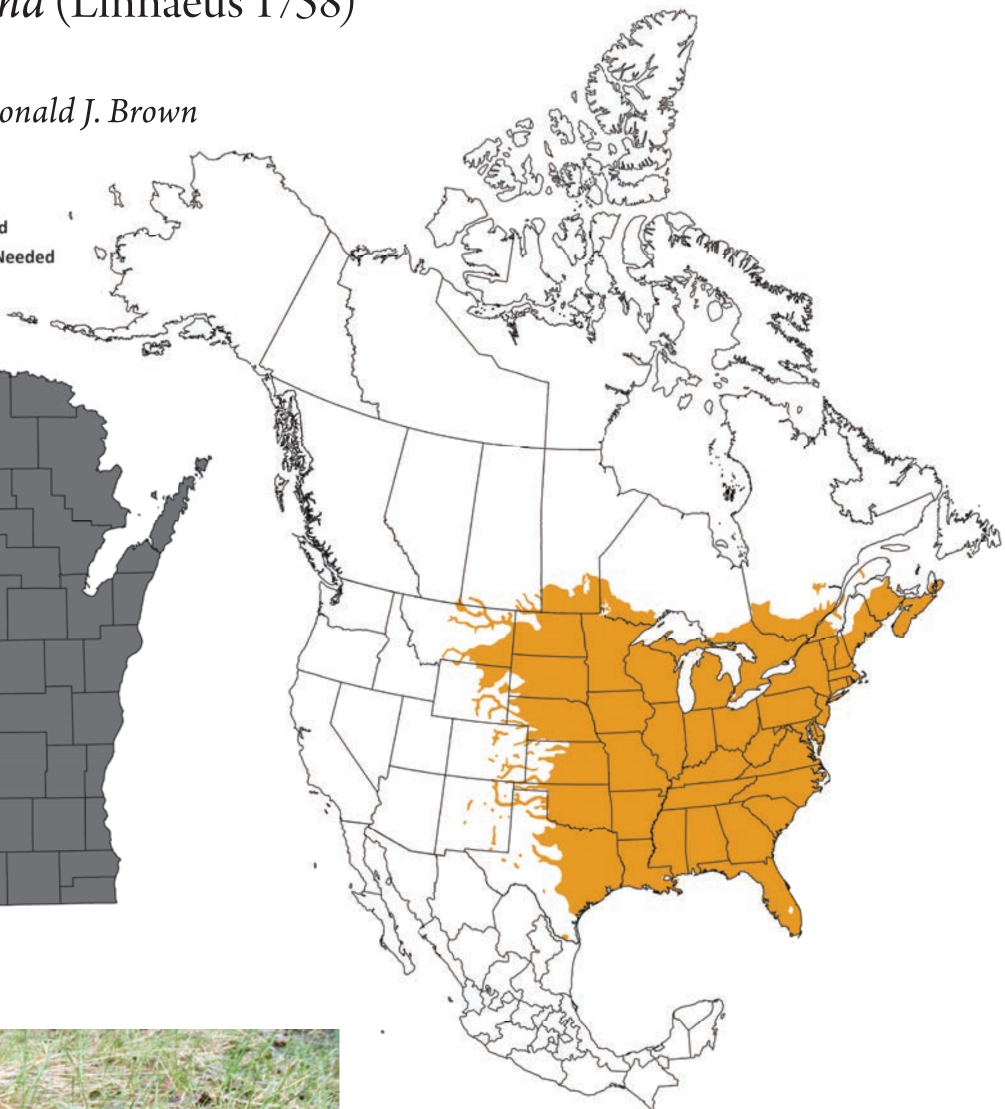
Snapping Turtle

Chelydra serpentina (Linnaeus 1758)

Deahn M. Donner and Donald J. Brown



Snapping Turtle (Oneida County; photo by D. Brown).

AT A GLANCE

Snapping Turtles are the largest turtles found in Wisconsin. They can be identified by their large body, wide head (with hooked upper jaw), long thick legs and tail, and brown, tan, or olive-green coloration. Mature males are larger than females. Snapping Turtles are omnivorous and consume a wide variety of food, including carrion. They are ambush predators and scavenge from all sections of the water column. This species can be found in most semipermanent and permanent waterbodies throughout Wisconsin but prefers slow-moving or still waterbodies with high turbidity and soft bottoms. They rarely leave the water and only occasionally bask above the surface to regulate their body temperature. Although they are highly aquatic, female Snapping Turtles can travel long distances over land to nest in early to mid-June. Nests are usually laid in loose sandy or loamy soil and can include anthropogenic habitats such as roadsides, railways, and dams. Hatchlings emerge from the nests in ca. three months. Adults are cantankerous when encountered on land or captured and will not hesitate to 'snap' at a perceived threat. Snapping Turtles are heavily exploited for consumption, educational purposes, and international trade. In response, the species was given CITES Appendix III protection in 2016, allowing for improved regulation of international trade by requiring international exporters to have a permit. The Snapping Turtle is currently listed as a Least Concern species by the IUCN and considered a common but declining species by the WDNR.

SYSTEMATICS

There are currently three accepted New World species in the genus *Chelydra*, although only *Chelydra serpentina* occurs naturally in the US (according to Ernst 2008). No subspecies of *C. serpentina* are currently recognized (Crother 2017). Historically, two North American subspecies were recognized: *Chelydra serpentina serpentina* (Eastern Snapping Turtle), the subspecies whose range covered most of the midwestern and eastern US, and *C. s. osceola* (Florida Snapping Turtle), whose range was restricted to the southeastern US. However, recent genetic work provided evidence against the use of subspecies, indicating that *C. serpentina* represented a "single, virtually invariant lineage" (Shaffer et al. 2008). This species was previously referred to as the Common Snapping Turtle due to its wide distribution, but 'Common' was dropped to avoid misperceptions related to abundance (Crother 2012).

DESCRIPTION

Adults: The carapace generally appears smooth in larger individuals but possesses three lengthwise keels (visible as scute knobs) that are obvious in smaller individuals (MCL <20.0 cm [7.9 in]; Figure 307). The posterior portion of the carapace is wider than the anterior portion, and the back edge is strongly serrated (Figure 308). The carapace of both sexes is brown, tan, or olive green to black, with light narrow lines between each scute (reviewed by Ernst and Lovich

Above, top: Figure 307. Adult Snapping Turtle showing typical coloration, a low lengthwise keel, and a moss-covered back (Polk County; photo by D. Donner).

Above, bottom: Figure 308. Adult Snapping Turtle showing its large head, strong posterior carapace serration, and long tail with elongated scales (Polk County; photo by D. Donner).

2009). Mud and algae are often present on the carapace, which can obscure the true color (Figure 309).

The plastron is yellowish to tan and diamond-shaped (Figure 310). The head, neck, and limbs are rough in appearance but mostly patternless, with occasional whitish flecks and thin black bars on the jaws (reviewed by Ernst and Lovich 2009). The head and limbs grade in color from gray or black at extremities to yellow or tan near the shell. The head is large, with a hooked upper jaw and barbels located on the chin (see Figures 308 and 309). Smooth round tubercles are also present on the dorsal side of the neck and limbs. The legs are large and powerful, and all four feet have webbed toes with long, strong claws. The tail is long (equal to or longer than the MCL), with three longitudinal rows of elongated scales on the dorsal surface (Figure 308).

Above, top: Figure 309. Adult Snapping Turtle with algae on its carapace and displaying its chin barbels (Walworth County; photo by N. Rudolph).

Above, bottom: Figure 310. Diamond-shaped plastron of the Snapping Turtle (Portage County; photo by J. Kapfer).

Knudsen (1956c) reported that large individuals in Wisconsin typically range from 46 to 61 cm CL (18 to 24 in) but can be as large as 71 cm CL (28 in). From 129 captured males along the St. Croix River in Wisconsin and Minnesota, mean MCL was 30.4 cm (12.0 in, range = 20.2–43.1 cm [8.0–17.0 in]), and mean PL was 21.9 cm (8.6 in, range = 9.9–33.3 cm [3.9–13.1 in]; DonnerWright et al. 1999). From 54 captured females along the St. Croix River in Wisconsin and Minnesota, mean MCL was 27.6 cm (10.9 in, range = 20.2–34.5 cm [8.0–13.6 in]), and mean PL was 20.4 cm (8.0 in, range = 12.1–25.8 cm [4.8–10.2 in]; DonnerWright et al. 1999). From the same study area, mean weight of males was 3.0 kg (6.7 lb, range = 0.8–7.8 kg [1.8–17.1 lb]), and mean weight of females was 2.1 kg (4.7 lb, range = 0.5–3.8 kg [1.0–8.4 lb]; Deahn Donner, USFS, unpublished data from the DonnerWright et al. [1999] study).

Preadult stages: Eggs are white and spherical, with leathery pliable shells (Figure 311). Fresh eggs have

Figure 311. Snapping Turtle eggs (Chippewa County; photo by R. Sajdak).

Figure 312. Hatchling Snapping Turtles. (a) Example showing the serrated posterior carapace and long tail (Polk County; photo by D. Donner). (b) Newly hatched individuals with yolk scars on their plastron (Rock County; photo by J. Kapfer).

a pinkish appearance on one end and a white appearance on the other end (Ernst and Lovich 2009). Ernst and Lovich (2009) reported that Snapping Turtle eggs range from 2.3 to 3.3 cm in diameter (0.9 to 1.3 in, $\bar{x} = 2.8$ cm [1.1 in]) and weigh 4.7–17.5 g (0.2–0.6 oz, $\bar{x} = 11.0$ g [0.4 oz], $n = 2{,}004$). From a collection of eggs in Wisconsin, egg diameter ranged from 2.3 to 3.2 cm (0.9 to 1.3 in, $\bar{x} = 2.7$ cm [1.1 in], $n = 84$ clutches), and mean weight of eggs was 10.6 g (0.4 oz, $n = 3{,}926$; Yntema 1970). Hatchlings are about the size of a nickel, and yolk scars are apparent on newly hatched individuals (Figure 312). Hatchlings and juveniles are similar in color to adults, but the three keels on the carapace are more prominent in younger age classes. As it is with adults, sex of hatchlings and juveniles can be determined by their pre-cloaca tail length (Ernst and Lovich 2009).

Variation: No significant geographic variation among Wisconsin individuals is known, although some sexual dimorphism occurs. Adult males reach larger sizes than females (Mosimann and Bider 1960, Hammer 1969, Froese and Burghardt 1975). The tail of adult females is thinner at the base than males, and the cloaca is beneath or just under the carapace rim, whereas in males the cloaca is posterior to the edge of the carapace (Ernst and Lovich 2009).

Diagnosis: Adult and juvenile Snapping Turtles are characterized by a carapace with serrated posterior margins that is covered with keratinized scutes and a narrow plastron that leaves the legs exposed. The body size and tail length of Snapping Turtles make adults easily identifiable among other turtle species found in Wisconsin. From a distance, juveniles and small adults might be confused with Eastern Musk Turtles (*Sternotherus odoratus*) or Wood Turtles (*Glyptemys insculpta*) because of coloration. However, these species are easily distinguished from Snapping Turtles by their carapaces, negating the need for physical handling to identify them. The carapace of Eastern Musk Turtles is highly domed with smooth marginal scutes, and the carapace of Wood Turtles contains raised concentric growth rings, resulting in pyramid-shaped interior scutes, in contrast to the three lengthwise keels in Snapping Turtles (see Figure 307).

Snapping Turtle eggs are spherical, like those of the softshells (*Apalone* spp.) found in Wisconsin (see Preadult stages subsection). Although this similarity in shape makes it difficult to differentiate the eggs of these three species, their eggs can generally be distinguished from the more elliptical eggs of other turtles in Wiconsin.

DISTRIBUTION AND HABITAT

Global distribution: Snapping Turtles range from Texas to southern Canada. The species is distributed throughout the eastern two-thirds of the United States, with the western edge of its distribution in central Montana. In addition, at least four isolated regions are currently occupied in the US and southern Canada, including a large stretch of the Rio Grande in New Mexico (reviewed by Ernst and Lovich 2009).

Distribution in Wisconsin: This species has been reported from every county in Wisconsin, although associated vouchers are missing or suspect for several counties (see the Appendix). For example, Vogt (1981) reported this species in Lincoln and Rusk Counties, but the only known specimens from these counties that existed in local natural history collections were eggs (Lincoln: UWZM 20760, Rusk: UWZM 23952). Because it is difficult to independently confirm species identification from eggs, collection of additional vouchers from these counties is desirable.

The voucher for Outagamie County (MPM VZP450; Casper 1996) is one of several photographs of an artistically modified turtle carapace collected by "J. Povlich" and adorned with a painting of a Flathead Catfish by George S. Bachay. On the underside of the carapace are the handwritten notes "7-4-88", "38 lbs," and "New London," and museum records include additional information ("trib. of Wolf R." with associated township and range). Another photographic specimen reportedly from Outagamie County also exists (MPM VZP451; Casper 1996), which is similarly modified (but with North American River Otters [*Lontra canadensis*] painted on the carapace). These photographic specimens are problematic as vouchers for various reasons. They rely heavily on the assumed accuracy of anecdotal reports and the recollection of associated collection information by a third party. This is exacerbated by the fact that the photograph vouchers do not show a whole (or even nearly whole) specimen in situ at the point of capture. Despite this, Snapping Turtles surely occur in Outagamie County, and new vouchers should be sought.

Localities of possible occurrence: Snapping Turtles are reported from every county in Wisconsin, although several current voucher specimens are missing or questionable (see Distribution in Wisconsin subsection).

Habitat: Snapping Turtles are a highly aquatic species and occupy many types of semipermanent and permanent waterbodies (e.g., Bodie et al. 2000, Swihart et al. 2006, Anthonysamy et al. 2014a; see Amphibians and Reptiles in Wisconsin Plant Communities chapter). In Wisconsin, this species frequently associates with slow-moving or still waterbodies, particularly those with high turbidity and soft bottoms (Vogt 1981, DonnerWright et al. 1999). Paterson et al. (2012) found that at the population level, Common Snapping Turtles showed no apparent preferences for specific aquatic habitat types in Ontario. However, individual variation in habitats used was detected, with some turtles showing a strong preference for marshes and swamps over flowing waterbodies. Similarly, Tucker et al. (2008) found that Snapping Turtles in the upper Mississippi River system used all surveyed habitats but were most frequently captured in stagnant backwater areas (i.e., 174 of 243 total Snapping Turtles captured). Primary productivity of aquatic systems does not appear to influence Snapping Turtle habitat use patterns (Brown et al. 1994), but more productive systems can support larger populations (Galbraith et al. 1988; see Populations subsection).

In Illinois, Snapping Turtles used microhabitats that possessed a broad range of characteristics (Anthonysamy et al. 2014a). Yet Paisley et al. (2009) studied a population in the Mississippi River adjacent to Wisconsin and Minnesota and found that individuals selected specific microhabitats with dense live aquatic vegetation. Braun and Phelps (2016) further found that Snapping Turtles preferred shallow (<1 m [3.3 ft]) slow-moving water with soft or silty substrates, as is often found in river tributaries of the middle Mississippi River. In addition, there appears to be an ontogenetic component to aquatic habitat selection, with hatchlings and juveniles showing stronger preferences for shallow and warm microhabitats than adults (Congdon et al. 1992, Bury et al. 2000). A laboratory experiment also concluded that juveniles preferred covered areas over open water during periods of darkness (Froese 1978). Thermoregulatory behavior does not appear to influence habitat selection in Snapping Turtles to the degree of many other aquatic turtle species. Although they do not bask frequently, individuals will sometimes rest on shorelines, logs, and floating vegetation in the water (Figure 313; see Activity section). Nests are typically located in areas with open tree canopies and

Above, top: Figure 313. Steep sandy bank where Snapping Turtles were observed basking close to the water's edge in the St. Croix River (Polk County; photo by D. Donner).

Above, bottom: Figure 314. Female Snapping Turtle nesting on the side of a road (Dane County; photo by J. Kapfer).

loose sandy or loamy soil (Punzo 1975, Thompson et al. 2017b). In Wisconsin, Mathiak (1966) reported Snapping Turtle eggs in muskrat houses throughout Horicon Marsh (Dodge County), and females will also use beaver lodges as nest sites (Ernst and Lovich 2009). Disturbed habitats such as roadsides, railways, and dams are also often used for nesting (Figure 314).

Snapping Turtles hibernate underwater or buried deep in soggy muck (Lagler 1943, Brown and Brooks 1994). Selection of overwintering habitat is primarily influenced by water temperature and oxygen level, with individuals selecting waterbodies that are cold but that do not freeze completely to both reduce energy use and possibly allow oxygen uptake (Brown and Brooks 1994, Paterson et al. 2012, Strain et al. 2012; see Activity section). Brown and Brooks (1994) identified three primary types of hibernacula used by Snapping Turtles in Ontario: in streams beneath logs and overhanging banks, in lakes beneath logs (but not buried in sediments) 5 m (16 ft) from shore, or buried deep in mud or beneath vegetation in "marshy areas" that froze but were not covered in water. Paterson et al. (2012) further noted that individuals hibernated in marshes, ponds, lakes, and creeks in Ontario. Paisley et al. (2009) found that most individuals hibernated under dense vegetation mats in backwater sloughs associated with the Mississippi River in Wisconsin and Minnesota. Abandoned North American Beaver (*Castor canadensis*) dens, Muskrat (*Ondatra zibethicus*) lodges, and submerged tree root systems are also favored spots for Snapping Turtle hibernacula (Mathiak 1966, Paisley et al. 2009, Strain et al. 2012).

Brown and Brooks (1994) documented 18 interyear recaptures at hibernacula, and 13 of these individuals showed fidelity for specific overwintering locations. Individuals moved underwater during the wintering hibernation period, with 95% of observations separated by <10 m (33 ft, maximum observed movement = 13 m [43 ft]). Less is known about the overwintering habitat of young age classes. However, Ultsch et al. (2007) found that hatchlings in New York successfully overwintered in "spring seeps," while hatchlings in New Hampshire overwintered in a shallow "wetland stream."

REPRODUCTION AND DEVELOPMENT

Mating in Wisconsin is most frequent in spring and autumn right before and after hibernation but can occur throughout the active period (Vogt 1981). Mating behavior was reviewed by Ernst and Lovich (2009), who stated that either the male will mount the female after a brief chase or the male and female will court each other by facing one another and repeatedly moving their heads back and forth. Often, the male will mount the female near the water surface, and then the pair will slowly sink to the bottom. During copulation, the male will grip the female's shell with its claws using all four feet and use his chin to press the female's snout down so that she cannot extend her neck forward while also extending his tail beneath the female to facilitate copulation (Hamilton 1940a). The male will sometimes grip the female's neck with his jaws. The female usually remains passive but may struggle if the male bites her. Sperm can remain viable in the female for several years, and multiple paternity has been detected in clutches of Snapping Turtle eggs (Galbraith et al. 1993). Reproductive physiology of Snapping Turtles has been the subject of much research in Wisconsin (e.g., Mahmoud et al. 1986, Mesner et al. 1993, Mahmoud et al. 2004).

In Wisconsin, females begin nesting migrations in May, with early to mid-June being the peak of the nesting season (see Natural History Box: Use of Camera Traps to Monitor Nesting Behaviors of Snapping Turtles in Wisconsin). Obbard and Brooks (1981) also reported that mid-June was the peak nesting period for Snapping Turtles in Ontario. Iverson et al. (1997) synthesized the Snapping Turtle nesting season literature and found that northern populations began nesting later than southern populations and that duration of the nesting season was variable among studies (ca. two to five weeks). Congdon et al. (1987) studied nesting activity of a Snapping Turtle population in Michigan and found substantial annual variation in both initiation of nesting activity (22 May to 12 June) and duration of nesting season (13–31 days). Congdon et al. (1987) further noted that cooler springs resulted in later initiation of nesting activity.

Female migration distances to nesting locations can be substantial. Maximum observed total migration distances (including in water and over land) range from 1.6 km (1.0 mi) in Michigan (Congdon et al. 1987) to 16 km (9.9 mi) in Ontario (Obbard and Brooks 1980). Maximum observed distances traveled over land during nesting migrations range from 183 m (600 ft) in Michigan (Congdon et al. 1987) to 500 m (1,640 ft) in Ontario (Obbard and Brooks 1980). Variability was observed in the likelihood that females will return to the same nesting sites in Michigan, where some nested within 5 m (16 ft) of previous nest locations and others nested up to 1,000 m (3,281 ft) from previous locations (Congdon et al. 1987). Loncke and Obbard (1977) reported that 34.3%–73.7% of tagged nesting females returned to the same nesting locations in subsequent years.

Nesting activity occurs primarily in the morning and evening hours in Wisconsin (Table 19). In Nebraska and South Dakota, 47% of nests were laid in the morning during a warmer than average June ($n = 36$), but only 20% of nests were laid in the morning during colder than average June temperatures ($n = 30$; Iverson et al. 1997). In Michigan, 60% of nests were laid by 11:00 a.m., and 27% were laid between 8:00 and 11:00 p.m. ($n = 70$; Congdon et al. 1987). The female digs the nest using her hind feet and may test several locations (see Natural History Box: Use of Camera Traps to Monitor Nesting Behaviors of Snapping Turtles in Wisconsin). Heinen (2014) recorded aggregated nesting by four adult Snapping Turtles in a marsh in Michigan. The size of nesting females ranged from ca. 26 to 33 cm MCL (10 to 13 in). Two females nested within 1 m (3.3 ft) of each other, while the other two were ca. 10–15 m (33–49 ft) apart. Nightly visits to the location suggested synchronized nesting behavior. Robinson and Bider (1988) also reported synchronized nesting in Quebec and obtained strong evidence that this behavior can increase overall nest success by decreasing probability of predation of individual nests.

Females deposit eggs in a bowl-shaped nest with a narrow opening that descends at an angle to a large egg chamber 7–20 cm (2.8–7.9 in) belowground (Ernst and Lovich 2009). Ernst and Lovich (2009) reported that clutches range from 4 to 109 eggs (typically 25–45, $\bar{x} = 35.2$, $n = 252$). Vogt (1981) considered ca. 25 eggs to be a typical clutch size in Wisconsin. Mathias (1966) investigated 70 Snapping Turtle egg clutches from muskrat houses in the Horicon Marsh (Dodge County) and reported that the mean clutch size was 44 but that the largest clutch observed included 85 eggs. Clutch size appears to increase with latitude, averaging 30–35 eggs in the northern parts of the turtle's range (Iverson et al. 1997). Larger females lay more eggs and have the greatest clutch mass, but typically only one clutch is produced each year (Iverson et al. 1997). Not all females oviposit annually (Ernst and Lovich 2009).

NATURAL HISTORY BOX: Use of Camera Traps to Monitor Nesting Behaviors of Snapping Turtles in Wisconsin

In 2015 and 2016 we monitored Snapping Turtle nesting activity at four sites across Florence and Marinette Counties using camera traps (Ltl Acorn Model 5210, Reconyx HyperFire HC600). Camera traps were deployed in both years by mid- to late May and programed to snap photographs once per minute from late afternoon (3:00 p.m.) to late morning (10:00 a.m.) through late June. The camera traps also recorded date, time, and air temperature with each photograph.

Most Snapping Turtles investigated nesting locations from early to mid-June, primarily in the morning (prior to 10:00 a.m.), when air temperatures were between 10°C and 21°C (50°F and 70°F). Snapping Turtles also spent substantial time on land exploring possible nesting locations prior to egg deposition, during which they employed several apparent methods for nest site assessment and selection. For example, as females meandered throughout a potential nesting area, they occasionally stopped to rest their chin or nose on the ground for brief periods (a poorly understood behavior referred to as “chin rubbing” and “sand sniffing” by Congdon et al. [2008a]). This was presumably a method used to assess soil surface temperature prior to digging. In addition, females employed what we describe as ‘plowing’ behavior, which appeared to assist in nest-site selection or perhaps facilitated digging the egg chamber by loosening the soil in the immediate vicinity first. This behavior typically began with the female pushing headfirst into the soil to upturn a small area of earth. These actions were repeated in several directions to expand the disturbed area so that it was slightly larger than the body of the turtle. During the process, some females would sometimes dig down farther into the upturned soil than others, either headfirst or feetfirst, which we presumed was to test subsurface soil conditions with their head or feet. Although it was possible to confuse nesting and plowing behaviors, we identified the latter by the general orientation of the turtle (i.e., a turtle headfirst in soil was obviously not nesting) and the duration of activity. Furthermore, we assumed that females were nesting when they backed into nests and slowly rocked back and forth as their hind legs removed soil for prolonged periods. In most instances, nesting females also ended activities by completely covering nests with soil, which was then smoothed with their plastrons (rather than simply walking away from disturbed soils, which they did at the end of plowing behavior that was not followed by nesting).

Plowing behaviors always occurred prior to nesting (if nesting followed), and often females plowed several locations per visit. The mean number of locations plowed per site visit by female Snapping Turtles was 2 (range = 1–3), regardless of whether they ultimately nested. Plowing events were shorter in duration than nesting, ranging from 2 to 87 min ($\bar{x} = 25.9$ min, $n = 16$). In several instances, cameras recorded complete bouts of actual nesting by female turtles. Bouts of nesting ranged from 111 to 152 min ($\bar{x} = 130.2$ min, $n = 5$, not including one instance where the camera shut off prematurely and another where the presence of people may have deterred normal nesting behavior; Table 19). We also observed that while assessing nesting locations, individuals frequently returned to a location they had previously plowed or investigated a location plowed by other turtles on a prior date. Although we could not be certain if the same individual or different individuals returned on these subsequent visits, this observation suggests that plowing behavior influenced future selection of nest sites. It is noteworthy that not all nesting Snapping Turtles appeared to undertake this behavior, although it could have been performed outside the camera’s field of view.

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Table 19. Detailed summary of nesting activity and associated behaviors exhibited by Snapping Turtles at sites in Florence and Marinette Counties.

Site, County	Date	Air Temperature, °C (°F)	Number of Locations Visited by Turtles	Duration of Plowing Behavior	Duration of Nesting	Comments
2, Florence	6/5/2015		1	16:00–16:12	No nesting observed	
2, Florence	6/18/2015	16.1–20.6 (61–69)	2	05:59–07:00	07:42–08:59[a]	Returned to plowed location from 6/5/2015
2, Florence	6/13/2016		2	06:11–06:46; 06:57–08:24	No nesting observed	
2, Florence	6/14/2016	13.3–17.2 (56–63)	3	06:18–06:21; 06:27–06:31; 06:32–07:41	07:42–09:45	Last location plowed on 6/14/2016 was also where nesting occurred and was the same location as the one plowed on 6/13/2016
2, Florence	6/16/2016	11.1–14.4 (52–58)	3	22:20–22:23; 22:37–22:42	Nesting unlikely	Backs in and digs as if nesting from 22:42 to 01:02, then appears to abandon nest; seen in water until 01:13 and then leaves; does not return
1, Marinette	6/5/2015	13.9–16.7 (57–62)	2	06:28–06:30	06:52–09:00	Second location was primarily nesting activity, which the turtle returned to after briefly leaving, and was also the site visited on the previous day by a Snapping Turtle
1, Marinette	6/11/2015	11.7–12.2 (53–54)	1	06:47–07:08	No nesting observed	
1, Marinette	6/12/2015	11.7 (53)	1	05:44–05:56	No nesting observed	
1, Marinette	6/20/2015	6.7–7.2 (44–45)	1	04:41–05:31	No nesting observed	Although an individual wandered the area from 04:09–04:29, it did not plow
1, Marinette	6/3/2016				No nesting observed	On 6/1/2016 and 6/3/2016 turtles entered the area on three occasions from 05:45–07:33, but no plowing or nesting was observed
1, Marinette	6/8/2016	10.6–15.6 (51–60)	1		20:57–23:29	
1, Marinette	6/10/2016	20.0–22.8 (68–73)	1		18:32–19:49	Possibly rushed due to a fisherman being nearby during nesting
1, Marinette	6/15/2016	14.4–19.4 (58–67)	1		06:36–08:27	
3, Florence	6/4/2016	12.8–13.9 (55–57)	2	05:12–05:41	05:51–08:14	Second location was nesting only
4, Florence	6/9/2015	20.6–21.7 (69–71)	2	07:37–07:41; 07:42–08:00	No nesting observed	

[a] Camera turned off before nesting was completed.

Snapping Turtles have temperature-dependent sex determination, with males produced at lower incubation temperatures (ca. ≤26°C [79°F]; Yntema 1979).

Vogt (1981) stated that in Wisconsin "the young emerge in the fall," and a multiyear research project from Michigan found that the average incubation period (from egg laying to hatching) was 93.2 days (Congdon et al. 1987). Vogt (1981) also reported that "overwintering may take place in the nest in some areas" in Wisconsin. Lovich et al. (2014) monitored turtle nest emergence patterns over a 20-year period in Pennsylvania and confirmed that Snapping Turtles can overwinter in the nest (known as a facultative nest emergence strategy). Specifically, they found that 27% of emergences occurred prior to winter (August and September), and 73% occurred the following spring (April and May, $n = 264$). The hatchlings that exhibited delayed emergence were significantly larger (CL) than those that emerged prior to winter. Lovich et al. (2014) reported that precipitation in August and September was positively correlated with the number of hatchlings that delayed emergence until the following spring. In Wisconsin, the extent to which individuals overwinter in the nest and the relationships between emergence strategy and weather patterns are currently unknown. Upon emergence, hatchlings apparently use visual cues and migrate toward open 'illuminated' horizons that may or may not be associated with waterbodies (Congdon et al. 2011a). For a detailed review of hatchling physiology and ecology, see Finkler and Kolbe (2008).

Snapping Turtle size (MCL), growth rates, and age at maturity vary geographically. Females in Nebraska and South Dakota were larger, matured earlier, and had faster growth rates than populations in northern latitudes such as Ontario (Iverson et al. 1997). In Ontario, hatchling growth was ca. 1 cm/yr (0.4 in/yr) from ages 1–3, and females matured at 11–13 years of age; males matured at 17–19 years of age (Galbraith et al. 1989). In Iowa, Christiansen and Burken (1979) reported similar growth rates between males and females until ca. 5 cm PL (2 in), after which point males grew faster than females. Males also matured earlier, at 4–5 years of age, and 14.9–15.5 cm PL (5.7–6.1 in, $n = 27$), compared to females, which matured at 6–7 years of age (or more) and 12.3–17.5 cm PL (4.8–6.9 in, $n = 38$; Christiansen and Burken 1979). In Quebec, males and females matured at 20–21 cm MCL (7.9–8.3 in) and ca. 15 cm PL (5.9 in), but the smallest mature male had a ca. 14–15 cm PL (5.5–5.9 in; Mosimann and Bider 1960). In Tennessee, White and Murphy (1973) reported that both males and females sexually matured at ca. 14.5 cm PL (5.7 in, $n = 28$ males and 25 females). In southeastern Michigan, females matured at 15.9–23.5 cm PL (6.3–9.3 in; Congdon et al. 1987). In Ontario, females showed ovarian follicle enlargement at an estimated 11–13 years of age, but mean age of first nesting was estimated at 17–19 years of age.

ACTIVITY

The active season in Wisconsin starts in mid-April (Vogt 1981) and is stimulated by increasing water temperature at hibernacula (Strain et al. 2012). Obbard and Brooks (1981) found that Snapping Turtles in Algonquin Park (Ontario) emerged from hibernation when water temperatures were 7.5°C (46°F). Mahmoud and Licht (1997) noted that Snapping Turtles in central Wisconsin were most active during the summer when water temperatures were 18°C–26°C (64°F–79°F). In a Minnesota lake, activity levels were highest in June (Schneider et al. 2019). In Ontario, Brown and Brooks (1993) reported seasonal and sexual variation in activity levels throughout the year. For example, they found that male activity was significantly higher than female activity shortly after emergence in May, which was explained by the tendency of males to move frequently while searching for mates. By June, female activity was similar to that of males and then exceeded male activity in July due to onset of the nesting season. Activity is primarily diurnal and greatest during crepuscular hours, although some nocturnal activity has been reported (Obbard and Brooks 1981, Smith and Iverson 2004, Ernst and Lovich 2009, Schneider et al. 2019).

Field and laboratory investigations of Snapping Turtle body temperature support that they actively regulate their body temperature either by selecting water of a desired temperature or (more rarely) by basking above the water level (reviewed by Spotila and Bell 2008). For example, Schuett and Gatten (1980) found that Snapping Turtles in the laboratory selected a preferred temperature ($\bar{x} = 28.1°C$ [82.6°F]) when offered a gradient of temperatures. Yet mean body temperature of active wild Snapping Turtles at various sites in Canada was lower than that recorded in laboratory investigations and ranged from 19.5°C to 22.7°C (67.1°F to 72.9°F; Brown et al. 1990, 1994). Past research supports that when active wild Snapping Turtles are not basking above the water, their body temperature does not vary greatly from water temperature (Punzo 1975), or it is similar to the coolest water temperature available (Brown et al. 1990).

Although basking can increase their body temperature, Snapping Turtles are not as frequently observed basking as other aquatic turtle species in Wisconsin. The possible explanations for this and the advantages of basking in certain situations but not others are complex (reviewed by Spotila and Bell 2008) and could be related to season, latitude, solar radiation, and maximum air temperature (Obbard and Brooks 1979, Obbard and Brooks 1981, Brown et al. 1994). Instead of basking above water, individuals often regulate body temperature while submerged just below the water surface, with only eyes and nostrils exposed to the air (Lagler 1943). Other turtle species, such as the Painted Turtle (*Chrysemys picta*), will sometimes bask on floating Snapping Turtles (Ernst and Lovich 2009). Based on laboratory investigations, Hutchinson et al. (1966) concluded that the mean critical thermal maximum (CTmax) of adult Snapping Turtles was 39.5°C (103.1°F).

Daily movements are likely limited outside of the mating and nesting seasons (see Reproduction and Development section). Snapping Turtles rarely swim in open water, instead usually opting to slowly walk along the bottom of a given aquatic habitat (Ernst and Lovich 2009). They spend much of their time in shallow water buried in mud, hiding beneath muskrat and beaver mounds, or resting below aquatic debris (e.g., stumps, roots, brush; Ernst and Lovich 2009, Paisley et al. 2009). However, Snapping Turtles can migrate several kilometers between their hibernacula and their summer home ranges (Brown and Brooks 1994, Haxton 2000b). In the Upper Midwest, Paisley et al. (2009) found that the average migration distance to hibernacula was 0.62 km (0.39 mi, range = 0.03–3.20 km [0.02–2.00 mi], $n = 103$ migration distances). Otten and VanDeWalle (2014) further documented strong homing ability in three displaced Snapping Turtles from Michigan, which moved ca. 2 km (1.2 mi) along a river from their released location back to their original capture locations.

Several studies have estimated home range sizes for Snapping Turtles in northern locations. Paisley et al. (2009) used radio telemetry to estimate home ranges on Pool 8 of the upper Mississippi River (adjacent to Minnesota and Wisconsin) from 1997 to 2001 ($n = 76$ females and 7 males). The overall mean home range size was 11.3 ha (27.9 ac) for females and 9.3 ha (23.0 ac) for males based on a Poly-Buff estimator and 32.3 ha (79.8 ac) for females and 18.3 ha (45.2 ac) for males based on an MCP estimator. Several additional studies have found variation in movement patterns by sex. In a marsh area of Lake Ontario, females traveled farther than males due to nesting activities (Pettit et al. 1995). Ryan et al. (2014b) studied movement patterns of 23 radio-tracked Snapping Turtles for two years in an urbanized canal in Indiana. They found that total range of movement (i.e., maximum distance between two relocation points) significantly differed between years for females only and that mean annual movement (i.e., distance between locations and number of movements) significantly differed between years for males only. In Lake Ontario, home ranges were typically larger for females ($\bar{x} = 8.5$ and 9.7 ha [21.0 and 24.0 ac], $n = 15$) than males ($\bar{x} = 2.3$ and 3.4 ha [5.7 and 8.4 ac], $n = 4$) over two study years (modified MCP estimator; Pettit et al. 1995). However, Obbard and Brooks (1981) reported that summer aquatic home ranges for a population in Algonquin Park (Ontario) did not significantly differ between sexes, with a mean home range size of 3.4 ha (8.5 ac, $n = 10$, modified MCP estimator). The variability in movement documented across these studies could indicate that movement patterns are influenced by the aquatic system a population inhabits (e.g., marsh vs. canal) and can vary annually.

Paisley et al. (2009) reported that Snapping Turtles in a Wisconsin population typically moved to hibernacula from mid-September to mid-October and entered hibernation in late October, which is reportedly triggered by decreasing water temperature (Strain et al. 2012). During hibernation, Snapping Turtles rarely (if ever) surface to breathe. Given the duration of the overwintering period (potentially four to six months in Wisconsin), these turtles face many challenges related to insufficient oxygen availability. Their physiological mechanisms to deal with low oxygen conditions are complicated, but we provide a cursory overview based on extensive reviews by Gatten (2008) and Ultsch and Reese (2008). Importantly, the metabolic (and, therefore, oxygen) demands of Snapping Turtles are reduced when they are submerged, regardless of water temperature. Snapping Turtle metabolic rates decline even farther when turtles are submerged in cold water during hibernation. While submerged, Snapping Turtles are capable of some oxygen uptake through the skin. As such, the simple act of selecting well-oxygenated aquatic locations as hibernacula (e.g., those with flowing water that do not freeze at the surface) can permit sufficient oxygen uptake across the skin to help meet lowered metabolic demands in winter. In an Ohio marsh system, for example, Meeks and Ultsch (1990) reported that Snapping Turtles moved to shallow water near mouths of tributaries or into streams presumably to ensure well-oxygenated waters throughout winter months, a pattern also seen by Lagler (1943). However, this species frequently hibernates in locations that become anoxic during the winter (e.g., buried in mud or in stagnant aquatic systems that are completely ice-covered). In these situations, there is no oxygen available from the surrounding water for absorption through the skin to meet even low metabolic demands. Yet in these situations Snapping Turtles can make use of metabolic pathways that do not require oxygen (i.e., anaerobic pathways such as glycolysis). This can be dangerous, because a product of anaerobic metabolism is lactate, an acid that can build to potentially lethal levels in the blood and tissues. However, a Snapping Turtle's shell contains substantial calcium and magnesium carbonates, which can be mobilized to help offset the dangerous buildup of lactic acid. As such, these turtles are capable of withstanding prolonged winter periods in anoxic environments.

PREY AND PREDATORS

Snapping Turtles are considered ambush predators (Feuer 1971, Punzo 1975). They often obtain food by burying themselves in the mud, then swiftly striking with their head and jaws to grab passing animal prey (Lagler 1943). Their ability to quickly extend their neck and snap their jaws during predation (or defense) is well-known. Video analyses have revealed that Snapping Turtles can reach a mean velocity of up to 77.8 cm/sec (30.6 in/sec) during neck extension and generate up to a mean of 136.5 newtons of bite force (Vervust et al. 2011). Snapping Turtles consume small food items whole, while they seize large items with their jaws and then tear those items into smaller pieces using their front feet (Lagler 1943).

Mathias (1966) reviewed the intestinal contents from a "series" of turtles trapped in the Horicon Marsh (Dodge County) and found that "bullheads, carp, crayfish, and white waterlily leaves were the main food items." Based on stomach contents of 173 Snapping Turtles captured in Michigan, vegetation was the principal dietary component (36.2% stomach composition by volume), followed by game and pan fishes (34.2% by volume), and carrion or live birds and mammals (19.6% by volume; Lagler 1943). Snapping Turtles prey on both juvenile and adult waterfowl (Lagler 1943). Abel (1992) even reported Snapping Turtle attacks on reintroduced Trumpeter Swan (*Cygnus buccinator*) cygnets at several sites in Wisconsin. Yet Kenow et al. (2009) found that the consumption of juvenile waterfowl in several pools of the upper Mississippi River adjacent to Wisconsin was low and less intense than that of other vertebrate predators. Smith and Casper (2015) reported an observation of a Snapping Turtle preying on a young live Porcupine (*Erethizon dorsatum*) on the Turtle-Flambeau Flowage in Wisconsin. The observed turtle succeeded in drowning the Porcupine and then proceeded to consume it. In Pennsylvania, several individuals were observed gathering leaves of Skunk Cabbage (*Symplocarpus foetidus*) on land and then retreating to the water to consume them (Hartzell 2016). The diet of juvenile Snapping Turtles is rarely documented, but in Ontario they were observed consuming aquatic insects and amphibian larvae in ephemeral wetlands (Moldowan et al. 2015).

There are probably few predators that regularly consume adult Snapping Turtles. Bald Eagles (*Haliaeetus leucocephalus*), Red-shouldered Hawks (*Buteo* *lineatus*), and Broad-winged Hawks (*Buteo platypterus*) have been reported as predators (Ross 1989a). North American River Otters also depredated 17 hibernating Snapping Turtles over two winters in Ontario (Brown and Brooks 1994). Eggs and juveniles are more susceptible to predation than adults, with nest predation rates as high as 100% in some locations (e.g., Congdon et al. 1987). In the lower Wisconsin River, Raccoons (*Procyon lotor*) were the primary predators of *Graptemys* species nests (92%, $n = 561$), followed by Striped Skunks (*Mephitis mephitis*), Virginia Opossums (*Didelphis virginiana*), and Coyotes (*Canis latrans*; Geller 2012c). During this study, Snapping Turtles were observed traveling through the nesting sites of these other turtle species, and thus it is likely that Snapping Turtle nests were susceptible to these same nest predators. Review of other studies suggests that similar species are primary nest predators across northern latitude locations (e.g., Hammer 1969, Congdon et al. 1987). Interestingly, no evidence of predation on nests located in muskrat lodges was detected in Horicon March (Dodge County) by Mathiak (1966).

Parasitic protozoans and sometimes leeches can reduce the fitness of females, potentially negatively impacting clutch sizes (Brown et al. 1994). The primary tactics used by Snapping Turtles to avoid threats is to remain underwater, lodged beneath debris or buried in sediments, where they are rarely encountered. Snapping Turtles are very aggressive if cornered on land or captured. When approached or handled, they fiercely snap with their powerful jaws, which can cause appreciable damage. This turtle is not a threat, however, if left alone or observed from a respectable distance. Reports of Snapping Turtle 'attacks' on humans engaged in aquatic recreation are rare and often unsubstantiated.

CONSERVATION

Status: Globally, the Snapping Turtle is listed as a Least Concern species by the IUCN. In Wisconsin, it is considered common but declining (Christoffel et al. 2002). In response to continued exploitation for the international turtle trade, the species was given CITES Appendix III protection in 2016, allowing for improved regulation of international trade by requiring international exporters to have a permit.

Populations: There is little population information available on this species in Wisconsin, and robust population analyses do not exist. The only published density estimate found comes from Pearse (1923), who reported that the density of Snapping Turtles in Lake Mendota (Dane County) was 0.17/ha (0.07/ac) but probably based this on an inadequate sample size. Gailbraith et al. (1988) synthesized the Snapping Turtle density literature across its geographic distribution and found that density ranged from 1.01 to 74.30/ha (0.41 to 30.07/ac) and was positively correlated with habitat productivity. In Ontario, density was estimated to be 30 times higher in a eutrophic effluent pond compared to an oligotrophic lake (Gailbraith et al. 1988).

Snapping Turtles are often reported as less common than other turtles within sampled communities. For example, they comprised only 1%–11% of all turtles captured at six locations in Illinois (Cagle 1942). In Wisconsin, Pearse (1923) reported that of 1,006 total turtles captured in Lake Mendota, only 15 were Snapping Turtles. Many investigations have calculated statistically unbiased sex ratios in study populations (e.g., Mosimann and Bider 1960, Hammer 1969, Froese and Burghardt 1975, Hogg 1975, Obbard 1983), although male-biased sex ratios occur (reviewed in Iverson and Smith 2010). Based on hoop net trap capture data, DonnerWright et al. (1999) found male-biased sex ratios at 10 of 12 sampled sites in the St. Croix River in Wisconsin and Minnesota, with the remaining 2 sites having equal sex ratios (overall sex ratio = 2.4M:1F, total $n = 183$, site-level $n = 3–44$).

Estimates of survival probability are low for eggs but increase with age. Over a 17-year study in Michigan, mean annual survival of Snapping Turtles from egg deposition to hatchling emergence was only 23% ($n = 378$ monitored nests; Congdon et al. 1994). This same study found that the mean estimated annual survival of juveniles between the ages of 2 and 12 was 77% (range = 65%–82%, $n = 997$ original captures), while adult female survival was 88% ($n = 1{,}121$ original captures). Other studies have also determined that adults have high survival rates. For example, a four-year study of an urban population in North Carolina estimated that annual survival was 91.4% for adult females and 99.4% for adult males ($n = 21$ original captures; Eskew et al. 2010). On Pool 8 of the upper Mississippi River (Minnesota and Wisconsin), annual survival ranged from 85.7% to 100% for adults over four years of age ($n = 89$ radio-tracked adults; Paisley et al. 2009). Based on recaptures 7–13 years after initial captures, mean annual adult female survivorship was estimated to be 96.6% ($n = 75$ original captures) for a population in Ontario (Galbraith and Brooks 1987). In Ontario, annual female recruitment for a population estimated at 63 individuals was 1.8% (Brooks et al. 1991). Snapping Turtle populations appear to be more sensitive to changes in adult or juvenile survival than age of sexual maturity, nest survival, or fecundity (Brooks et al. 1991, Congdon et al. 1994).

Threats: Habitat loss and alteration likely affect this species in various ways, and general threats associated with aquatic habitats, road mortality, and ecotoxicology are applicable to Snapping Turtles (see Introduction to Conservation and Management of Wisconsin's Amphibians and Reptiles chapter). The impacts of habitat disturbance can be obvious (e.g., direct mortality due to habitat degradation) or subtle (e.g., habitat alteration affecting reproductive success). Wirsing et al. (2012) found that Snapping Turtle nests in locations that experience high human disturbance (e.g., heavy human activity, heavy road traffic, routine mowing) were 1.9 times more likely to be destroyed by nest predators. Thompson et al. (2017b) reported heavy nest predation in agricultural fields in Virginia ($n = 23$ of 32 nests). Heavy nest predation can directly influence the number of Snapping Turtles in a population. It can also reduce the recruitment of juveniles and cause shifts in the size and age distribution of impacted populations (Browne and Hecnar 2007). In addition, Kolbe and Janzen (2002a) reported that lower nest temperatures in disturbed landscapes (due to shading from houses and greater tree canopy cover) could negatively impact embryo survival, size, and offspring sex ratios in northern Illinois.

Urbanization is associated with higher road densities, which can impact Snapping Turtle populations (Gibbs and Steen 2008, Patrick and Gibbs 2010). Adult females use roadsides as nesting sites and thus are disproportionately vulnerable to road mortality (Steen et al. 2006). As a consequence, male-biased sex ratios can occur in wetlands adjacent to roads (Steen and Gibbs 2004, Steen et al. 2006, Patrick and Gibbs 2010). Roads can also result in reduction of mean size of individuals (and thus possibly reduced fecundity) in populations (Patrick and Gibbs 2010). Haxton (2000b) performed road searches for Snapping Turtles during the nesting season over a three-year period in Ontario. The percentage of encountered individuals that were dead each year was 35.2% ($n = 37$ killed), 23.9% ($n = 21$ killed), and 32.6% ($n = 28$ killed), respectively, with 80.2% of these individuals found along a major highway.

Overharvesting of Snapping Turtles is a concern, as they are widely exploited for the pet trade, human consumption, and educational purposes (van Dijk 2012). Between 1999 and 2014, reported exportation of live Snapping Turtles from the US increased from 7,279 to 1,324,089 individuals (Colteaux and Johnson 2017). In Wisconsin, large numbers of turtles are sometimes taken by professional trappers who use various methods, ranging from traditional baited hoop net traps to a 'hooking' harvest technique, which employs hooks at the end of long poles to snag and extract Snapping Turtles while they are congregated and inactive at wintering sites (Knudsen 1956c, Paisley et al. 2009). Paisley et al. (2009) reported that four of seven adult Snapping Turtles that died during a radio telemetry study in the upper Mississippi River (Goose Island, Wisconsin, and Lawrence Lake, Minnesota) were from legal harvesting. Furthermore, Paisley et al. (2009) stated that "interviews with turtle trappers and discussions with commercial fishermen indicate that Snapping Turtle populations have declined substantially over the past 20–30 years on Pool 8" of the upper Mississippi River. Interestingly, some studies indicate that Snapping Turtles are less often captured by commercial fishermen than other turtle species. For example, <1% of turtles captured as bycatch by commercial fishing operations in the Mississippi River system near Missouri and Illinois were Snapping Turtles (*n* = 11 of 2,584 turtles; Barko et al. 2004). However, estimated proportion of individuals taken during mock harvests at four sites in Missouri ranged from 0.086 to 0.568 (Shaffer et al. 2017). Common Snapping Turtle populations can be particularly susceptible to even small population impacts, given their unique life histories. Adults are long-lived but slow to mature, and juveniles can experience high but variable mortality (reviewed by Brooks et al. 1991). In an Ontario population, Brooks et al. (1991) found that elevated adult mortality, coupled with poor juvenile recruitment and immigration rates, led to rapid population declines with slow potential for recovery. These findings led the authors to suggest that even low levels of adult "exploitation" would have long-term negative impacts (see also Management subsection). Although typically not sought by those engaged in recreational 'hook-and-line' fishing, Snapping Turtles that accidentally ingest recreational fishing tackle (e.g., hooks and lead sinkers) or monofilament line can experience intestinal perforations and lead poisoning (Borkowski 1997). Substantial research on the ecotoxicology of northern Snapping Turtle populations has been conducted, with numerous studies having detected various contaminants in tissues and impacts to several life stages (e.g., Golet and Haines 2000, de Solla and Fernie 2004, de Solla and Martin 2007, Eisenrich et al. 2009).

Management: Many general management considerations associated with aquatic habitats, road mortality, and overharvesting potentially apply to Snapping Turtles (see Introduction to Conservation and Management of Wisconsin's Amphibians and Reptiles chapter). Snapping Turtles appear to be fairly tolerant of structural modifications to their aquatic and surrounding terrestrial habitats (reviewed by Ernst and Lovich 2009). For example, they are often observed in disturbed wetlands and artificial waterbodies, such as stormwater retention ponds, in Wisconsin (Joshua Kapfer, UW–Whitewater, personal communication). They are also reported to rapidly colonize constructed wetlands (e.g., Palis 2007). However, the survival and reproductive success of turtles in these disturbed or unnatural situations are unknown, and such habitats could act as ecological traps. Due to the potential for skewed sex ratios resulting from female road mortality, construction of road barriers to reduce road mortality may be an effective management action to enhance population viability (Christoffel and Hay 1995b). Widespread implementation of this management tool would undoubtedly benefit Snapping Turtles and many other reptiles and amphibians in the state.

Protection of known nests may offset nest predation and increase population recruitment. Work in Michigan suggests that early detection and protection of nests is important, as 59%–73% of monitored Snapping Turtle nests were destroyed within one to six days of egg deposition (Congdon et al. 1987). Steen et al. (2012b) further analyzed a compilation of many reports (*n* = 1,043) and found that 95% of reported Snapping Turtle nests or gravid females were within 116 m (381 ft) of wetlands. These findings can help generate guidelines for implementation of terrestrial buffers around wetlands that can potentially protect Snapping Turtle nests.

It is currently legal to harvest this species in Wisconsin between 15 July and 30 November (WNDR 2015). The existing harvest regulations include a possession limit of ten individuals on the Mississippi River and three individuals in the remaining waterbodies of Wisconsin (WDNR 2015a). Although these harvest limits protect populations from commercial-level harvest, even minimal removal of individuals could negatively impact populations. Zimmer-Shaffer et al. (2014) estimated that only 2.3% of adult and juvenile Snapping Turtles could be harvested annually without causing population declines based on mean demographic rates. The life-history characteristics of turtles make them difficult to manage as a game species, and thus harvested populations should be closely monitored to ensure that the populations remain viable. Wisconsin regulations currently restrict harvest of Snapping Turtles to individuals that are 30.5–40.6 cm MCL (12–16 in). Implementation of size restrictions on harvested turtles has effectively reduced the total number of turtles harvested in the US (Colteaux and Johnson 2017). However, harvests that target large individuals can lead to shifts in the distribution of population size toward smaller and less fecund individuals, which can negatively impact population viability (reviewed by Zimmer-Shaffer et al. 2014, Colteaux and Johnson 2017).

SPECIAL REMARKS

Intraspecific aggressive behavior has been documented surrounding competition for food, with individuals biting or clawing each other (Raney and Josephson 1954, Froese and Burghardt 1974). Ritualized aggressive interaction between two males was observed in a small pond in Champaign, Illinois (Merrill 2004). The behavior involved the turtles facing each other with their heads submerged while their carapaces remained above the surface of water and periodically lunging at one another.