2009), and massasaugas were encountered on trails by park users on at least 5 occasions from 2010 to 2016 (J. D. Choquette, Wildlife Preservation Canada, unpublished data).

The eastern massasauga is a stout-bodied rattlesnake with saddle-shaped blotches running the length of its grey or brown dorsum and is the only extant venomous snake species in the Canadian province of Ontario (OMNRF 2016). Across its North America range, the massasauga uses marshes, bogs, shorelines, forests, and tallgrass prairie (OMNRF 2016). In southwestern Ontario, the massasauga is

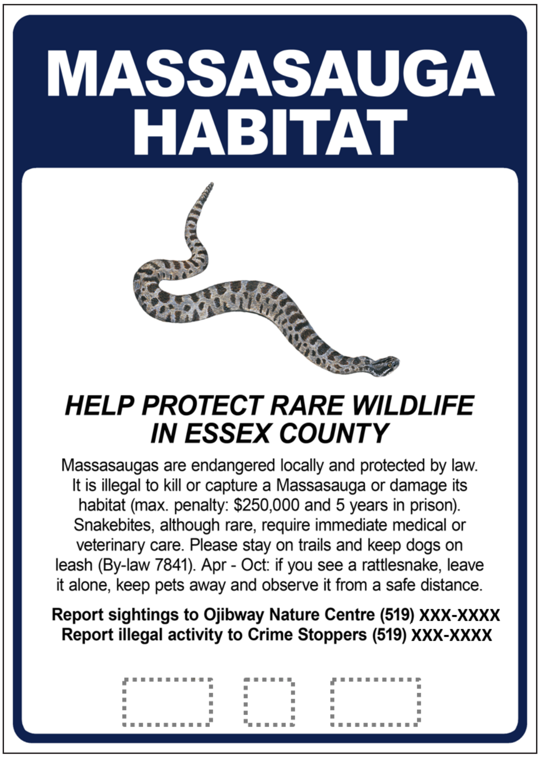

Figure 1. Massasauga rattlesnake (*Sistrurus catenatus*) informational sign installed in late August 2016 at 6 trailheads at the Ojibway Prairie Complex and Greater Park Ecosystem, Ontario, Canada. Phone numbers and 3 partner logos at the bottom of the sign have been removed from this figure (denoted by hatched polygons) but were included on the installed signs. Signs were printed with a navy blue border, black text, and grayscale snake. Signs were evaluated between August and October 2016.

active above ground from April to October and makes annual migrations between summer foraging habitat and hibernation sites in fall and spring (OMNRF 2016). During fall and winter, it hibernates in animal burrows, rock crevices, or tree root systems that provide access to moist but flood-free conditions below the frost line (Yagi et al. 2020). Pregnant females bask conspicuously at gestation sites from late spring to mid-summer and give birth to live young in August, which disperse away from their birthing site only to return to hibernate in the fall (Jellen and Kowalski 2007). Adult males generally make movements in search of mates from mid to late summer (Jellen et al. 2007). Risk of HSC with massasaugas is presumably greatest at our study area during spring and fall migrations and the summer mating/birthing period.

Methods

Informational sign messaging and installation

On August 26, 2016, we installed 1 aluminum 23 x 30-cm "Massasauga Habitat" informational sign (Figure 1) at each of 6 distinct locations in the park. Installation date was chosen to be within 2 days of a preplanned public information session on massasaugas. Sign messaging was selected based on information that a community stakeholder group believed to be relevant and important. The stakeholder group had been previously established to provide feedback on various massasauga recovery projects in the OPCGPE, was composed of representatives from 7 organizations (city of Windsor, Essex Region Conservation Authority, Ontario Ministry of Natural Resources and Forestry, Ontario Parks, Toronto Zoo, town of LaSalle, and Wildlife Preservation Canada), and provided comments on sign location, messaging, content, and design. Sign messaging included information related to presence of massasauga habitat in the park, conservation and legal status of massasaugas, snakebite prevention and first aid measures, and contact information for the local nature center (Figure 1). All signs were placed at trail heads, which were ideal for sign placement as they represented all major pedestrian entrance points to the park (Roggenbuck 1992, Bradford and McIntyre 2007). All signs were installed on the same day and were mounted to new or existing u-channel posts 1.5–1.8 m above grade. Total cost of new materials (i.e., signs, posts, and hardware), before tax, was ~$435 CDN.

Sample size and target population

To test short-term sign effectiveness, we conducted a random questionnaire survey of park users during a 3-week (21-day) period both before (n = 51) and after (n = 54) signs were installed (see supplemental materials). These surveys were conducted during the massasauga mating/birthing and fall migration periods. The "before" questionnaires were conducted immediately preceding sign installation (August 10–25, 2016), and the "after" questionnaires were conducted approximately 3 weeks post-installation (September 28 to October 16, 2016).

The target population was defined as all

Table 1. Target population size (N), sample size (n), and sample demographics from a park user questionnaire before and after installation of massasauga rattlesnake (*Sistrurus catenatus*) informational signs at the Ojibway Prairie Complex and Greater Park Ecosystem, Ontario, Canada. Signs were evaluated between August and October 2016. CI = confidence interval.

	"Before" period (95% CI)	"After" period (95% CI)
N	8,144 (4,704–11,584)	7,031 (4,082–9,979)
Male:Female sex ratio of "N"	4.5:5.5	4.7:5.3
n	51	54
Male:Female sex ratio of "n"	4.1:5.9	4.8:5.2
Average age of "n"	55	53
% Who live in the same municipality as the park	84	85
% Who have previously walked a dog at the park	45 (32–58)	50 (37–63)
% Who have visited the park with young children	57 (44–70)	67 (54–79)
% Who visit the park daily or weekly	86	87
% Who visit the park monthly or yearly	14	13

adults using the park during our study (August to October 2016), and target population size was estimated by conducting a park user count before and after sign installation (i.e., concurrently with the questionnaires). Three survey stations were situated geographically to intercept the majority of visitors entering the park from 6 major access points (i.e., each station intercepted visitors at 2 distinct entrances). During each count, all adult visitors entering the park were tallied using a hand counter (those who entered the park prior to the start were not counted). A count occurred at each station 8–9 times during both the "before" and "after" periods. Each count lasted 1 hour and took place on a random date, at a random time of day (within daylight hours), and at a random survey station. To estimate the number of visitors per hour at each survey station within a given survey period, data from each count were summed and averaged. The averages from each of the 3 stations were summed to provide an average number of visitors per hour for the entire park during each period. The target population size was then estimated by multiplying the average number of park visitors per hour by the number of daylight hours (14 hours before, 12 hours after) and again by the number of days in each study period (21 days).

The target population size of park users was slightly higher, but similar, during the "before" period ($N = 8{,}144$) when compared to the "after" period ($N = 7{,}031$; Table 1), and these estimates were used to determine confidence intervals around summed questionnaire responses. We did not account for park users that made repeat visits during either count period (which we know occurred); therefore, our target population size estimates more closely approximate the number of visits and are overestimates of the number of unique park users during either count period (perhaps by as much as 3.5 times, based on the estimated proportion of park users visiting daily, weekly, and monthly/annually from questionnaire data). Under a small population scenario such as ours, assuming a larger target population size than necessary will result in a more conservative assessment of significance due to inflated confidence intervals (Veal 2006).

We surveyed 2 samples of the target population of park users, which we deemed to be representative because: (1) sample sex ratios (Table 1) were similar to that of the target population (i.e., 4.5:5.5, based on park user count data), (2) the "before" and "after" groups were equivalent with respect to demographic variables (Table 1) and many key characteristics (see results section), (3) our random sampling approach targeted all major park entrances and times of day, allowing for equal opportunity for all park users to be included in the samples, and (4) the sample of questionnaires was proportionate to park visitation rates based on time of day (Table 2).

Table 2. Proportion of total visitors counted and total questionnaires completed within each survey sampling period before and after installation of massasauga rattlesnake (*Sistrurus catenatus*) informational signs at the Ojibway Prairie Complex and Greater Park Ecosystem, Ontario, Canada. Signs were evaluated between August and October 2016. Note the slight bias toward sampling evening visitors in the "before" period and early afternoon visitors in the "after" period.

Sampling period	% of visitors	% of questionnaires
Before (hours)		
0630–1000	0	0.06
1000–1330	0.32	0.35
1330–1700	0.10	0.10
1700–2030	0.39	0.49
After (hours)		
08:00–11:30	0.27	0.17
11:30–15:00	0.36	0.53
15:00–18:30	0.37	0.30

Questionnaire development and delivery

Questionnaires were conducted mostly by 2 surveyors, with 1 surveyor asking the questions and the other recording the respondents' answers by hand (in 19% of surveys only 1 surveyor was present to both ask questions and record responses). Seven different surveyors (male and female) were involved in the study, one of which was the lead surveyor (female) who conducted all surveys. The surveyor(s) stood at 1 of 3 previously chosen survey stations, which were situated to allow equal opportunity to intercept any given park user, regardless of point of entry. Survey stations were inside the park and 20, 60, and 200 m down the trail from the nearest sign. A questionnaire sampling period was ~3.5 hours in length and included 3 1-hour visits to each station. A single survey took an average of 10 minutes for a participant to complete. The first station visited as part of a sampling period was chosen at random (e.g., station 1), and the following stations were then visited in numerical sequence (e.g., station 2, station 3). Start time of each sampling period was randomly selected from a set of possible start times that included all daylight hours (Table 2). Each station was visited 9–10 times during both periods.

The "next to pass" method (Veal 2006) was used to solicit potential questionnaire respondents. While surveyors stood at a given station, each park user that passed was asked a brief introductory question ("Hello. Did you know this park is massasauga rattlesnake habitat?"), and their answers were recorded in the form of a simple tally. The lead surveyor then introduced herself and asked if the park user would be willing to participate in a brief questionnaire (when a couple or group arrived at the survey station, the questionnaire was conducted with 1 willing member of the party). During the "after" period only, each park user was also asked a second introductory question by the lead surveyor immediately after she introduced herself ("We are following up with park users after the recent installation of massasauga awareness signage in this park. Did you happen to notice the new signage?"), and answers were also recorded in the form of a tally. Only adult park users who provided verbal consent were allowed to proceed with the questionnaire. As necessary, potential respondents were asked if they were at least 18 years old before proceeding. Respondents were informed that the questionnaire was voluntary and that answers would remain anonymous.

In general, the questionnaire included questions about values toward nature, local snake diversity, conservation and legal statuses of local snakes, past and future encounters with local snakes, response to (and prevention of) snakebites, perceptions of safety, and massasauga recovery options. The "before" and "after" questionnaires consisted of 15 and 17 parent questions, respectively (5 included sub-questions), in addition to 5 demographic questions. Questions that related to income or completed education level were not included because of the possibility of response bias (Frick and Grabka 2005, Korinek et al. 2005, Chittleborough et al. 2008). Most questions were yes-or-no questions (n = 9–11), 5 questions were open-ended, and 1 question was Likert-based (scale of 1–5). Answers to open-ended questions were generally categorized on the spot (e.g., surveyor had a list of possible answers to circle). The questionnaire was designed so that more general questions were asked before more specific questions (to avoid the contrast effect), and the order of questions remained the same between survey periods (to reduce bias when tracking trends over time; Pew Research Centre, questionnaire design, www.pewresearch.org). The 2 new questions in the "after" questionnaire were placed near the end and related to whether the respondent read the new signs or participated in the "before" questionnaire.

Data analysis

Summary statistics were completed in Microsoft Excel. Confidence intervals (CI) for each answer proportion were calculated separately using estimated population size and sample size (Creative Research Systems, sample size calculator, www.surveysystem.com). Significant differences ($P < 0.05$) between before and after response proportions were evaluated using a nonparametric 2-sampled Whitney-Wilcoxon-Mann test (Mann-Whitney U test) because data were not normally distributed and the samples were assumed independent of each other (Whitlock and Schluter 2009). We used the "rcmdr" package in program R (v. 2.15.1) and selected the 2-sampled Wilcoxon test (nonparametric tests) from the statistics menu. For 2 yes-or-no questions, non-binary responses (e.g., "I don't know") were equated with "no" for the purposes of statistical analyses (Question 3: n = 9; Question 13d: n = 19; supplemental materials). Odds ratios and associated confidence intervals were calculated using an online calculator (Medcalc Software, odds ratio calculator, www.medcalc.org).

Results

During the "before" period, 104 potential respondents were introduced to the survey via the introduction question, and of these, 49% (n = 51) agreed to participate in the questionnaire. In the "after" period, 100 potential respondents participated in the first introduction question, 66% of whom answered the second introduction question, and 54% of whom agreed to participate in the questionnaire. Over half of potential respondents (59/100: 59 ± 9.6%) and questionnaire respondents (33/54: 61 ± 12.9%) in the "after" period answered "yes" when asked if they noticed the new signage. Fewer questionnaire respondents, however, also answered "yes" when asked if they had an opportunity to read the new signs (20/54: 37 ± 12.8%). Finally, only 2 respondents claimed to have completed both the "before" and "after" questionnaires; therefore, we are confident that the act of conducting the questionnaires and later answering respondents' questions in the "before" period had minimal influence on responses in the "after" period.

Sample demographics and other key characteristics of respondents were similar between periods (Table 1). Before and after sex ratio did not differ (n= 105, t = -0.71, df = 103; P = 0.48), and the majority of respondents in both periods were residents of the same municipality who frequently visit the park (Table 1). Both groups were supportive of protecting habitat (96% before; 98% after) and endangered species (94% before; 96% after). Half of respondents in both groups reported they or a family member encountered a snake in the park within the past year (53% before; 50% after), and just under half knew for over a year that the park was home to massasaugas (43% before; 47% after). Furthermore, both groups expressed a similar level of tolerance toward massasaugas in the park. For example, when asked who they would call for assistance if they encountered a rattlesnake in the park, most respondents said they would leave the snake alone (78% before; 76% after). Also, the majority of respondents in both groups felt "very safe" using the park knowing massasaugas are present (82% before; 96% after). Conversely, fewer respondents in the "after" group claimed that snake encounters in the park were "problematic" (12% before, 2% after; n = 105, W = 1,240.5, P = 0.04), a greater proportion of respondents

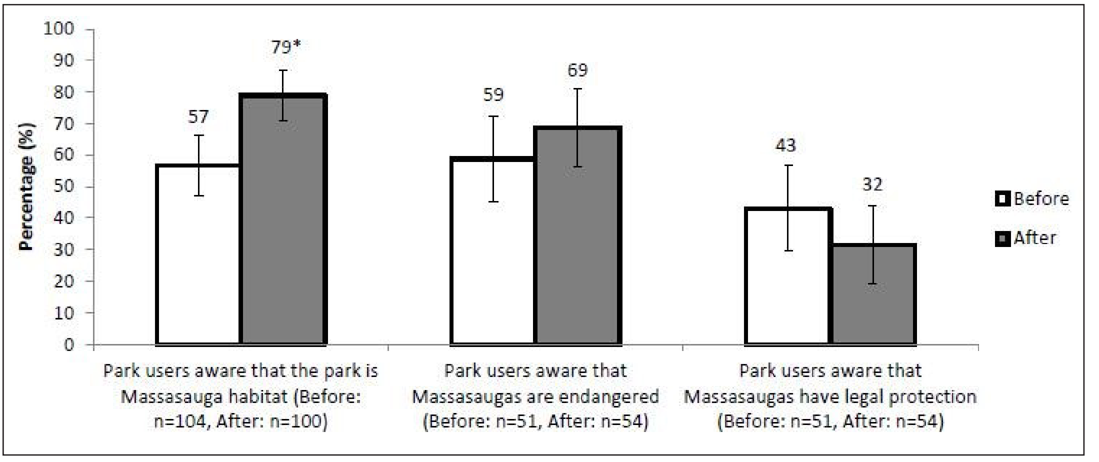

Figure 2. Awareness of massasauga rattlesnake (*Sistrurus catenatus*) presence, status, and legal protection among members of the target population, before and after sign installation, based on a questionnaire survey at the Ojibway Prairie Complex and Greater Park Ecosystem, Ontario, Canada. Number of respondents to each question is denoted by "n." Error bars denote 95% confidence interval. Asterisk (*) = significant difference ($P \leq 0.05$). Signs were evaluated between August and October 2016.

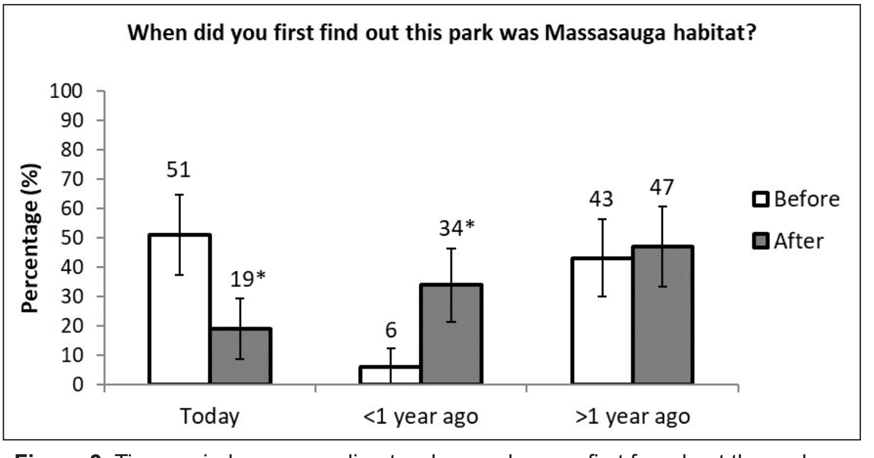

Figure 3. Time period corresponding to when park users first found out the park was massasauga rattlesnake (*Sistrurus catenatus*) habitat, before and after sign installation, based on a questionnaire survey at the Ojibway Prairie Complex and Greater Park Ecosystem, Ontario, Canada. Error bars denote 95% confidence interval. Sample size (n) before = 51 and after = 54. Asterisk (*) = significant difference ($P \leq 0.05$). Signs were evaluated between August and October 2016.

in the "after" group could correctly name one local snake species other than massasauga (51% before, 80% after; $n = 105$, $W = 1{,}771.5$, $P = 0.002$), and awareness that massasaugas were threatened by habitat loss/destruction was higher in the "after" group (57% before, 82% after; $n = 105$, $W = 1{,}716$, $P = 0.006$).

Awareness of massasaugas

Awareness that the park contained massasauga rattlesnake habitat significantly increased among park users by 22% after the signs were installed ($n = 204$, $W = 6{,}523$; $P \leq 0.001$; Figure 2). The proportion of respondents who said they found out the park was massasauga habitat on the day they completed the questionnaire (i.e., as a result of us informing them during the introduction question) significantly declined by 32% after signs were installed ($n = 105$, $W = 930$; $P \leq 0.001$), and the proportion of respondents who said they found out "less than a year ago" significantly increased by 28% after the signs were installed ($n = 105$, $W = 1{,}755$; $P \leq 0.001$; Figure 3). There was a strong positive associa-

Table 3. Response types provided by park users when asked what they could do to reduce the risk of massasauga rattlesnake (*Sistrurus catenatus*) bites to people and pets, before and after sign installation, based on a questionnaire survey at the Ojibway Prairie Complex and Greater Park Ecosystem, Ontario, Canada. Multiple responses were permitted. CI = 95% confidence interval. Signs were evaluated between August and October 2016. Based on the park user count data, a high proportion of dog walkers were already keeping their pets on a leash before sign installation (94%), and this rate remained high (89%) following sign installation.

Preventing snakebite to people				
	Stay on trails	Be aware	Avoid snakes	Other
% Before	59 (CI = 13.5)	35 (CI = 13.1)	22 (CI = 11.1)	18 (CI = 10.2)
% After	56 (CI = 13.2)	20 (CI = 10.7)	35 (CI = 11.3)	15 (CI = 9.8)
Preventing snakebite to pets				
	Keep dog on leash	Avoid snakes	Stay on trails	Other
% Before	68 (CI = 19.1)	27 (CI = 19.1)	9 (CI = 12.0)	14 (CI = 17.2)
% After	67 (CI = 18.8)	17 (CI = 14.8)	25 (CI = 17.3)	4 (CI = 8.0)

tion between respondents in the "after" group who noticed the signs and were also aware of massasauga presence (n = 54, Z = 2.64, P = 0.008, OR = 50.92 [95% CI: 2.75, 941.41]). Also, the ability to name at least 1 other species of local snake was not associated with awareness of massasauga presence in the "after" period (n = 54, Z = 1.04, P = 0.30, OR = 2.31 [95% CI: 0.48, 11.26]), whereas this association did exist in the "before" period (n = 51, Z = 2.85, P = 0.004, OR = 5.79 [95% CI: 1.73, 19.34]). Further, awareness of habitat loss as a threat to massasaugas was not associated with awareness of massasauga presence in the "after" period (n = 54, Z = 0.31, P = 0.76, OR = 1.32 [95% CI: 0.23, 7.59]), nor was support for massasauga recovery (n = 54, Z = 1.22, P = 0.22, OR = 0.16 [95% CI: 0.01, 3.05]). Finally, 22% of respondents to the "after" questionnaire informed us directly that they found out the park contained massasauga habitat from the signs.

Awareness of massasauga status and threats

Prior to sign installation, over half of park users knew that massasaugas were endangered, while less than half knew the species was legally protected (Figure 2). Neither knowledge of conservation nor legal status changed among park users following sign installation (n = 105, W = 1,216.5, W = 1,510.5; P > 0.05). Similarly, awareness of 2 important threats to massasaugas living within the park (i.e., intentional killing and illegal collection) were relatively low (16% and 0%, respectively) and did not change after sign installation (n = 105, W = 1,263, W = 1,402.5; P > 0.05). We did find a weak positive association between respondents in the "after" group who read the sign and who were also aware that massasaugas had legal protection (n = 54, Z = 2.74, P = 0.006, OR = 5.70 [95% CI: 1.64, 19.84]), but this was not the case for endangered status (n = 54, P = 0.86).

Awareness of snakebite prevention and response

When asked how to avoid snakebites to people and pets while using the park, "stay on trails" and "keep dogs on leash" were the most common types of answers provided, respectively, before and after sign installation (Table 3). Although the 2 latter responses did reflect the recommended approaches for snakebite prevention included on the signs, neither increased in the "after" period. The majority of respondents knew to seek appropriate medical attention (i.e., call 911, veterinarian, etc.) in the event of snakebite to a person or a pet (78% and 96%, respectively), and this did not change in the "after" period (76% and 88%, respectively).

Support for massasauga recovery

The majority of park users were supportive of massasauga recovery initiatives (Yes: 65% before, 87% after; No: 26% before, 6% after; Unsure: 10% before, 7% after). Support level increased after signs were installed (n = 105, W = 1,684; P = 0.008); however, this could not be attributed to park users noticing (n = 54, Z = 0.23, P = 0.82, OR = 1.21 [95% CI: 0.24, 6.04]) or reading (n = 54, Z = 0.49, P = 0.62, OR = 1.55 [95% CI: 0.27, 8.86]) the signs and was likely due to a baseline difference between groups of respondents (i.e., respondents in the "after" group were more supportive of massasauga recovery). Support for specific massasauga recovery actions, however, was mixed and did not change after sign installation. Most respondents supported both the use of woody debris piles (78% before, 80% after) and the installation of massasauga awareness signs (94% before, 100% after). Fewer park users supported the use of barrier fencing to prevent snakes from entering roadways and residential areas (49% before, 52% after) or the release of captive-bred massasaugas to augment the population (35% before, 52% after; n = 105, W = 1,605; P = 0.09).

Discussion

Signage effectiveness at information sharing

During our study, approximately 50–75% of the target population noticed the signs, confirming that these were effectively placed to be seen by most park users. A smaller proportion, however, actually read the signs (25–50% of park users), suggesting that the full suite of messaging was understood by only a minority of park users. Combined, these results suggest that we could only expect signs to be partially effective at facilitating information sharing with park users. The fact that we observed increased awareness in some endpoints (e.g., awareness of massasauga presence) but not others (e.g., knowledge of massasauga conservation status) supports this notion.

One likely explanation for partial information sharing is that we included too much information on our signs to be processed during a single viewing. The average time spent examining messaging on a sign is 3–10 seconds (McCool and Cole 2000), and as the number of messages on a sign increases there is a decrease in message retention and attention to individual messages (Cole et al. 1997). By comparison, our signs contain ~9 messages and take ~30 seconds to read in full. The first message, however, is in the largest print size and takes only ~3 seconds to read (i.e., "Massasauga Habitat" and snake picture; Figure 1) and is therefore most likely associated with the change we observed. Accordingly, awareness of the presence of massasauga habitat in our study park increased among park users after sign installation.

Conversely, our attempt to increase awareness of massasauga status, threats (intentional killing and illegal collection), and snakebite prevention and treatment through the signs were ineffective likely due to sign design. These messages were all written in the smallest font in a single paragraph at the center of the signs (Figure 1), in such a way that a park user would have had to stop and read all the text for ~30 seconds. Supporting this idea is the association found between respondents who said they actually read the sign and awareness that massasaugas had legal protection. Since less than half of respondents actually read the signs, it is logical to presume the messages in the smallest font were generally not read, and therefore the information was not conveyed to park users.

Another possible explanation for the lack of increased awareness, in particular with regard to the legal status of massasaugas, is that the type of messaging we used was ineffective. Our signs included prohibitive messages regarding illegal actions toward massasaugas and their habitat (Figure 1). This type of messaging is not as influential as behavioral and attribution type messages that target a person's beliefs or values to influence behavior (Widner-Ward and Roggenbuck 2000, 2003; Bradford and McIntyre 2007). Furthermore, information on rules and regulations may be of little interest to recreationalists (Chavez and Mainieri 1995, as cited by Winter and Cialdini 1998).

Awareness of venomous snake presence

The difference we observed in park user awareness of massasaugas after sign installation could have been due to respondents in the "after" period being more knowledgeable of local snakes or more supportive of massasauga recovery and therefore more aware of massasauga presence. For example, a greater number of respondents in the "after" group could correctly name 1 local snake species (other than massasaugas), were aware that massasaugas were threatened by habitat loss/destruction, and supported massasauga recovery. If increased snake knowledge or support for recovery among respondents in the "after" group explained the relatively higher proportion that were aware of massasauga presence, we would have expected a strong positive association between these factors and massasauga awareness, which was not the case. An association between snake knowledge (i.e., the ability to name at least 1 local snake species) and awareness of massasauga presence was observed in the "before" period, not the "after" period, which is what we would expect if it were the signs (as opposed to prior knowledge of snakes) that largely influenced massasauga awareness.

Increasing awareness of the presence of venomous snakes is an important first step toward reducing HSC in a park setting. Christoffel (2007) found that individuals in Michigan, USA, who believed they were living in areas with rattlesnakes expressed more positive attitudes toward both non-venomous snakes and rattlesnakes than respondents who thought rattlesnakes were absent from the area or were unsure of their presence. The suggestion by Christoffel (2007) was that people who live in proximity to rattlesnakes might acclimatize to rattlesnake presence, and/or rare encounters with rattlesnakes result in reduced risk perceptions. Furthermore, when provided alongside safety information, knowledge of venomous snakes could influence park users to take proper precautions to prevent snakebite, such as: (1) keeping pets on a leash, (2) using designated trails, (3) wearing appropriate footwear and clothing when recreating off trail, and (4) avoiding the capture or handling of snakes. Our results suggest that informational signs in a day-use park setting were an effective and low-cost method to raise awareness of pit viper presence among park users and are therefore an important component of HSC management locally.

There is an inherent risk associated with "advertising" the location of a legally protected species to the public. In the case of venomous snakes, the location may be targeted by enthusiasts for illegal collection, or by "public safety" advocates for illegal snake culls. Under such circumstances, the management instinct is to favor strict secrecy with regard to public dissemination of location information. Within the context of a declining and endangered urban population of pit vipers, however—a population that will require intensive management and associated public support in order to be recovered (OMNRF 2016)—transparency surrounding local presence of the species and proposed recovery actions is justified. Furthermore, secrecy coupled with ongoing declines and less frequent encounters with the species may lead to a rapid erosion of local ecological knowledge (e.g., Turvey et al. 2010), along with the resulting loss of potential conservation advocates and stewards. In our study area, the combination of high levels of awareness of snakebite prevention and treatment, heightened tolerance for sharing a park with a venomous species, and strong feelings of safety among park users, coupled with increased awareness of massasauga presence and elevated levels of support for recovery, suggests an ideal social context for massasauga recovery.

Implications of small sample size and non-response

Our questionnaires were conducted within a very short timeframe before and after sign installation (10 weeks total). The reason for this was to reduce the likelihood that any changes observed in park user awareness or knowledge levels were influenced by factors other than the signs (i.e., news media stories, other outreach, etc.). However, this imposed an important limitation on our study with regard to our small sample size. We only sampled ~1.3–4.7% of park users in each period for the introduction questions (average *n* of 102) and ~0.7–2.5% of park users in each period for the full questionnaires (average *n* of 53; Table 1; methods section). Although there is no ideal sample size proportion, so long as proper sampling procedures are followed (Veal 2006), our small sample size limited our ability to detect differences between samples due to wide confidence intervals (e.g., many confidence intervals were 10–13%; 420 questionnaires would have been required to reduce these by half: [Veal 2006]). Furthermore, smaller sample sizes have less chance of being representative of the population (Veal 2006), and our 2 samples did show slight differences (e.g., the "after" group was more supportive of massasauga recovery, more knowledgeable of local snakes and threats to massasaugas, and less likely to find snake encounters problematic). Regardless, there were many similarities between the groups, and the slight bias we detected did not appear to influence awareness of massasauga presence.

During "before" and "after" periods combined, 95% of park users we approached (204/215) answered the first introduction question, whereas only 49% (105/215) completed a questionnaire. While non-response to the introduction question was low (i.e., only 11 people did not respond), it was substantially higher to the questionnaire itself (i.e., 99 of the 204 people talked to declined the questionnaire). Low response rates generate concern that results are affected by non-response bias (i.e., when answers provided by respondents differ significantly from answers that would have been provided by non-respondents; Barclay et al. 2002). In such cases, results would not be representative of the total population of park users, but biased toward the sample group. Some park users declined to complete the questionnaire if they were too busy/running/biking (63%; 12/19 reasons recorded), if they previously completed a questionnaire in the park or at their residence (n = 5), or if they did not speak English well (n = 2). However, in most cases (n = 80), reason for non-response was not recorded. During the "before" and "after" periods combined, park users other than walkers (cyclists, runners, etc.) made up a sizeable proportion of adult park users tallied (37%; 165/447; 45% before and 30% after), and it is likely to presume, then, that many park users were missed (i.e., non-responders) due to their being too busy or focused on their physical activity to stop for long enough to complete a questionnaire. We do not think transportation mode would have skewed our results with regard to attitudes toward nature or snakes (e.g., see Thomas and Walker 2015), and anecdotally, non-respondents had a wide range of viewpoints and knowledge levels. It is possible, however, that people moving fast through the park were less likely to notice or read the signs, and if that were the case, then our results would be more attributable to park users walking along the trails than those running or cycling. By extension, massasauga awareness may not have increased similarly among runners and cyclists.

Management implications

As part of an overall strategy to mitigate human–snake conflict, managers elsewhere could benefit from this cost-effective approach to increase awareness of venomous snake presence in an urban park setting. Development of informational signs ought to involve careful consideration of number of messages, readability (i.e., font size and read time), and message type. It is also important to examine if and how messages are conveyed to the target audience to assess sign effectiveness at information sharing and update signs as required. We recommend keeping information short and concise (e.g., 1–3 important messages) so that park users can read the sign in only a few seconds, rather than presenting them with excessive amounts of information. For example, our results suggest the paragraph of text in the smallest font in the middle of our signs (Figure 1) provided no measurable added benefit in terms of increasing park user awareness. We suspect, therefore, that conservation or safety messages (i.e., in addition to snake awareness messaging) may be conveyed if presented in 1–2 sentences of large, clear text. Finally, we caution that managers strongly weigh the perceived benefits of signs against the potential costs associated with increased awareness of venomous snakes prior to proceeding.

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Supplemental materials

The "before" and "after" questionnaires can be downloaded as a supplemental files at https://digitalcommons.usu.edu/hwi/vol15/iss1/18.

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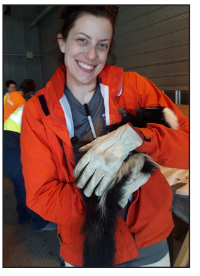

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