

# The Common Snapping Turtle, *Chelydra serpentina*

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Figure 1. The Common Snapping Turtle, one of the most widespread reptiles in North America. Photo taken in Quebec, Canada. Image from <https://www.flickr.com/photos/yorthopia/7626614760/>.

## Classification

Order: Testudines

Family: Chelydridae

Genus: *Chelydra*

Species: *serpentina* (Linnaeus, 1758)

Previous research on *Chelydra serpentina* (Phillips et al., 1996) acknowledged four subspecies, *C. s. serpentina* (Northern U.S. and Canada), *C. s. osceola* (Southeastern U.S.), *C. s. rossignonii* (Central America), and *C. s. acutirostris* (South America). Recent IUCN reclassification of chelonians based on genetic analyses (Rhodin et al., 2010) elevated *C. s. rossignonii* and *C. s. acutirostris* to species level and established *C. s. osceola* as a synonym for *C. s. serpentina*, thus eliminating subspecies within *C. serpentina*. Antiquated distinctions between the two formerly recognized North American subspecies were based on negligible morphometric variations between the two populations. Interbreeding in the overlapping range of the two populations was well documented, further discrediting the validity of the subspecies distinction (Feuer, 1971; Aresco and Gunzburger, 2007). Therefore, any emphasis of subspecies differentiation in the ensuing literature should be disregarded. Continued usage of invalid subspecies names is still prevalent in the exotic pet trade for *C. serpentina*, often describing turtles with specific colorations or physical features associated with turtles from that region.

## Identification Key

### Common Snapping Turtle

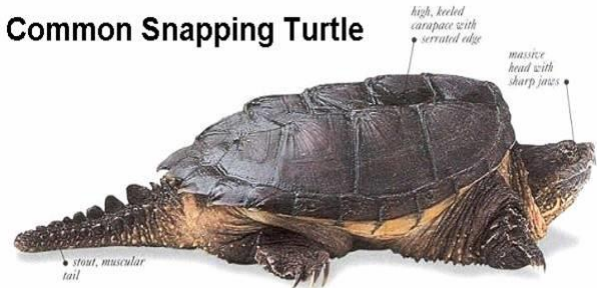


Figure 2. Side profile of *Chelydra serpentina*. Note the serrated posterior end of the carapace and the tail's raised central ridge. Photo from <http://pelotes.jea.com/AnimalFact/Reptile/snapturt.htm>.



Figure 3. Front-view of a captured *Chelydra serpentina*. Different skin textures and the distinctive pink mouth are visible from this angle. Photo from <http://www.itsnature.org/ground/amphibians-land/common-snapping-turtle/>.

*Chelydra serpentina* (the common snapping turtle) is a large, robust aquatic turtle. Mature individuals can have a carapace length of up to 19 inches, and can achieve a maximum weight of 86 lbs. (USGS Database). The carapace is composed of three flattened rows of plates, smooth on the anterior end and serrated at the posterior end (Chelydra.org). Coloration of the carapace is variable and indicative of the turtle's environmental conditions, ranging from a matte charcoal black to a polished, tanned brown. Often shells are mottled and discolored by algal

growth and muddy sediment accumulation. The plastron, usually yellowed, is drastically reduced, to such an extent that the turtle cannot withdraw completely into its shell. The skin of *C. serpentina* is also highly variable in coloration, typically darker on its dorsally exposed surfaces and lighter on ventrally exposed surfaces. The texture is irregular, containing a mix of densely organized scales (near the head, tail, and feet) and thick wrinkled folds. The turtle's head is large, terminating in a wide beaked mouth, and can be withdrawn into the carapace. The toothless mouth's interior coloration is pale pink. The eyes are dorsally directed, and exhibit a crossed yellow and black pattern. Supporting the head is an elongated neck, which can be rapidly extended up to half of the turtle's carapace length. Legs are stout and heavily scaled, and each webbed foot has five clawed digits. The tail can be as long as the individual's carapace, and is characterized by three rows of dermal ridges. The middle ridge can be dramatically raised, resulting in a distinctly saurian appearance. Juveniles resemble miniature adults, but possess a rougher carapace texture that gradually smoothens later in life. Sexual dimorphism in *C. serpentina* is most accurately demonstrated by the difference in pre-cloacal tail length; in males, the distance from the posterior end of the plastron to the cloaca is greater. Males also generally have longer and thicker tails than females.



Figure 4. Difference in pre-cloacal tail length in female and male *Chelydra rossignonii*, a Central American snapping turtle that was previously considered a subspecies of *C. serpentina*. Photo from [http://www.chelydra.org/snapping\\_turtle\\_identification.html](http://www.chelydra.org/snapping_turtle_identification.html).

Those unfamiliar with the reptilian faunal assemblage of North America may mistake *C. serpentina* for its notorious relative *Macrochelys temminickii*, the alligator snapping turtle. This is primarily a concern within the mutual range of the two species, namely the freshwater ecosystems of Mississippi River system and the coastal Southeastern United States. While *C. serpentina* and *M. temminickii* share a superficial resemblance, there are a number of features that make correct identification simple and effective. Perhaps the most striking difference between these two chelydrids is carapace morphology; the shell of *M. temminickii* is composed of rows of strikingly jagged scutes, while the shell of *C. serpentina* is largely smooth with the exception of its posterior plates. The head of *M. temminickii* has sharper, jagged features, including a dramatically pronounced beak that contrasts *C. serpentina*'s rounded mouth. Inside of its darkly colored mouth, *M. temminickii* possesses a bright pink lure, which it uses to attract prey. *C. serpentina* lacks this feature entirely. Finally, *M. temminickii* can grow far larger than *C. serpentina*, with individuals regularly exceeding 150 lbs. In addition to qualitative physical differences, these species may be distinguished by their particular behavioral attributes. Ecological studies suggest that the two chelydrids occupy disparate microhabitats in areas where they occur simultaneously, effectively partitioning available resources (Lescher et al., 2013). In shared environments, *C. serpentina* was found in shallower depths and *M. temminickii* dominated the deepest reaches of freshwater systems, indicating the possibility of predator avoidance on *C. serpentina*'s part and/or direct outcompetition by *M. temminickii* for deep-water territory. From comparative behavioral observations and tracking studies, *C. serpentina* displays characteristics of a generalist, while *M. temminickii* is more of a specialist. Additionally, *C. serpentina* can tolerate freezing temperatures (Costanzo et al., 1995), an adaptive environmental response that its larger relative does not possess. This is likely an indispensable physiological trait for the northern population of *C. serpentina*, allowing it

to endure the harsh winter conditions present in eastern Canadian provinces and the northern United States.



Figure 5. *Chelydra serpentina* (left) and *Macrochelys temminckii* (right). Photo from [http://www.chelydra.org/common\\_alligator\\_snapping\\_turtle.html](http://www.chelydra.org/common_alligator_snapping_turtle.html). (This site provides additional visualizations of the differences between these two North American snapping turtle species).

### **Life Cycle and Basic Ecology**

#### *Life Cycle*

The life history of *C. serpentina* is typical of large freshwater chelonians; low hatchling recruitment rates and accelerated growth rates before sexual maturity give way to high adult survival rates and greatly reduced growth rates for most of the turtle's life (Congdon et al., 1987; Aresco and Gunzburger, 2007).

Annual recruitment rates are heavily restricted by high egg and juvenile mortality rates and long generation times. The average rate of nest survivorship is 23% (Congdon et al., 1994), with high mortalities associated with extreme temperature fluctuations and nest predation. A study on *C. serpentina* nests in the Midwest estimated that the nests experienced a 70% predation rate, mostly from mammals such as raccoons and foxes (Wilhoft et al., 1979). Hatchlings are susceptible to predation from snakes, frogs, and several aquatic and non-aquatic bird species (Janzen et al., 2000). Approximate chance of survival to year one is 22%. By year two, this chance increases to 65%, and between the ages of 3 and 12 (approximate sexual maturity) this statistic is 77%. Average

annual survivorship of *C. serpentina* post-maturation range from 88% to 97%. Females reproduce with 85% regularity, indicating a less-than-annual frequency, but considering the longevity of these animals (over 100 years), the successful reproduction of a *C. serpentina* female in its estimated maximum lifetime is virtually guaranteed. The approximate generation time is 25 years (Congdon et al., 1994).

Hatchlings and juveniles grow at a steady, considerable rate, which gradually decreases as the turtle approaches sexual maturity. At age 20 the growth rate becomes constant, and remains so for the rest of the turtle's life. The growing season is prolonged in warmer climates due to increased quantity and quality of food sources (Patersen et al, 2011). *C. serpentina* have virtually no predators except for the American alligator (*Alligator mississippiensis*) in its southern range (Aresco & Gunzburger, 2007).

Annual hibernation in *C. serpentina* is well studied and apparently inconsistent in duration and timing across its broad geographic range (Reese et al., 2002; Strain et al., 2012; Brown and Brooks, 1994). Hibernation is a common strategy employed by freshwater turtles in northern latitudes, serving as an effective mechanism to reduce metabolic costs and decrease acidosis in winter months (Patersen et al., 2011). As much as half of an adult *C. serpentina*'s life can be spent in a state of hibernation. Hibernation entry periods are regionally determined by the local climate, coinciding with decreasing temperatures in autumn, assumed to be detectable by the turtles through a decrease in water temperature. In Ontario, *C. serpentina* was found to select hibernacula that offered colder temperatures than the surrounding ambient environment. In its northern range, *C. serpentina* often hibernate underwater, sometimes under sheets of ice. The turtle does not leave the water after entering hibernation, suggesting its capacity to efficiently thermoregulate through a combination of behavioral and physiological adaptations. The three main types of aquatic hibernacula utilized were streams, lakeshores, and anoxic mud. It is hypothesized that all three of these hibernacula

offer protection from predators, as well as providing the turtle with adequately low temperatures to cause a beneficial reduction in metabolic activity. When no submerged hibernacula are available, terrestrial hibernacula are chosen instead. Turtles show a high fidelity for hibernacula, with records of 75% fidelity in Ontario and 95% fidelity in West Virginia (Strain et al., 2011). This may be due to territoriality, as each turtle would hibernate in the most appropriate available space within its home range. Upon emergence from hibernation in spring, individuals are physiologically prepared for mating.

### *Environmental Optima*

*C. serpentina* is often found in still or slow-moving freshwater habitats (Ryan et al., 2014; Anthonysamy et al., 2014). This includes swamps, marshes, conventional lakes, oxbow lakes, and ponds. Some populations are well adapted to estuarine conditions, thriving comfortably in 25% seawater (Kinneary, 1992). The thermal preference of *C. serpentina* is roughly 28 °C (Kobayashi et al., 2006), but this species demonstrates an impressive resistance to extreme cold temperatures in high latitudes, with some reports of this species swimming under the frozen surfaces of rivers (USGS Database). Hatchlings were observed to tolerate -1.5 °C with no discernable adverse effects (Costanzo et al., 1995).

Basic environmental conditions that are favored by *C. serpentina* are muddy substrates, heavily vegetated banks, presence of obstructions (submerged logs, woody debris), and mid-water basking sites (Froese, 1978). The morphological characteristics of this species provide it with a convincing camouflage in its favored benthic microhabitats. Curiously, *C. serpentina* rarely basks, instead burrowing into the soft, silted undersides of basking sites (DonnerWright et al., 1999). In areas home to diverse turtle assemblages, this leads to habitat partitioning, and allows the otherwise territorial *C. serpentina* to coexist with smaller, less competitive turtle species that regularly bask. Intraspecific competition in *C. serpentina* is reduced by different microhabitat usage in different life stages; hatchlings and juveniles tend to live in

shallow water, adults live in the depths (Kobayashi, 2006; Aresco and Gunzburger, 2007). These habitats provide the different life stages of *C. serpentina* with vital resources and ecosystem benefits. Shallow water offers shelter for the vulnerable hatchlings, and deeper, muck-lined benthic zones of freshwater systems provide both a hiding space from predators and habitat for the wide array of invertebrates consumed by adult turtles.

Outside of its natural habitat, *C. serpentina* can be found in man-made canals, ponds, and reservoirs in the continental United States (Stone et al., 2005; Connor et al., 2005). In its limited introduced range in Japan, *C. serpentina* has established populations in rice paddies and urbanized river systems (Kobayashi, 2006; Kobayashi, 2007); however, ecological assessment of the rice paddy populations determined that the high summer temperatures of the rice paddies were unsuitable for prolonged usage by *C. serpentina*.

### *Feeding Habits*



Figure 6. An adept swimmer with webbed feet, *C. serpentina* is equally suited for ambush predation on unwary waterfowl at the surface as foraging in benthic muck for aquatic invertebrates. Terrestrial foraging has also been documented. Photo from <https://animalgals.wordpress.com/2014/07/16/snapping-turtle-swimming/>.

*C. serpentina* is an opportunistic omnivore, maintaining a generalist diet that consists of region-specific types and amounts of macrophytes, crayfish, snails, leeches, fishes, amphibians, turtles, snakes, small mammals, and birds ([www.willametteturtles.com](http://www.willametteturtles.com), USGS database). In the Pacific Northwest, *C.*

*serpentina* is known to prey on the native western painted turtles, *Chrysemys picta bellii*, and the western pond turtles, *Actinemys marmorata*. *C. serpentina* is predominantly crepuscular, actively foraging at twilight with some activity at dawn (Smith and Iverson, 2004). These turtles display a unique post-feeding behavioral response, often burrowing into thick muddy substrate after a meal. As opposed to seeking warmer temperatures such as a basking site, *C. serpentina* has a digestive strategy that does not rely on temperature changes to quicken metabolic functions. By prolonging digestion, *C. serpentina* can remain satiated for longer intervals, reducing foraging time while simultaneously conserving energy and avoiding predators. Hatchlings similarly do not show thermophilic post-feeding responses (Knight et al., 1990), showing a life-long consistent non-reliance on temperature-linked digestion.

#### *Biotic associations*

Like a number of other freshwater turtles found in North America, *C. serpentina* is a known carrier of *E. coli*, *Salmonella*, and *Enterococcus* (Habersack et al., 2011; Gaertner et al., 2008). Dispersal of these pathogens through fecal matter is of primary concern for metropolitan areas that draw their water from turtle inhabited sources, as dense concentrations of chelonians could result in high concentrations of pathogenic bacteria in the municipal water supply. Other organisms associated with *C. serpentina* include leeches from the genus *Placobdella*, for which *C. serpentina* is a primary host (Stone, 1976; Readell et al., 2008). These leeches can often be found in great abundances on the skin and carapace of these turtles as they traverse overland. The migratory tendencies of female *C. serpentina* may therefore assist in the dispersal of these leeches to new locations.

Perhaps the most peculiar of *C. serpentina*'s biotic associations is its symbiotic relationship with the painted turtle, *Chrysemys picta* (Bodie et al., 2000). In a diverse turtle assemblage in the Lower Missouri Floodplain, *C. picta* populations were positively correlated with *C. serpentina* abundance. Closer observations of

interspecific interactions between these two turtle species revealed that the larger snapping turtle unintentionally provides the smaller painted turtle with food in the form of excess algae and leeches on its skin and carapace. The painted turtle in turn provides a service for the snapping turtle, by removing parasites and growth that could potentially inundate the lethargic chelydrid. This is possibly the first instance of symbiosis between chelonians in any environment.

#### *Reproduction*

Early work on *C. serpentina* reproductive strategies noted that both sexes were sexually mature at ~145 mm (~5.7 inches) in carapace length (White and Murphy, 1973). Depending on regional growth rates, which rely on the length of the growing season and availability of nutrients, this size can be attained in different years of a turtle's life. The youngest mature female in a population of Michigan *C. serpentina* was found to be 12 years old (Congdon et al., 1987), while an older study on *C. serpentina* in Iowa estimated a minimum female reproductive age of 8-9 years (Christiansen and Burken, 1979). The same study suggested a minimum male reproductive age of 5 years. Mating occurs primarily during the onset of spring in April-May, coinciding with the end of hibernation, and peak egg laying follows soon after in late May and June. *C. serpentina* females are known to conduct long distance nesting migrations, over 5.5 kilometers in some observations (Obbard and Brooks, 1980); much shorter migrations are common, averaging 180 meters (Congdon et al., 1987). Preferred nesting substrates include rotting vegetation, sandy soil, sawdust piles, and rodent lodges. Egg and clutch size increases with the size of the female, with larger females having the highest fecundity (Iverson et al., 1997). Over 100 eggs can be found in some nests of particularly large females, but the average number of eggs per nest is 24. Hatchlings spend an average of 93 days in the nest before emerging in the fall, usually centered around September, with overwintering in nests not uncommon in particularly cold regions (Costanzo et al., 1995). *C. serpentina* may be

capable of exerting a debatable level of control over the sex ratios of their offspring via nest site selection (Juliana et al., 2004). Female offspring are produced at low and high temperature extremes, while males are produced at intermediate temperatures. Mean temperature of the nest generally lies between 17.2 °C and 23.3 °C. Manipulation of site placement, and by extension temperature (i.e. proximity to shade, type of substrate used) therefore leads to sex determination in the offspring. The water content of the nest substrate, and subsequently the eggs, plays a key role in embryo development (Finkler, 2001; Finkler et al., 2002; Packard et al., 1999). Comparisons between embryos incubated in dry and wet substrates showed that wet substrate embryos grew larger and had reduced yolk size upon hatching, indicating an increase in metabolism. Consequently, dry substrate embryos were smaller and had more yolk, and also accelerated

cardiac tissue development that compensated for the increased viscosity (reduced water content) of the embryo's blood (Packard and Packard, 2002). Hatchlings from the upper layers of nests tended to be smaller bodied, while those from the lower, less exposed levels of the nest tended to be larger; however, this disparity in hatchling size did not dictate a predisposition for greater survival probabilities (Kolbe and Janzen, 2001). While larger hatchlings proved to be more resilient to desiccation, their reduced yolk content necessitated the immediate location of food. Smaller hatchlings were more vulnerable to environmental conditions, but compensated by reduced feeding pressure. Instead, reduced distance to water and similar nest microhabitat qualities were reliably correlated with higher survivorship in *C. serpentina* hatchlings.

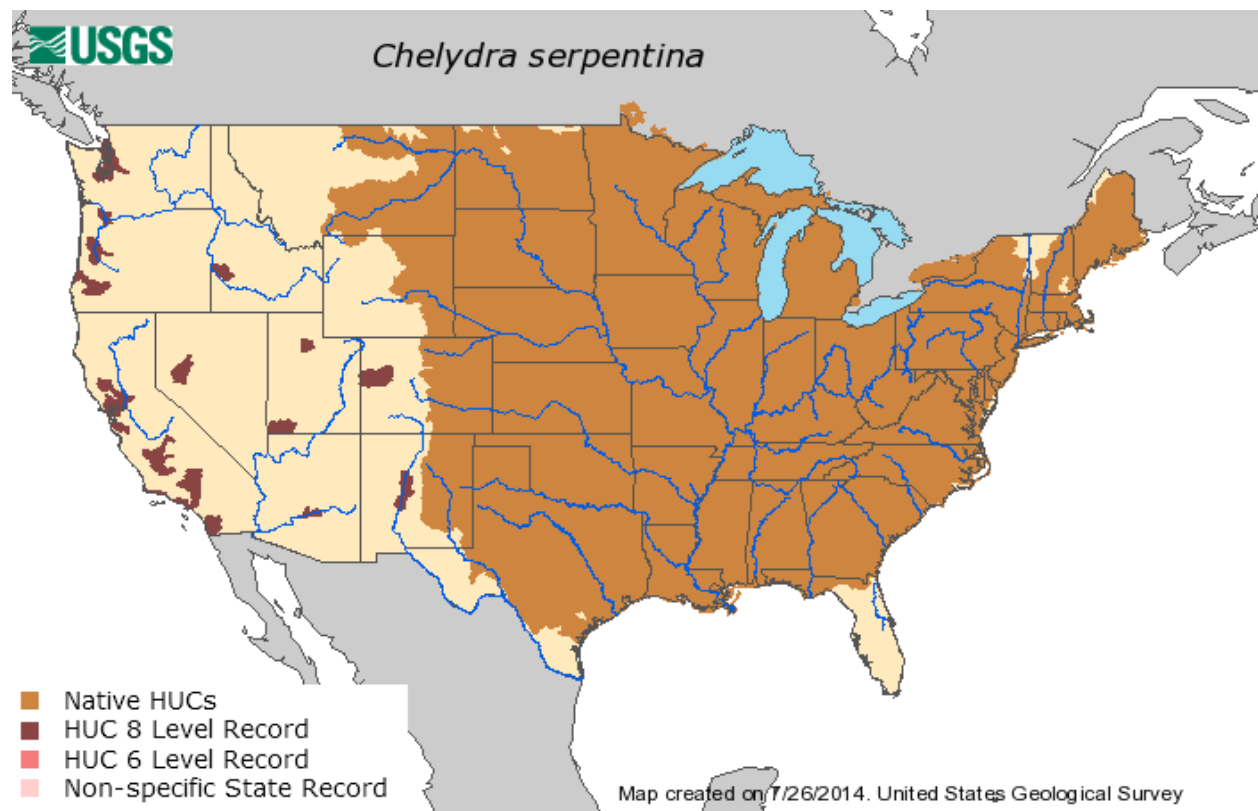


Figure 7. Map showing the distribution of *C. serpentina* in the continental United States, both native range (orange) and introduced range (maroon). Photo from <http://nas.er.usgs.gov/queries/factsheet.aspx?speciesID=1225>.

## Current Geographic Range in North America

True to its name, the common snapping turtle has a widespread native distribution across North America. Its range extends as far north as Nova Scotia, encompassing the entire east coast of the United States and the Gulf of Mexico in the south (USGS database, Phillips et al., 1996). Areas of high density include the Great Lakes region and the middle and lower Mississippi River system. The farthest natural western reach of *C. serpentina* is the base of the Rocky Mountains, where it can be found in the far reaching tributaries of the Mississippi River (DDevender and Tessman, 1975). Fossil evidence suggests that its historic range was in even broader than its modern range, with virtually identical fossilized *C. serpentina* individuals found in southern Nevada. This implies that, at some post-glaciation point in time, *C. serpentina* managed to circumnavigate the Rocky Mountains into the western United States. Later unfavorable climate changes in the region and subsequent disappearance of ideal habitat probably led to its disappearance from this portion of the United States.

The introduced range of *C. serpentina* includes the remaining western states of California, Oregon, Washington, and Arizona. Additional recoveries in the remaining western states (Colorado, Utah, Nevada, and Idaho) effectively exemplify *C. serpentina*'s propensity to establish itself in every state in the continental United States. In the Pacific Northwest, *C. serpentina* has successfully established populations in the Willamette, Tualatin, and Sandy Rivers in Oregon, with individuals collected from Eugene, Portland, Corvallis, Springfield, Coos Bay, Benton County, and Multnomah County. One individual was collected from the Columbia River. In Washington state, *C. serpentina* can be found in Lake Washington, Bellevue, King County, and possibly in Thurston County. Limited introductions in British Columbia have not resulted in breeding populations.

## Invasion History of *C. serpentina*

### *Pathways, Vectors, and Routes of Introduction*



Figure 8. Hatchling “normal” and “albino” *C. serpentina* for sale. Photo from <http://www.theturtlesource.com/i.asp?id=300200522&p=Albino-Common-Snapping-Turtles>.

The primary pathway for *C. serpentina* introductions in the United States and abroad is the exotic pet trade (USGS database). Although not as prevalent in the aquatic reptile market as the red-eared slider, *Trachemys scripta elegans*, or its close relatives, *C. serpentina* is a popular species among hobbyists due to its prehistoric characteristics and impressive adult size. It can be purchased for a reasonably cheap price for a chelonian, with juveniles commanding prices around \$30-\$40. Adult turtles on turtleshack.com cost roughly \$400. One online store, theturtlesource.com, offers *C. serpentina* in a number of colorations such as “albino”, “leucistic”, and “cinnamon”. All three of these are priced at values of \$2000 or more (the “albino” variety is priced at \$5000). Clearly *C. serpentina* is marketed not only towards the casual hobbyists, but also to the dedicated enthusiasts who are willing to pay top dollar for color morphs of a turtle they can likely find somewhere in their state’s local watersheds. Shipping information from various freshwater turtle distributors indicate centralized distribution from Florida, with additional locations in California and Texas. Florida state laws prohibit the removal of *C. serpentina* from the wild by individuals for commerce, leading the proliferation of extensive turtle farms to create sustainable stocks. Therefore, juvenile turtles for sale originating from Florida are probably from these farms. The sale of *C. serpentina* is restricted in California, Washington, Oregon, Arizona, and New York. (Oddly enough, *C. serpentina* is the state reptile of New York).



The broad, inclusive diet and prolonged digestion period of *C. serpentina* make it a viable option for novice pet owners, even if various online pet stores discourage this species for beginners due to its large adult size and confrontational disposition when handled (note its popular name, the common *snapping* turtle). Thanks to its wide temperature tolerances, *C. serpentina* can be kept outdoors in virtually any locality in the United States, although indoor setups are common. While this might suggest the possibility of *C. serpentina* introductions in the western United States via pet escapes, the more likely explanation is direct owner releases of individuals that either outgrew their indoor enclosures or proved too troublesome for the owner.

Outside of the U.S., *C. serpentina* has established breeding populations in Japan, almost certainly the result of pet releases (Kobayashi et al., 2006). Formally identified as an invasive species in Japan in 2005, *C. serpentina* dwarfed the native turtle species and had few predators in its new environment. Its spread has so far been limited to rice paddies and man-made waterways near high density urban centers (Kobayashi et al., 2007). Huge Asian market demand for turtles (mainly as food sources and medicinal ingredients) have led to massive unregulated trade between the U.S. and its trade partners in Asia. Over a three-year period, 31.8 million turtles, mostly farm raised, were exported to international markets. Turtle farming in China has boomed, leading to concern over the increased potential for accidental release of farmed turtles into the native ecosystems.

The imminent threat of *C. serpentina* invasions in Europe has only recently been acknowledged (Kopecky et al., 2013). Using climate match methods that mapped favorable snapping turtle habitats in Europe in accordance with the frequency of *C. serpentina* importation from the U.S., the successful establishment of *C. serpentina* in the near future is almost guaranteed.

#### *Factors Influencing Establishment and Spread*

Upon release, survival of *C. serpentina* individuals, especially sexually mature adults, in

the natural conditions of any given state's watersheds is relatively high (Stone et al., 2005). High adult survivorship, generalist tolerances and food preferences, long life spans, and low initial detectability make *C. serpentina* establishments a prolonged affair unless recognized immediately.

Since the primary source of *C. serpentina* introductions is the freshwater reptile trade, it can be assumed that larger population centers will likely have a greater number of hobbyists who purchase and subsequently release turtles into the wild. Indeed the invasion patterns seen in California, Oregon, and Washington correlate strongly with dense human populations, with breeding *C. serpentina* populations found in Los Angeles county, Eugene, and Seattle suburbs (USGS Database). Repeated introductions of large individuals that have outgrown their enclosures are strong candidates for an initial population base.

Studies on population dynamics and behavioral ecology in urban establishments of *C. serpentina* have defined the species as "temporally urbanoblivious" (Ryan et al., 2014). Human activity both promotes and inhibits *C. serpentina* survival and spread, suggesting the potential for complex multifaceted interactions between *C. serpentina* and human development (Kobayashi et al., 2006; Decatanzaro and Chow-Fraser, 2010). One study on the impact of urbanization on an assemblage of turtles found *C. serpentina* in intermediate water qualities, but absent in heavily altered reaches of the river system. Aquatic systems in urban landscapes are often associated with increased nutrient input from municipal and agricultural runoff, and it is possible that the increased nutrient load in this particular system both increased food availability for *C. serpentina* and hindered it via higher concentrations of pollutants. Although *C. serpentina* may have benefitted from the additional nutrients by means of increased fecundity and growth rates, these benefits may be offset by the bioaccumulation of harmful compounds over its considerable lifetime and inundation by algal proliferation on the turtle's body.

Within urban environments, *C. serpentina* tends to inhabit cryptic niches found in "the urban development matrix" (Ryan et al., 2014; Aresco

and Gunzburger, 2007). These niches must offer both adequate terrestrial and aquatic habitat, a necessity for freshwater turtle species. Man-made ponds were found to have high densities of *C. serpentina*, where it partitioned habitat with *C. s. elegans*, *Pseudemys concinna*, and *Sternotherus odoratus* (Dreslik et al., 2005). Fragmentation of suitable habitats in this matrix limits the turtle's capacity to migrate between bodies of water. Vehicular mortality rates in *C. serpentina* are extremely high in urban environments, often selective for gravid females that must cross roads in their nesting migrations (Congdon et al., 1994).

#### *Potential Ecological and Economic Impacts*

In the Pacific Northwest, the primary threats posed by a *C. serpentina* invasion are the contamination of local water supplies with pathogenic bacteria originating from turtle fecal matter and the potential for negative impacts on native waterfowl and turtle species. Proliferation of *E. coli* and *Salmonella* strains in pristine watersheds will necessitate the creation of water treatment facilities, a cost that will ultimately fall to the individual states. From their eastern native range, *C. serpentina* may carry unfamiliar reptilian pathogens that could decimate native turtle populations. *Placobella* leeches attached to introduced *C. serpentina* individuals could make their way into the rivers in the Pacific Northwest, potentially finding new preferred hosts in the native turtle assemblage or native salmon species. In Oregon there is concern that *C. serpentina* will prey on the hatchlings of native western pond turtles and western painted turtles, a possibility that is substantiated by the voracious feeding tendencies of *C. serpentina*.

#### *Management Strategies and Control Methods*



Figure 9. A 45 lb. common snapping turtle caught in the Blacklick Woods in Central Ohio. Removal projects that target sexually mature individuals such as this one represent the most cost-effective management strategy for dealing with *C. serpentina* invasions. Photo from <https://www.flickr.com/photos/tpeck/4897475824/>.

The aforementioned life history of *C. serpentina* provides crucial insight into effective management strategies for dealing with an established *C. serpentina* population. This species relies heavily on high adult survivorship to allow repeated reproduction events that result in eventual reproductive success over a number of years (Aresco and Gunzburger, 2007). Further reductions of nest and hatchling survivorship (via nest destruction and shore collections of hatchlings) would have no impact on the remaining adult turtles' capacity to attempt reproduction the following year. Instead, management efforts should focus on the removal of sexually mature adults from invaded areas. The goal of any of these removal projects would be to reduce the number of remaining *C. serpentina* adults in the wild to a level consistent with an unsustainable stock. Sudden, repeated depletions of the number of adults in a population would lower the number of reproduction events that occur in a year. Given the already statistically low odds of successful yearly reproduction, this method practically ensures at the very least ample depletion of *C. serpentina* populations to negligible significance levels. This process would most likely occur over a number of decades; one study calculated that an increase of 10% in annual adult (age 15) mortality with no density dependent compensation would reduce the number of breeding adults in a population in less than 20

years (Condgon et al., 1994). This 10% mortality rate, or in this case removal rate, could be raised by increasing removal efforts, thereby accelerating the decline in population size. Trapping of adults is likely the most cost efficient method of removing these target individuals, and this has been done to great effect in many previous studies on turtle ecology in the eastern United States (Lescher et al., 2013). Supplementary measures can be taken in smaller, urbanized systems if the establishment persists. The dredging of muck substrate from the bottom of canals and the removal of riparian cover from the banks of these canals can reduce available habitat (Aresco and Gunzburger, 2007).

On a final note, it is worthwhile to mention that native *C. serpentina* populations in certain eastern U.S. localities are being depleted by harvest removals. The dual status of *C. serpentina* as a native turtle worthy of regional protection and an invasive species for which management plans must be drawn and enacted is a curious phenomenon. Ironically, the proper, regulated application of the very forces that put this species at risk in its native range may ultimately prevent it from causing unwanted damages in its introduced range.

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### Other Key Sources

USGS Profile on *C. serpentina*:  
<http://nas.er.usgs.gov/queries/factsheet.aspx?speciesID=1225>

Washington Department of Fish and Wildlife:  
<http://wdfw.wa.gov/>

The Lower Wilamette Turtle Conservation Project's website:  
<http://www.willametteturtles.com/>

Article on the presence of common snapping turtles in Oregon rivers and their impact on native fauna:  
[http://www.gazettetimes.com/news/local/giant-snapping-turtles-cropping-up-in-mid-valley/article\\_972f18a8-6245-5de8-9ddf-44d6c875f769.html](http://www.gazettetimes.com/news/local/giant-snapping-turtles-cropping-up-in-mid-valley/article_972f18a8-6245-5de8-9ddf-44d6c875f769.html)

Article in Chinese regarding the profitability of farming common snapping turtles in China:  
<http://www.gui138.cn/xinwen/gbxw/201007/765.html>

Article on the international turtle trade:  
<http://www.turtlesurvival.org/blog/1/63>

Site dedicated to the extant lineage of Chelydrids: <http://www.chelydra.org/index.html>

Common snapping turtles for sale online:  
<http://www.theturtlesource.com/i.asp?id=100200352>

[http://turtleshack.com/store/index.php?main\\_page=advanced\\_search\\_result&search\\_in\\_description=1&keyword=snapping&gclid=CPEzIK7drcICFYeBfgodHnQAIQ](http://turtleshack.com/store/index.php?main_page=advanced_search_result&search_in_description=1&keyword=snapping&gclid=CPEzIK7drcICFYeBfgodHnQAIQ)

<http://www.backwaterreptiles.com/turtles/snapping-turtle-for-sale.html>

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### Current Research and Management Efforts

National Wetlands Research Center, Index of Suitable *C. serpentina* habitat:  
<http://www.nwrc.usgs.gov/wdb/pub/hsi/hsi-141.pdf>

Missouri Department of Conservation:  
<http://mdc.mo.gov/your-property/problem-plants-and-animals/nuisance-native-wildlife/common-snapping-turtle-control>

Field Guide, Diagnostic Ecological Assessment and Proposed Management Strategies in Montana:  
<http://fieldguide.mt.gov/speciesDetail.aspx?elcode=ARAAB01010>

### Appendix I. Additional Viewing

Excellent footage of the swimming capabilities of *C. serpentina*:

<https://www.youtube.com/watch?v=fx8z1O1LzYE>

Educational video on the basics of *C. serpentina* biology and ecology in Ontario, Canada:

<https://www.youtube.com/watch?v=1FaTfpXs3vo>

Amateur capture of an exceptionally large *C. serpentina*:

<https://www.youtube.com/watch?v=dmEhZ2QI9mc>

Demonstration of how to safely move *C. serpentina* off roads:

[https://www.youtube.com/watch?v=Lgd\\_B6iKPxU](https://www.youtube.com/watch?v=Lgd_B6iKPxU)

A pseudo-scientific demonstration of the bite force exerted by a juvenile *C. serpentina*:

<https://www.youtube.com/watch?v=5HQpbGq010c>