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Michigan Turtles with Recommendations for Conservation and Recreational Use

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Fisheries Report 28, 2017

Michigan Turtles with Recommendations for Conservation and Recreational Use

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Introduction

Turtles evolved from amphibians during the Pennsylvanian Period about 320 million years ago. According to fossil records dating back to the Triassic period, turtles have remained virtually unchanged in appearance during the last 200 million years (Ernst et al. 1994). Some traits that allowed turtles to survive throughout time are now considered to predispose them to endangerment (Lovich 1995). Turtles have delayed maturity with low and variable annual reproductive success that makes them highly susceptible to increased adult mortality (Brooks et al. 1991; Congdon et al. 1993, 1994). As human populations increase and wild habitat decreases, populations of reptiles and amphibians are seriously declining throughout the world (Schlaepfer et al. 2005). Most reports of turtle population declines come from researchers who observe a decrease over many years in specific study populations. Because only a few of these discrete populations are studied, it is difficult to quantify declines across the range of any one species or on a continental scale across several species (Reed and Gibbons 2004). Factors contributing to turtle declines include collection of animals from the wild for subsistence or commercial purposes; roadway mortality; habitat alteration, destruction and fragmentation; climate change; disease; effects from nonindigenous species; ultraviolet radiation; and xenobiotic chemicals (Gibbons et al. 2000, Houlahan et al. 2000, Schlaepfer et al. 2005).

Turtles are found in freshwater, marine, and terrestrial habitats and play significant roles as carnivores, herbivores, and scavengers. Worldwide there are 260 living species in 13 families and about 75 genera (Harding 1997). Forty-eight species occur in the United States and Canada, with the highest diversity reported in the southeastern states. Michigan has 10 turtle species (Table 1) represented by four families: Family Chelydridae (common snapping turtle *Chelydra serpentina serpentina*); Family Kinosternidae (common musk turtle *Sternotherus odoratus*); Family Emydidae (Blanding's turtle *Emydoidea blandingii*, common map turtle *Graptemys geographica*, eastern box turtle *Terrapene carolina*, painted turtle *Chrysemys picta*, red-eared slider *Trachemys scripta elegans*, spotted turtle *Clemmys guttata*, wood turtle *Glyptemys insculpta)*; and Family Trionychidae (spiny softshell turtle *Apalone spinifera spinifera*). Of these, nine are native to Michigan, with the red-eared slider introduced from pet releases (Harding 1997).

In spite of their evolutionary persistence, few substantive studies exist on the population biology of turtles. Such studies require considerable time and effort, requiring two decades or longer to follow a single cohort. Fortunately, long-term population studies have been conducted on turtles in Michigan (Congdon et al. 1993) and Ontario, Canada (Galbraith and Brooks 1987; Brooks et al. 1991). Lack of scientific information, especially life-history trait values, has hindered development of conservation programs for these unique animals (Congdon et al. 1993).

Table 1.–Life history attributes of Michigan turtles [a].

Life expectancy (years)	Adult carapace length	Age at maturity (years)	Clutch size (number)	Nesting period (months)	Incubation period (days)	Nest distance from water	Habitat preference	Food preference	Home range [b]	Population trend [c]
Common snapping turtle *Chelydra serpentina serpentina* (Medium-risk species):										
Wild unknown; Captive 38 [d]	8–19.8 in (20–47 cm) ♂ larger	11–16; 17–20 farther north	10–100+; 28 ave.	May–Jul	65–95	3.3–600 ft; 122 ft ave. (1–1,625 m; 37 m ave.) [b]	Slow-moving rivers, marshes, and muddy bottomed lakes with dense vegetation	Omnivorous; insects, worms, leeches, crayfish, snails, amphibians, fish, algae, carrion, aquatic plants	0.6–22 ac (0.25–9 ha)	Generally common in Great Lakes basin, but some local populations have been depleted by overharvest
Common musk turtle *Sternotherus odoratus* (Low-risk species):										
Wild 28; Captive 54	3.5–5.4 in (7.5–13.5 cm)	♀ 7–11; ♂3–4	1–12; 3–5 ave.	Apr–May	60–90	<98 ft (<30 m)	Shallow, slow moving or quiet waters with soft bottom	Omnivorous; macroinvertebrates, snails, crayfish, worms, tadpoles, aquatic plants	–	Locally common in lower Great Lakes; declining in areas with residential development
Spotted turtle *Clemmys guttata* (High-risk species):										
Wild 26; Captive 42	3.5–5.4 in (9–13.6 cm)	7–14	2–7	Mar–May	45–83	>328 ft (>100 m)	Clean, shallow, slow-moving waters, small ponds, wide variety of shallow wetlands with soft bottom and vegetation	Omnivorous; small animals, aquatic plants, macroinvertebrates, snails, worms, slugs, crayfish, tadpoles, duckweed, algae, fruit	1.2–8.6 ac (0.5–3.5 ha)	Uncommon to rare throughout Great Lakes range and confined to isolated colonies with good habitat
Wood turtle *Glyptemys insculpta* (High-risk species):										
Wild 50+; Captive 58	6.3–9.8 in (16–24.9 cm)	12–20	3–18; 10.5 ave.	May–Jun	47–69	–	Usually within 500 ft (150 m) of sandy-bottomed streams and rivers with herbaceous vegetation	Omnivorous; worms, insects, berries	2.5–12.4 ac (1–5 ha)	Generally uncommon to rare with significant decline due to human actions and disturbances; predation by subsidized predators especially raccoons

Table 1.–Continued.

Life expectancy (years)	Adult carapace length	Age at maturity (years)	Clutch size (number)	Nesting period (months)	Incubation period (days)	Nest distance from water	Habitat preference	Food preference	Home range [b]	Population trend [c]
Eastern box turtle *Terrapene carolina carolina* (High-risk species):										
Wild 40–50+; Captive 138 record	4.6–7.8 in (11.7–19.8 cm)	10; most are >15	3–11	Jun	50–90	–	Deciduous or mixed woodlands with sandy soils near a source of water	Young are carnivorous; adults are omnivorous; snails, crayfish, insects, fungi, and fruits	≤5 ac (<2 ha)	Locally common in parts of range with significant decline in much of former Michigan range
Blanding's turtle *Emydoidea blandingii* (High-risk species):										
Wild 50–70; 80+ record	6–10.8 in (15.2–27.4 cm)	14–20	6–21; 10.2 ave.	May–Jun	50–75	>328 ft (>100 m)	Productive, clear, shallow waters over firm substances, ponds, marshes, etc.	Omnivorous; crayfish and macroinvertebrates	–	Has been eliminated in many places, but can be fairly common where suitable habitat exists
Common map turtle *Graptemys geographica* (Low-risk species):										
Wild unknown; Captive 18	♀ 6.7–10.7 in (17–27.3 cm); ♂4–6.3 in (10–16 cm)	♀ 10–14; ♂3–5	6–20	May–Jul	50–70	<98 ft (<30 m)	Larger lakes and rivers with abundant basking sites	Primarily mollusks; macroinvertebrates, snails, and crayfish	–	Have disappeared from heavily polluted urban areas but locally common throughout lower Great Lakes basin
Painted turtle *Chrysemys picta sp.* (Low-risk species):										
Wild 35–40	3.5–9.8 in (9–25 cm)	♀ 6–10; ♂3–7	3–20; 7–8 ave.	May–Jul	50–80	>328 ft (>100 m)	Quiet, slow moving ponds, lakes, marshes or streams	Omnivorous; aquatic plants, macroinvertebrates, snails, crayfish, tadpoles, etc.	–	Common-to-abundant throughout most of region except far north

Table 1.–Continued.

Life expectancy (years)	Adult carapace length	Age at maturity (years)	Clutch size (number)	Nesting period (months)	Incubation period (days)	Nest distance from water	Habitat preference	Food preference	Home range[b]	Population trend[c]
Red-eared slider *Trachemys scripta elegans* (Low-risk species):										
Wild 19; Captive 42	5–11.4 in (12.5–28.9 cm)	♀ 6–8; ♂2–5	2–30	May–Jul	65–80	>328 ft (>100 m)	Still water habitats with soft bottom and vegetation	Omnivorous; aquatic plants, crayfish, snails, tadpoles	–	Generally common throughout most of range but restricted to few localized populations
Spiny softshell turtle *Apalone spinifera spinifera* (Medium-risk species):										
Wild unknown; Captive 25	♀ 9.4–18.9 in (24–48 cm); ♂5–9.4 in (12.7–24 cm)	♀ 8–10; ♂4–5	9–38	Apr–May	55–85	<98 ft (<30 m)	Larger rivers, lakes and impoundments with sandy or muddy bottoms	Carnivorous; crayfish, macroinvertebrates, snails, tadpoles and fish	–	Locally common in western Great Lakes region, but uncommon to rare in eastern part

[a] Harding 1997, unless noted otherwise
[b] Semlitsch and Bodie 2003
[c] Harding, MSU, personal communication
[d] Ernst et al. 1994

This management plan is the initial step for providing additional conservation protection and attention to Michigan turtle species. The primary goal of this management plan is to provide natural resource users and managers, scientists, conservationists, and educators with a conservation strategy for the protection of self-sustaining populations of Michigan turtles, specifically:

1. To protect Michigan's native turtles from overexploitation.
2. To preserve native turtle populations for future generations.
3. To provide recreational sport harvest of turtles where sustainable and appropriate.
4. To identify knowledge gaps and work with external groups to fill these gaps.
5. To increase public awareness about Michigan's turtles.

Life History

Turtles have evolved a suite of life history traits that severely limit their ability to respond to increased loss of breeding-age adults (Congdon et al. 1987). This life history suite has been described as a "bet-hedger" strategy where adults are characterized as having delayed sexual maturity, low reproductive success, and high survival rates (Brooks et al. 1988; Congdon et al. 1993, 1994). High annual adult survivorship is important to have many mating events to offset high egg and hatchling mortality, a low rate of recruitment into the breeding population, and relatively late maturity and low fecundity (Galbraith and Brooks 1986). Congdon et al. (1993) reported that a Blanding's turtle population in southern Michigan required a high annual adult (93%) and juvenile (72%) survivorship to maintain a stable population. Reed and Gibbons (2004) report that there is no reason to believe that annual adult survival rates for any turtle species are below 90% in healthy populations.

Life histories of many turtle species include annual or seasonal movements over land for foraging, breeding, nesting, juvenile dispersal, and overwintering. A turtle's protective shell is key to their longevity since it protects juvenile and adult turtles from predation. A turtle may lose an appendage, however, it still may be able to live out its life effectively reproducing and contributing to the viability of a population. In contrast, a turtle's hard shell is no match for a car, truck, or bullet which removes reproductive adults from a population.

Turtle populations have difficulty coping with additional mortality, particularly of reproductive adults, since they have little or no density-dependent behavioral responses that facilitate increases of reproductive success. Brooks et al. (1991) and Congdon et al. (1993) reported that an annual increase of 10% mortality of mature females may lead to population declines. Congdon et al. (1994) constructed a life table from turtle population data collected from 1975 – 1992 and concluded that population stability was most sensitive to changes in adult or juvenile survival. They concluded that an increase in annual mortality of 10% on adults over 15 years of age would halve the number of adults in the population in less than 20 years. A snapping turtle population model analysis indicated that it would take at least 42 years for a population to recover to the initial number of adult females if 10% of the adult females were harvested during a single event. Congdon et al. (1994) reported that a stable population of snapping turtles resulted in a cohort generation time of approximately 25 years. Adult turtles are largely immune to predation other than by humans. In contrast, a wide diversity of predators prey on turtle eggs (raccoons, opossum, skunks, foxes) and hatchlings (herons, large fish), and mortality is very high during these stages (Brooks et al. 1988).

Compared with most other animals, turtles have exceptionally high ages at maturity and require high annual survivorship. Only Lake Sturgeon *Acipenser fulvescens*, whales *Cetacea*, elephants *Elephantidae*, hippos *Hippopotamidae*, chimpanzees *Pan* spp., lions *Panthera leo*, and a few seals *Pinnipedia* spp. exhibit high ages at maturity (7–15 years), have total life spans comparable to turtles, and have high adult female survivorships in the range exhibited by turtles (Reed and Gibbons 2004). Yet, few resource managers would argue that Lake Sturgeon or any of these mammalian species can

be heavily exploited without causing population declines. In fact, these species are of considerable conservation concern due to past or current unsustainable exploitation rates. Therefore, reptilian turtle species that exhibit similar demographic characteristics deserve the same intensive monitoring and conservation protection.

Turtle populations are considered to be generally in a state of decline regionally as well as globally (Ernst et al. 1994; Schlaepfer et al. 2005). Four of the 10 turtle species are state-listed, affording them with special protection from harvest or collection: Blanding's turtle (special concern), eastern box turtle (special concern), wood turtle (special concern), and spotted turtle (threatened).

Reproduction

The reproductive process begins in mature males when sperm is produced and stored over winter in the male testes. Sperm is transferred to females the following spring during mating (May and June ovulation) and new ova start to mature. A courtship precedes the actual mating event that varies by species. Turtles deposit their eggs on dry land where females dig a nest, arrange eggs, and cover the nest using their hind feet only. Female turtles, upon completion of egg deposition, do not return to the nest. Incubation period varies across species (Table 1) and environmental conditions can play a role in nesting success. As hatchlings emerge (July or August), they are on their own since turtle adults do not provide parental care.

Clutch sizes for each of the turtle species vary widely (Table 1) and some species have the ability to produce more than one clutch per year. Research indicates that the ability to produce more than one clutch per year is dependent upon the length of the active season; generally, multiple clutches are less likely at the northern extremity of the range (Ernst et al. 1994). Congdon et al. (1994) estimated that only 85% of the mature female common snapping turtles nest in a given year. Eggs hatch after an incubation period ranging from 45 to 95days depending upon species (Table 1) and environmental temperature variability.

Most Michigan turtle species have temperature (environmental) dependent sex determination, where the incubation temperature an embryo experiences during its development determines the sex of the hatchling (Bull and Vogt 1979; Bull 1980; Bull et al. 1982a, 1982b; Paukstis and Janzen 1990; Ewert and Nelson 1991; Janzen and Paukstis 1991). Incubation temperatures from 22.5°C – 27.5°C generally result in production of male hatchlings while warmer temperatures produce female hatchlings (Ernst et al. 1994). Spiny softshell and wood turtles are exceptions and have genetic sex determination (Janzen and Paukstis 1991).

Feeding Habits

Many species of turtles are carnivorous when young but make the transition to herbivory as they mature. Generally, turtles are considered opportunistic omnivores. They stalk their prey by actively searching, although some will lie in ambush (Ernst et al. 1994). They will eat invertebrate and vertebrate animals and plant material including worms, leeches, slugs, snails, mollusks, insects, crayfish, fish, amphibians, algae, aquatic plants, fruits, mushrooms, and carrion (Table 1). Lagler (1943) conducted a diet study on common snapping turtles and concluded that nongame fish, invertebrates, and plant material make up the bulk of the diet. In some cases, waterfowl and game fish have been documented in the diets of common snapping turtles (Coulter 1957; Abel 1992) which has resulted in a negative perception of this species by the public. According to Kynast (2003) birds are only an incidental prey item and rarely taken, and even then only in localized areas. However, research has shown that the consumption of young waterfowl by turtles is limited generally to those conditions where there is both

a high abundance of turtles as well as a high number of ducklings or cygnets confined in an area and this poses no threat to waterfowl populations (Brooks et al. 1988; Lagler and Applegate 1943).

Movement

Michigan turtles are primarily associated with aquatic habitats, with eastern box turtle the lone terrestrial species. The turtles are active from April through October, depending upon weather. Turtles hibernate during winter and research has shown that in northern parts of their ranges in North America, turtles may spend more than half of their lives in an overwintering state (Ultsch 2006). They become active again to feed and move around as water and air temperatures rise into the range of 15 – 20°C.

Mating occurs in spring as males and females actively search for mates and go through courtship activities. During June and July, females may travel distances greater than 183 meters to search for nesting sites (Table 1). During hot, dry weather, some turtles will aestivate until temperatures recede to lower levels. In late summer and during drought conditions turtles migrate from shrinking semipermanent wetlands to other wetlands with suitable water resources. Hatchlings generally emerge in August and September and move towards water where they can find food and cover from predation. Nest distances vary by species (as well as within species) and may contribute to mortality rates of young hatchlings trying to migrate to aquatic habitats. Normal daily activities for a turtle include sleeping, basking, and foraging. Turtles are generally diurnal with musk and common snapping turtles described as nocturnal. The described home ranges for several Michigan turtles (Table 1) are from 0.25 hectares to 9 hectares or larger.

Natural Mortality

Turtles are long lived and may live longer than any other living vertebrate (Ernst et al. 1994). This is especially true for box turtles that have been known to live for more than a century. Individual natural mortality events can occur at any time of year especially during stressful times like mating events or over wintering. On rare occasions, a large number of turtles in a local population can be killed by extreme weather events. For example, in April 2003 an unseasonably warm period was followed by a freeze in Bay County, Michigan. At that time, 13 to 14 large snapping turtles were reported to have died along a local drain. The dead turtles were reported by local residents who became alarmed at their numbers in one small area (James Baker, MDNR Fisheries Division, personal communication). Although still considered a natural mortality event, there can be long-term and profound consequences to a population experiencing this type of loss. James Harding (Michigan State University, personal communication) was consulted and indicated that the turtles had come out of hibernation during the warm weather and desperately needed to bask in order to clear their bodies of lactic acid that had built up during their hibernation. When the cold weather returned, the turtles were unable to stay warm and succumbed to bacterial infections. There were reports from at least seven other locations where this type of mortality event had been noted. As a result, the loss of mature turtles to that population has likely reduced the reproductive potential for years to come (J. Harding, Michigan State University, personal communication).

Distribution and Abundance by Species

In Michigan, turtle populations range from common to rare (state-listed as threatened). There are currently four species that are state-listed and require extra protection. As threats to habitat increase and more roads are built, there is reason to believe that many localized populations could be negatively affected by anthropogenic activities. Population data for Michigan turtle species is lacking since most information is

collected through small university studies, which are limited in size and scope. Michigan turtle populations have not been inventoried and most population information is based upon general assumptions focusing on regional or national trends. There is no recreational harvest-reporting requirement for the take of turtles in Michigan and until recently, commercial turtle harvest reporting, although required, was limited (Goniea 2015).

Historical distribution and abundance of turtles in Michigan is not well known; perhaps the best source of this information comes from records at the University of Michigan, Museum of Zoology. Turtle observation records are also compiled in Michigan Department of Natural Resources (MDNR), Fisheries Division Fish Collection database dating back to 1991 (Figure 1). However, compliance for turtle observation data entry and level of expertise of observers is not known. Painted turtles were the most common turtles observed (42%) followed by common map (20%), common musk (18%), spiny softshell (11%), and common snapping turtle (9%). Other turtles rarely observed included Blanding's, wood, spotted, red-eared slider, and eastern box turtle.

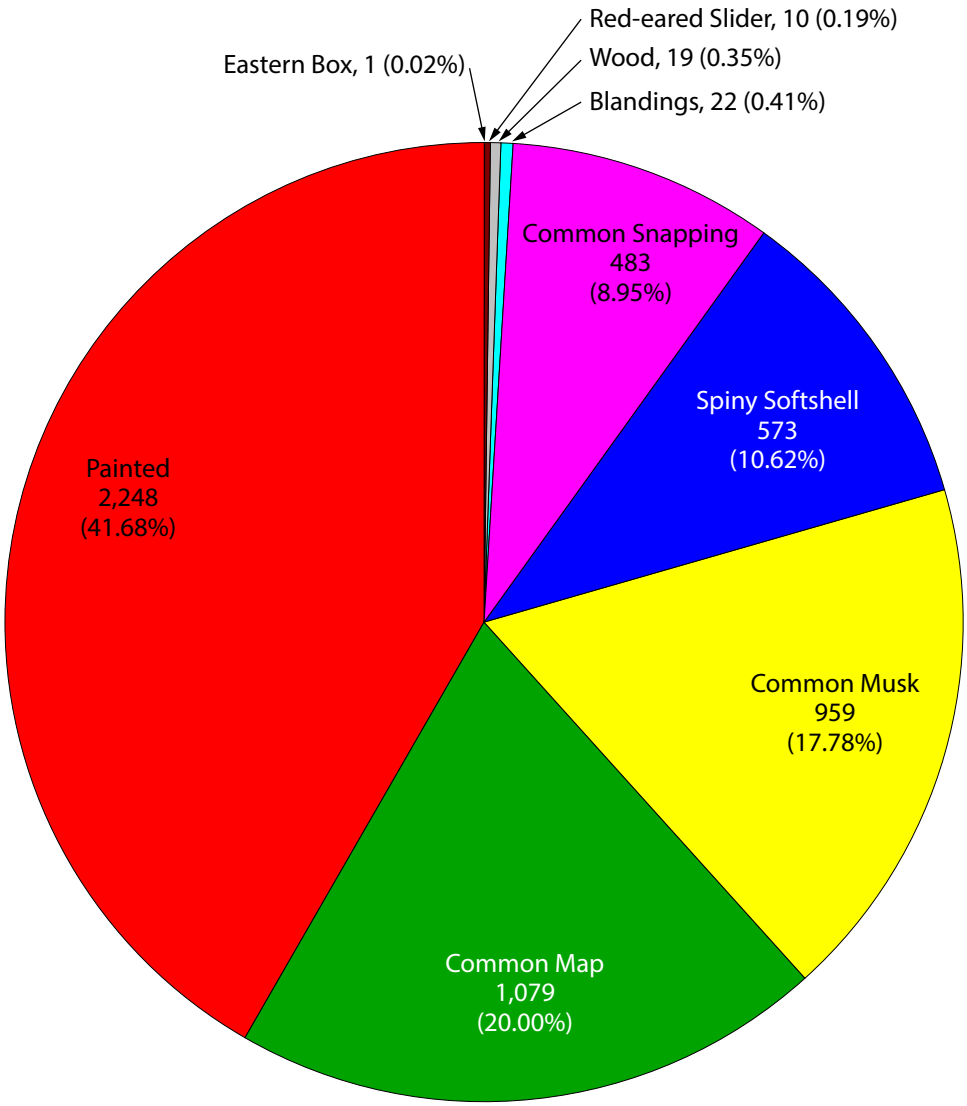


Figure 1.–Turtle observations recorded in MDNR, Fisheries Division Fish Collection database (1991–2007).

Limited turtle distribution information is collected annually by the MDNR Wildlife Division Natural Heritage Program through the Michigan Herp Atlas Project. In the program, volunteers report herpetological observations via data card submission. The manual and data cards are available online (www.michigan.gov/dnr). Distribution information about special-concern or state-listed species has been collected by Michigan Natural Features Inventory (MNFI) personnel who conduct field surveys to locate and identify threatened and endangered species and communities throughout the state. General distributional information is available for turtles primarily from two main sources; Harding (1997) and Harding and Holman (1990) in the excerpts below (taxonomy is based upon Harding 1997):

Common snapping turtle (*Chelydra serpentina serpentina*): Common snapping turtles are generally common with widespread distribution throughout lower and upper Michigan, except Isle Royale (Figure 2A). They are considered habitat generalists that can be found in any permanent or semipermanent lentic or slow-moving lotic water. They prefer shallow waters with a mucky or soft bottom that they can bury themselves in and still stick their heads up to breathe. They can spend considerable time out of water, but permanent bodies of water are required to maintain populations (Graves and Anderson 1987). Localized populations have been reduced by overharvest (J. Harding, Michigan State University, personal communication).

Common musk turtle (*Sternotherus odoratus*): Common musk turtles are locally common in the southern half of the Lower Peninsula with a few records of scattered populations in the north. The distribution of these turtles has been described as uneven in its Michigan range (Figure 2B). These turtles are known to inhabit shallow, slow-moving, or quiet waters associated with some aquatic vegetation. They prefer shallow areas of lakes with marl, sand, or gravel bottoms. Human waterfront development has caused some populations to decline or disappear in recent years (J. Harding, Michigan State University, personal communication).

Spotted turtle (*Clemmys guttata*): Spotted turtles have been recorded throughout the Lower Peninsula, except the northeastern counties and the northern Lower Peninsula (Figure 2C). The spotted turtle is state-listed as threatened in Michigan. They are most common in the southwestern corner of the state. Destruction of their specialized wetland habitat and exploitation by pet collectors has led to serious declines in numbers over much of their Michigan range. The species is considered generally rare and confined to localized colonies. Spotted turtles inhabit small ponds, bogs, sphagnum seepages, and grassy marshlands. They require clean, shallow water with a soft substrate and aquatic and emergent vegetation.

Wood turtle (*Glyptemys insculpta*): Wood turtles are primarily found in the northern two-thirds of the state (Figure 2D). Scattered records from the far southern part of the state may reflect movement of the species by humans. Wood turtles can be locally common in prime habitats with minimal human disturbances, but many populations have declined significantly over the past two or three decades. The wood turtle is listed as a species of special concern in Michigan. Wood turtles occur near rivers and streams in northern woodland areas. They prefer flowing waters with sandy bottoms avoiding fast currents and rocky sections. They spend much time wandering through adjacent swamps, woods, and meadows during summer. Significant population declines have been attributed to collection of wood turtles as pets. Road mortality is considered significant for this species, especially on roads built along northern rivers. This species appears to be more threatened by the actions or disturbances caused by humans than from loss of habitat.

Eastern box turtle (*Terrapene carolina carolina*): Eastern box turtles are distributed along the western and southern Lower Peninsula (Figure 2E). They are locally common in areas with good habitat, but have practically disappeared from much of their former Michigan range. They are considered uncommon to rare and steadily declining in the region, but were historically quite common and widespread in woodlands of the eastern Lake Michigan and western Lake Erie basins. The eastern box turtle is listed as a species of special concern in Michigan. This species is Michigan's only truly terrestrial turtle. They can be found inhabiting open woodlands often near water. They have also been known to wander into thickets, meadows, grassy dunes, and gardens. Eastern box turtles will soak in

water during hot weather but avoid deep water because they are poor swimmers. The most serious threat for this species has been loss of wooded habitats through human disturbance and many box turtles are killed on roads or collected as pets each year.

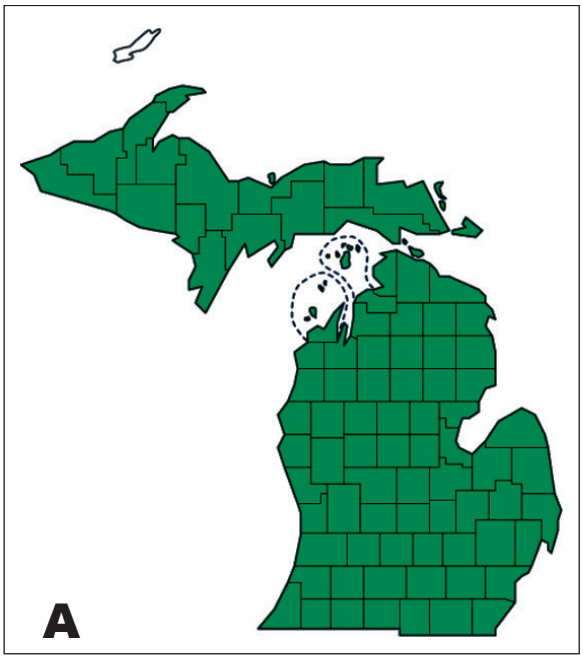
Blanding's turtle (*Emydoidea blandingii*): Blanding's turtles are fairly common in parts of the Lower Peninsula, but considered rare and localized in the central part of the Upper Peninsula (Figure 2F). The Blanding's turtle is listed as a species of special concern in Michigan. It inhabits shallow waters of marshes, ponds, and backwater areas with muddy substrates and aquatic vegetation. They are often seen traveling overland during spring or fall and females may travel long distances in search of suitable nesting habitat. Blanding's turtle populations have been affected by loss and alteration of wetland habitats.

Common map turtle (*Graptemys geographica*): Common map turtles are found in the southern and western counties of the Lower Peninsula (Figure 2G). They are common in larger lakes, rivers, and oxbow sloughs. Map turtles are often seen basking on emergent logs and rocks. When disturbed, they will dive into the water to hide under logjams or submerged brush. They are powerful swimmers that will inhabit waters with fairly strong current compared to most other turtle species. Some populations have been reduced or eliminated by pollution and other human disturbances (J. Harding, Michigan State University, personal communication).

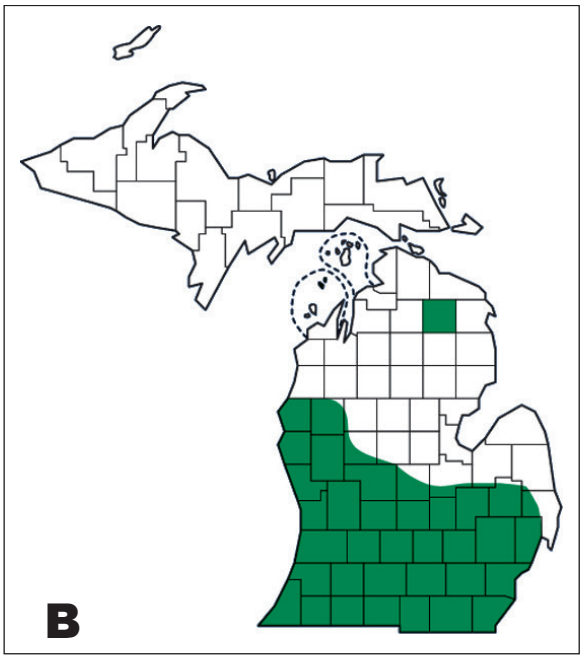
Painted turtle (*Chrysemys picta sp.*): Painted turtles are the most common turtles in Michigan and they are found throughout the state (Figure 2H). Two subspecies occur in Michigan: the midland painted turtle (*Chrysemys picta marginata*) and the western painted turtle (*Chrysemys picta belli*). The midland painted turtle is common throughout the state, except for the western Upper Peninsula, where the western painted turtle is more common. The western painted turtle occurs in the western and northern Lake Superior basin and intergrades with the midland race from the Upper Peninsula. Hybridization between the two is considered common throughout the Upper Peninsula. Painted turtles are found in ponds, lakes, marshes, and slow-moving streams and rivers. They prefer shallow water with muddy substrates and aquatic vegetation. Many are killed by vehicles on roads. Painted turtles are generally tolerant of organic pollution and can survive in urban areas.

Red-eared slider (*Trachemys scripta elegans*): Red-eared sliders are a nonnative species in Michigan that have established naturalized populations. Historically, many thousands of juvenile sliders were imported into Michigan via the pet trade. It is likely that breeding populations were initially established through released or escaped pets. Though considered generally common throughout most of its range, the red-eared slider is restricted to widely-scattered and very localized populations in Michigan. Several breeding populations have been documented in a few western and southern Lower Peninsula counties (Figure 2I). Red-eared sliders prefer quiet water habitats like lakes, ponds, and sloughs with abundant aquatic plants and numerous basking sites in the form of logs or other emergent objects.

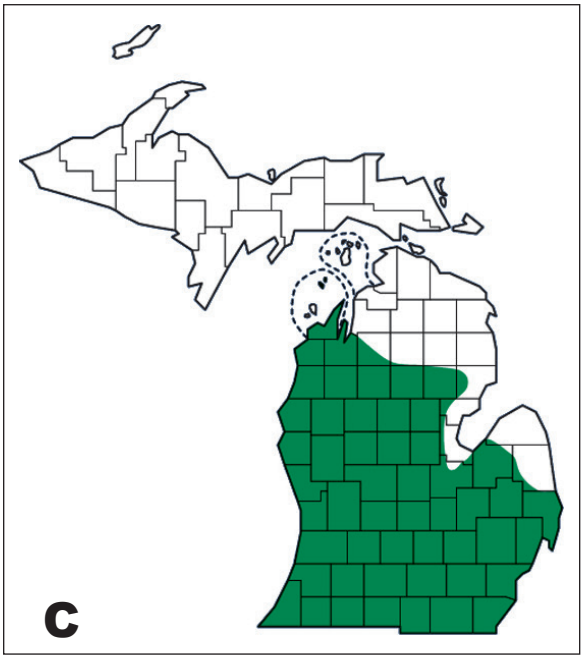
Spiny softshell turtle (*Apalone spinifera spinifera*): Spiny softshell turtles are locally common in many areas throughout the southern Lower Peninsula (Figure 2J). This species is highly aquatic and occurs in rivers, large lakes, and impoundments. They prefer waters with sandy or soft substrates. They will bask on logs, sloping banks, or spend time buried in sand or mud in shallow water. They spend most of their time in well-oxygenated water. They can spend up to five hours underwater by absorbing oxygen through their mouth and pharynx, which may explain their sensitivity to pollutants. They are agile swimmers but rarely venture inland except to nest. Some populations have been negatively affected by water pollution, exploitation, and loss of nesting habitat (J. Harding, Michigan State University, personal communication).



Common snapping turtle
Chelydra serpentine serpentina



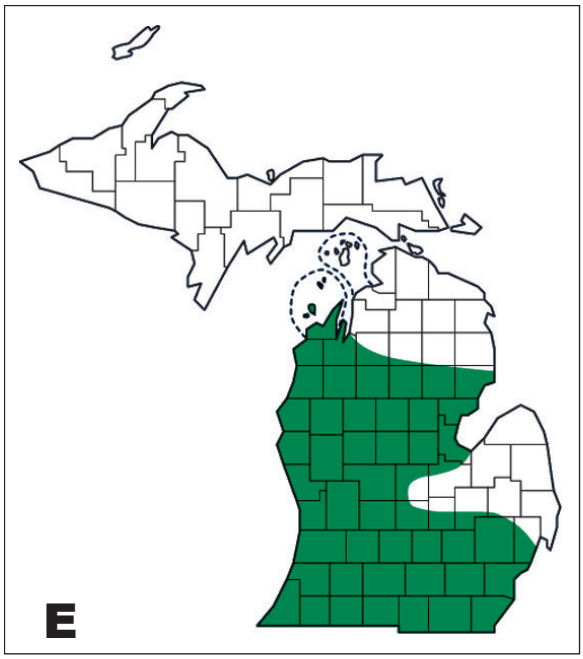
Common musk turtle
Sternotherus odoratus



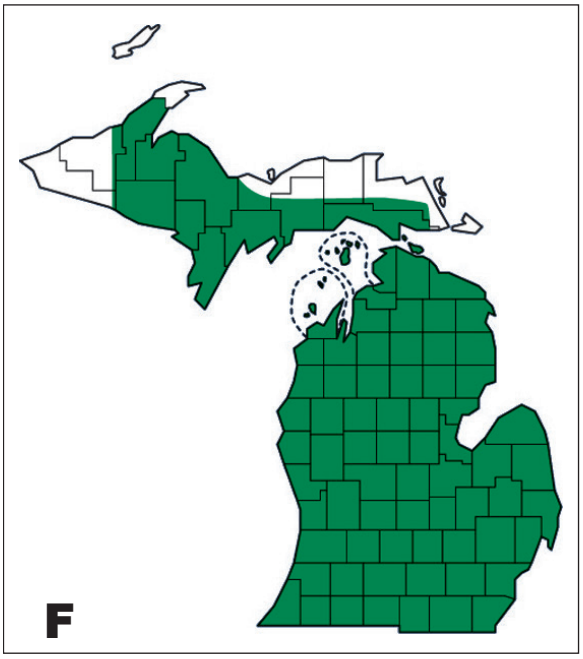
Spotted turtle
Clemmys guttata

Wood turtle
Glyptemys insculpta

Figure 2.–Turtle species distribution in Michigan, adapted from Harding and Holman (1990).

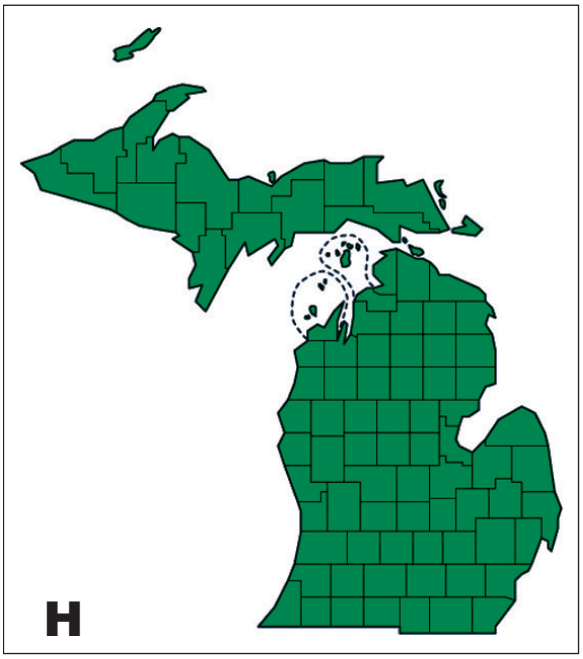


Eastern box turtle
Terrapene carolina carolina



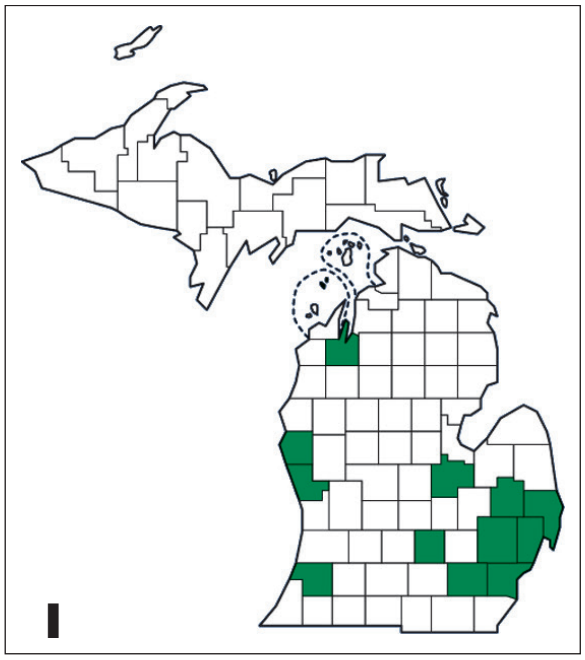
Blanding's turtle
Emydoidea blandingii

Common map turtle
Graptemys geographica

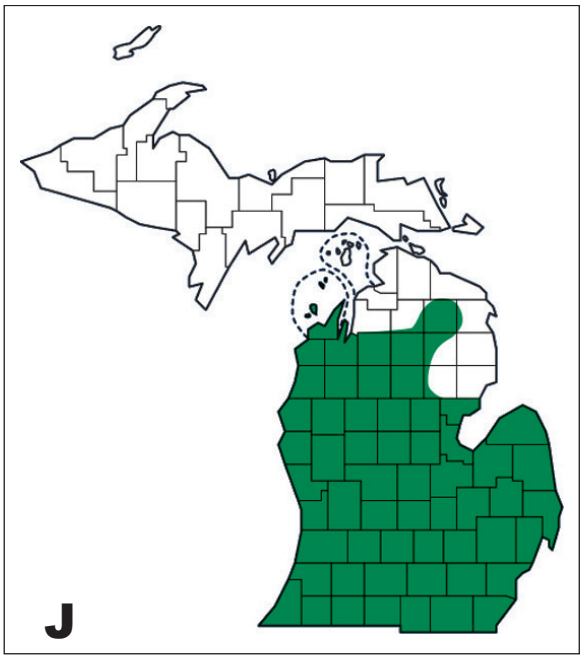


Painted turtle
Chrysemys picta sp.

Figure 2.–Continued.



Red-eared slider
Trachemys scripta elegans



Spiny softshell turtle
Apalone spinifera spinifera

Figure 2.–Continued.

Threats to Turtle Populations

Turtle and human populations appear to have an inverse relationship, with human populations expanding throughout the globe and placing more pressure on turtle populations. Ernst et al. (1994) states that turtle populations have been decreasing at an alarming rate in North America and if the trend continues all turtle species will be threatened with extinction in the 21st century. Turtles lack the ability to respond biologically to increased adult mortality (especially of mature females) that results in unstable populations (Brooks et al. 1991; Congdon et al. 1993). It can take many years for turtles to recover from just one catastrophic event where many adults are lost or removed. Turtles are not capable of producing large volumes of eggs like amphibians or fish; instead, they must rely on longevity, replacing themselves at least once over several decades. Therefore, one wild and mature adult represents an enormous genetic investment (Williams 1999a). Life-history traits of turtles limit their harvest potential and make them vulnerable to overharvest or exploitation (Congdon et al. 1993, 1994; Klemens and Thorbjarnarson 1995; Gamble and Simons 2003). Turtle populations are directly and indirectly affected by humans through harvest for food and biological supply, casual collection, pet trade, habitat destruction and alteration, roadway mortality, lack of predator control, spread of diseases, pollution or environmental contamination, and global environmental changes. The three primary factors contributing to the decline of turtles are over-collection for food, the pet trade, and habitat destruction (Ernst et al. 1994).

Harvest

Turtles are collected from wild populations throughout the world and are being sold in markets as food, folk medicine, biological supplies, and pets. Casual collection is also a problem for wild turtle populations. These uses are coming at the expense of wild populations, which are being depleted at

alarming rates. Turtles have an intrinsic and exceptionally high trade value associated with certain cultures where they have long-standing traditional medicinal values that can inflate demand and prices. Nowhere is this more evident than in Southeast and East Asia where it is estimated that one-half of all freshwater tortoises and turtles are currently endangered or critically endangered as a result of overharvest for food and production of traditional folk medicine (Jenkins 1995; Klemans and Thorbjarnarson 1995; van Dijk et al. 2000; Schlaepfer et al. 2005). According to Williams (1999b), wild-caught, mature turtles are highly prized in Chinese markets because they are thought to confer wisdom, health, or longevity to those who consume them. In Southeast Asia, human consumptive uses of turtles have been implicated in population decline and extinction of several turtle species (Thorbjarnarson et al. 2000). The recent explosive and insatiable demand on wild turtles has been traced to China's convertible currency that made turtles and tortoises a cash commodity, putting demand pressure on China's and other countries' turtle supplies (Barzyk 1999).

Although turtles are still commercially harvested domestically in several states, there is a strong global market that will undoubtedly increase the pressure for expanded turtle harvest in the United States, both legally or illegally (Schlaepfer et al. 2005). According to Senneke (2006), exported turtles are believed to experience one of four fates: (1) sent directly to food markets in China or Southeast Asia, (2) sent to Asian turtle farms to grow for later consumption, (3) used as broodstock in a farm, or (4) sent to a market for the pet trade. High demand could result in rising harvest for legitimate and illicit trade of highly valued species. Schlaepfer et al. (2005) reported that international trade of reptiles for the period of 1998 to 2002 included exports of 26,000,000 wild-caught whole reptiles from the United States. They also report that this is only a fraction of the world market and that total trade numbers are much higher. The World Chelonian Trust (Senneke 2006) reports that 31,783,380 live turtles were declared exports from the United States in just over three years (November 2002 to November 2005). The report indicated that this number did not include dead turtles exported most likely as food or unreported illegal exports.

Pet trade in reptiles is a global industry with values estimated between $1.5 and 2.0 billion annually in the United States (Reed and Gibbons 2004). Even though sale of turtles less than four inches (carapace length) for pets is prohibited by law, loopholes created by exemptions are being exploited. Reed and Gibbons (2004) also report that of households owning reptiles or amphibians, nearly half (46%) own turtles. It is believed that virtually every turtle purchased from a pet store is sick or infested with parasites, explaining why nearly 95% of the wild turtles that enter the pet trade are dead within a year (Williams 1999a). Pet stores make their money from repeat customers who often invest a large sum of money buying their pet's aquarium and supplies, with the turtle often being the lowest cost item purchased. Surveys of the online animal trade conducted by Reed and Gibbons (2004) revealed that 24 dealers had 17 native turtle species (including all 10 species found in Michigan) for sale with prices ranging from $0.62 for hatchling red-eared sliders to $240 for adult wild-caught spotted turtles. The large numbers of turtles being sold as pets is of concern since their collection origins are unknown and ongoing collections from wild populations are likely not sustainable.

Casual collection of wild adult turtles can also have a negative effect on wild turtle populations. Williams (1999a) reported on a 20-year study of wood turtles in Connecticut involving the collection and marking of 133 subjects in an area initially closed to public recreation. In 1983, the watershed was opened to public recreation, and the turtles immediately began to disappear. A closer look indicated that hikers were taking the turtles home one at a time. In 1991, only 14 marked turtles were collected, and in 1992, no marked turtles remained. Populations can be devastated over years by many individuals through casual collection or suddenly by a few experienced poachers.

Michigan is not immune to the exploitation of its native turtle fauna. Illegal collection of wild turtles, including each of Michigan's state-listed and protected turtle species, has been documented previously (W. Hamilton, 2007 memorandum to C. M. LeSage, MDNR, on exploitation of Michigan turtles). Operation Slither, conducted by the Law Enforcement Division Special Investigative Unit (SIU) infiltrated a group who commercialized and engaged in illegal sale of protected turtle species as well as

juvenile or hatchlings of many other species. This operation spread to a total 12 states where warrants and charges were filed against 14 individuals. A brief summary of the findings indicated that spotted turtles (state-listed threatened) were the rarest and most highly sought at values between $275 and $400. Shipping them to Europe or abroad could increase the price to ten times the amount. Blanding's turtles (special concern) were traded and sold in much higher volumes (nearly 1,000 taken illegally from the wild) with prices ranging from $75 to $100. Hundreds of wood turtles (special concern) were illegally sold with 100 being seized at a single residence and valued at $75–$125 for each. Eastern box turtles (special concern) would bring $15–$50 each. Snapping turtle juveniles would sell for $4–$10 and many other species would bring $25–$50 for an individual. According to SIU, juveniles (of any species) were highly valued. Color morphs apparently were the prized item in the industry, regardless of species, and could increase the value of an individual by ten times. As is the case in any other commodity, supply and demand directly affects the value of the product. Although some of the perpetrators have been detained, the amount of monetary wealth that can be attained through this type of activity makes this problem an ongoing threat. The investigation also concluded that there were an alarming number of individual citizens collecting state-listed species for personal pets.

Adult turtles are the primary target for these ventures and as Congdon et al. (1994) reported, just a 0.1 increase in annual mortality on adults over 15 years of age with no density-dependent compensation, would halve the number of adults in less than 20 years. Brooks et al. (1991) reported that populations of species with high stochastic juvenile mortality and long adult life spans may be decimated quickly by increased levels of adult mortality. A report conducted on painted turtle commercial harvest in Minnesota indicated that commercial harvest affects the population by lowering relative abundance and altering population demographics. Model simulations indicated that removal of a small proportion of the females can negatively affect population viability (Gamble and Simons 2003). The difficulties associated with long-term studies conducted on long-lived species hinder collection of good population estimates. However, existing research and increased awareness of an expanding domestic and international trade in turtles for food and pets has caused several state and federal agencies to limit or abolish commercial turtle activities (Anonymous 2002; Austin 2002; Close and Seigel 1997; Thorbjarnarson et al. 2000; Gamble and Simons 2003).

In Michigan, turtles have been harvested both commercially and recreationally over much of the past 100 years, although little is known about the effects of harvest on these turtle populations. According to Lagler (1943), "the softshell turtle was considered as the most prized for its taste while the snapping turtle was highly esteemed and most used due to greater abundance and ease of capture." Harvest activities were almost entirely unregulated until 1989, when MDNR initiated a Director's Order on Reptiles and Amphibians. Although regulations have been in place for nearly two decades, little harvest or population information is available to allow for regulation or community assessments. Specific information about general turtle harvest is lacking, though it can be assumed that increases in personal harvest can be expected as more populations are depleted in other areas of the world, thus driving up market values for live turtles from Michigan.

Habitat Destruction or Alteration

During the previous century, environmental laws were lacking and wetland habitat was drained and converted to farmland. Legislation, such as the National Environmental Protection Act (1970), the Clean Water Act (1972), and Michigan's Public Act 451 Part 303 (1994), has protected wetland habitat, which benefits many wildlife species including turtles. Terrestrial riparian habitat associated with wetlands is not afforded the same protection as wetland habitat and thus is still being lost at a fast pace. Terrestrial habitat that surrounds wetlands has been neglected in the past. Now more attention is being directed towards these critical areas. Riparian terrestrial habitats (also called buffer zones) are areas where physical and chemical filtration occurs. This is important for the protection of water resources

from siltation, chemical pollution, and temperature increases due to anthropogenic effects. Research indicates that riparian terrestrial habitats are essential to many different animals, including reptiles and amphibians, which often live and forage in aquatic habitats most of the year, but migrate to upland habitats to nest, overwinter, or forage (Semlitsch and Bodie 2003).

With the exception of the eastern box turtle, a terrestrial species with a preference for mixed woodland forests, Michigan turtles are primarily aquatic (Table 1) and people generally consider them associated with water. However, each turtle species requires suitable riparian habitat for nesting, which is critical to completion of their life cycles. Semlitsch and Bodie (2003) described the minimum (123 meters; 403 feet) and maximum (287 meters; 942 feet) core terrestrial distances (extending from the water's edge) associated with 28 turtle species. Nesting distances from water vary by species for Michigan turtles (Table 1). In a study conducted in Livingston County, Michigan on snapping turtles, Congdon et al. (1987) showed that snapping turtles wandered up to 1,625 meters (5,331 feet) in preparation for nesting. A general review of nesting migration distances indicates how important terrestrial habitats are for turtles; loss of this habitat type is most certainly detrimental to populations.

As land use changes from small family farms to rural suburbs, land parcels generally become more divided and fragmented. What was once an untouched wetland area may become an entirely different section or parcel subdivided with varying degrees of human development. Land that is stripped of its natural vegetative cover does not provide the same benefit to wildlife inhabiting the area. Animals become displaced and must move to other locations or perish. New road construction, which generally accompanies suburban development, has also been identified as contributing to fragmentation and isolation of habitats. Habitat fragmentation can cause loss of critical habitat such as nesting or overwintering sites, resulting in decline of turtle populations over time. Smaller patches of excellent habitat may not be enough to support the minimum number of individuals needed to sustain a viable population. Predators associated with human development can also have devastating effect on nest success and hatchling survival in these smaller sections of habitat.

Habitat degradation such as waterfront development can have negative effects on aquatic and terrestrial turtle communities. Waterfront development reduces nesting and juvenile nursery areas that are critical to the survival of these species. Natural shoreline areas are converted to sheet pile sea walls, rip rap, or rock walls that provide little habitat or cover. Loss of shoreline habitat and nesting sites has been especially hard on spiny softshell turtles (J. Harding, Michigan State University, personal communication). In most cases, riparian owners replace naturally occurring vegetative cover with manicured lawns to the water's edge. Habitat loss can result in concentrated nesting areas where a few predators can destroy a large number of nests or juveniles. It is believed that the eventual reduction in recruitment caused by habitat alterations will ultimately reduce or eliminate local populations (Marchand and Litvaitis 2004).

Roadway Mortality

Roadway construction over the past century has blanketed the landscape with networks of roads, leaving only a few scattered locations without them (primarily in the west) and contributing to the widespread decline of turtle populations in the United States (Gibbs and Shriver 2002). Roads have been described to have seven general effects: mortality from road construction, mortality from collision with vehicles, modification of animal behavior, alteration of the physical environment, alteration of the chemical environment, spread of exotics, and increased use of areas by humans (Trombulak and Frissell 2000). Slow-moving reptiles are highly vulnerable to roadway mortality where migration between aquatic and terrestrial habitats involves movement across a roadway. Roads with high traffic volumes have been described as impenetrable since slow moving turtles are most active at dawn and dusk when traffic volumes can be at their peak (Gibbs and Shriver 2002). Instances of roadway mortality increase as turtles migrate to upland habitats for nesting, overwintering, or foraging activities. In some instances, turtle mortality is

a result of "the heat-sink effect", where turtles are drawn from the water to bask and warm themselves on sun-heated bridges or overpasses (J. Harding, Michigan State University, personal communication).

Studies indicate that gravid or nesting females may be particularly vulnerable to roadway mortality as they nest along roadway shoulders or travel long distances in search of suitable nesting habitat (Haxton 2000; Steen and Gibbs 2004; Aresco 2005; Lee 2005; Lee 2006). Ernst et al. (1994) reports that high numbers of female turtles are killed each year when they wander overland in search of nesting sites. The disproportional loss of mature female (as compared with mature males) turtles from wild populations has compounded the effect of turtle declines over the past century (Gibbs and Steen 2005). Shortages of mature females most likely result in increased stress on males as they search for a receptive mate. The search for a receptive female could lead to increased frequency and distance of overland travel, thus increasing the likelihood of an eventual death on a roadway.

Lee's (2005 and 2006) assessment of turtle mortality along a section of US-31 adjacent to the Muskegon River found that turtles frequently died while attempting to cross the highway during annual nesting migrations. In 2005, the close association between Muskegon River floodplain habitat and the roadway resulted in 135 recorded turtle mortalities of five species during 18 survey trips, with an estimate of 219 mortalities during the month of June alone. In 2006, 116 roadway mortalities of six different species occurred in the same study area. Annual losses of mature turtles from the study area are most likely at an unsustainable level, since life-history traits of these animals require high annual adult survivorship to maintain stable and viable populations (Congdon et al. 1993).

Predation

Michigan turtles have many natural predators that eat their eggs and young, digging up nests or devouring hatchlings as they emerge from the nest to begin their journey to the water. The "bet-hedger" strategy, as described for turtles (Brooks et al. 1988), does not provide any parental care for their young. Turtles are most susceptible to predation as eggs and hatchlings, and juveniles are highly susceptible to predation until they reach a size where they are too large to be consumed by most predators. Even adult turtles are killed or suffer attacks from predators occasionally or may lose all or part of an appendage.

Although predation is a natural source of mortality for turtles, it can become a limiting factor affecting survival of populations that are in decline (Boarman 1997). Certain animals have been described as "subsidized predators" because their populations can flourish in association with human activity and human-altered habitats. Human-afforded "subsidies" include access to food, water, and shelter resulting in overabundance of predators; examples of such "subsidized" predators include raccoon (*Procyon lotor*), Virginia opossum (*Didelphis virginiana*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), and striped skunk (*Mephitis mephitis*). However, other predators like dogs (*Canis familiaris*), cats (*Felis domesticus*), river otter (*Lutra canadensis*), American crow (*Corvus brachyrhynchos*), bear (*Ursus americanus*), and predatory fish like largemouth bass (*Micropterus salmoides*) are also known threats for turtles. It should be pointed out that raccoons and opossum are the biggest predator threats to turtles and mesopredator release, terrestrial communities lacking top predator control, can contribute to high densities of both species (Crooks and Soulé 1999).

Overabundance of predators can elevate mortality rates to unnaturally high levels, which can negatively affect turtle egg and hatchling survival. Congdon et al. (1994) implicated nest predation as the greatest single source of mortality in turtles, averaging 77% over a 17-year period in Livingston County, Michigan. Lee (2005) reported that 303 turtle nests were destroyed along US-31 near the Muskegon River, and in 2006 predators destroyed at least 370 nests along a section of the river (Lee 2006). Studies indicate that most turtle nest predation occurs within 48 hours after the eggs have been deposited and often within a few hours of nest construction (Legler 1954; Burger 1977; Tinkle et al. 1981; Congdon et al. 1983, 1987; Christens and Bider 1987; Spencer 2002).

Conversion of natural habitats to subdivisions or commercial property has led to overabundant generalist species such as raccoons. Fragmentation or reduction in habitat can lead to increases in predation efficiency by reducing the amount of cover available for turtles. Smaller and more isolated areas of natural habitat are more accessible to predators that typically hunt along habitat edges. Roads are known to provide additional access as travel corridors to predators such as raccoons and opossum, which results in more pressure on turtle populations. Loss of suitable nesting habitat can lead to concentrations (or clumps) of nests that has been shown to result in increased predation (Marchand et al. 2002).

Female nesting migration distances can vary between species and within a species (Table 1). The distance between the water's edge and nesting site location can influence the amount of predation that takes place once a nest has been created. Marchand et al. (2002) reported that predation was greater on nests within 50 meters of pond edges than nests farther away. However, hatchlings in nests farther from water face a longer, dangerous journey to the safety of the water's edge.

Disease

Nearly all, if not all, water bodies contain pathogens with the potential to be harmful to many aquatic organisms including turtles. Some pathogens are ubiquitous and generally have only minor effects on local turtle populations. Other pathogens can seriously affect turtle populations; examples include upper respiratory disease and salmonella (Balazs 1986; Dodd 1988; Jacobson et al. 1991). Some highly deleterious pathogens have localized distributions, so transfers from population to population (globally or locally) could be lethal. Disease threats to turtles come primarily from the release of captive pets or transfers of turtles from one localized population to another. It can take turtles a year or two to show disease symptoms and another two years of treatment before they regain their health (Williams 1999a).

Sick turtles are often released by owners who grow weary of their pet's disposition, negatively affecting native populations. People in Asian cultures also believe that good karma can be attained by being kind to captive turtles and releasing them into the wild regardless of the turtle's origin (Williams 1999a). In Michigan, some communities or groups hold annual turtle races for various reasons. Although this type of event has the positive effect of creating increased awareness about the resource, the collaborative action of bringing turtles together in close quarters can be detrimental to their health, especially if carrier or infected turtles are released to the wild. Williams (1999a) reported that desert tortoises in the West and gopher tortoises in the Southeast have contracted fatal respiratory tract infections from imported tortoises released into the wild. The disease is believed to have been affecting North American box turtles as well.

Due to potential disease transmission of Salmonellosis between turtles and humans, the sale of turtles below four inches (carapace length) is restricted pursuant to federal law (see "Federal Regulations" and "Michigan Pet Trade Regulations", this report). For more information about Salmonellosis associated with turtles, see the Centers for Disease Control and prevention (CDC) information online (www.michigan.gov/mda).

Water Quality and Contaminants

Aquatic environmental contamination and pollution can affect turtle populations through exposure to dangerous chemicals and toxins or by reducing available habitat. Environmental absorption of toxic substances and chemical pollutants has been documented in turtles (Ernst et al. 1994; Heidtke et al. 2003; de Solla and Fernie 2004; Bell et al. 2006; Rattner et al. 2008). Some examples of toxic substances known to be absorbed by turtles include polychlorinated biphenyls (PCBs), dioxins and furans, organochlorine pesticides, polycyclic aromatic hydrocarbons (PAHs), and metals like lead and mercury (de Solla and Fernie 2004; Bell et al. 2006; Rattner et al. 2008). The longevity of turtles (Table 1) allows for long-term

bioaccumulation of persistent contaminants as they feed on other organisms or come into contact with toxic compounds in their environment. Accumulation of contaminants in biological resources may occur via aqueous, sedimentary, or dietary pathways, although the main route of contaminant exposure has been identified as the consumption of contaminated aquatic prey species such as fish (de Solla and Fernie 2004). The combination of being mobile and long-lived allows for the compounding effect of contaminant exposure over time and space. Environmental contaminants can be stored in a turtle's body fat, liver, muscle tissue, and eggs (Rattner et al. 2008). Toxicants can be later released to the blood stream as fat is metabolized during hibernation, aestivation, or migration, slowly poisoning the turtle (Ernst et al. 1994).

With continued exposure over the course of an animal's life, some contaminants will accumulate in the body. According to de Solla and Fernie (2004), exposure of this type may result in a reduced growth rate, reduced chances for successful reproduction, deformities, and reduced life spans. Aquatic turtles could be affected indirectly by environmental contaminants through loss of available forage (snails or clams) due to poisoning, or loss of habitat that has become too toxic to live in. This is especially true of common map turtles and musk turtles that need relatively unpolluted waterways to support their primary molluscan prey.

Bioaccumulation of toxic compounds in turtles could also pose a health risk to consumers (OHEPA 2008). Adult turtles are higher on the food chain, which means they could be harboring large quantities of toxic compounds in their flesh, or long-lasting chlorinated hydrocarbons that are stored in their body fat. Although, turtles were not sampled as part of the Michigan fish health consumption advisory program, consumers should consult the Michigan Department of Community Health Michigan Fish Advisory (MDCH 2004) for information on locations where contaminants are a concern (www.michigan.gov/fishandgameadvisory).

Climate Change

Average global temperatures are predicted to increase 0.6 to 8°C (33 to 46°F) over the course of the next century (Gates et al. 1992) and alterations to the precipitation regime are expected as a result of the changes. Information about global climate change is difficult to ignore and the threat to turtles and their habitat should not be disregarded. Changes to the world's climate have been identified as a factor in the decline of populations of amphibians and reptiles (Gibbons et al. 2000; Houlahan et al. 2000; Schlaepfer et al. 2005). Changes in global temperatures may have an adverse effect on turtle populations that exhibit temperature-dependent sex determination by skewing the offspring sex ratio to clutches where only females are being produced (Janzen 1994). In Michigan, all turtles except the spiny softshell turtle and the wood turtle exhibit temperature-dependent sex determination. Therefore, the other eight species in Michigan could be susceptible to this effect. Over time, this will lead to a decline in the number of males and genetic fitness as inbreeding occurs. Janzen (1994) reported that an increase in mean temperature of 4°C would result in an elimination of male offspring production unless these species can evolve rapidly enough to counteract the negative fitness consequences. On the other hand, the effects of warmer temperatures may allow for multiple clutches per year for some species.

Precipitation changes that can be detrimental to turtle habitat include more intense precipitation concentrated in the winter, higher evapotranspiration, and more frequent and intense summer drought conditions. For example, dryer summers with increased rates of evapotranspiration could degrade some turtle habitats.

Summary

Turtles are at risk in Michigan as a result of late maturation, low fecundity life history, high predation rates on young, high road crossing mortality, loss of habitat at alarming rates, overharvest from increased

commercial demand through Asian markets as food and folk medicine, and the collection of millions of turtles annually from the wild for the pet trade. Williams (1999a) reports that an estimated 95% of the wild turtles that enter the pet trade are dead within a year and virtually all turtles from pet stores are sick when purchased. Turtle populations are at risk of extirpation and extinction not only locally but also globally. Protection of all life stages is important since long-lived organisms have co-evolved specialized traits that have been shown to constrain their ability to respond to chronic disturbances (Congdon et al. 1994). Populations may exist for decades without any recruitment, thus giving a false sense of viability. An individual sighting of a few turtles in a water body does not indicate a viable population. Loss of breeding age adults places a reproductive burden on the remaining adult turtles resulting in a declining turtle population. A net loss of individuals from the turtle population could take years to recognize because the smaller juveniles are not often seen. Harding (personal communication, 2007) refers to failing populations as "ghost" populations where there are some adult turtles but juveniles have not been collected or documented for years. Management of turtles should be based on the best available scientific information, which indicates that managing for high adult survival and protection of nesting habitat will contribute more than other strategies to long-term population stability (Reed and Gibbons 2004). Data collection for these animals is difficult, yet lack of population data should not deter managers from protecting these special animals from the risks of unsustainable harvest or loss.

Regulatory Controls

2008 State Regulations

Based on the information provided above, more conservative turtle regulations were put into place in 2008 to provide greater protection for Michigan's wild turtle populations (Table 2) as fully detailed in Fisheries Order FO-224 - Regulation on the Take of Reptiles and Amphibians. The following regulations were unchanged: (1) a fishing license is required to take turtles for personal use; (2) it is unlawful to buy or sell reptiles or amphibians taken under a fishing license or to shoot turtles with firearms (including spring, air, or gas propelled) or bow and arrow; (3) gear allowed for collection of turtles includes hand, trap, nets, seines (up to 12 x 4 feet overall dimensions), and hook and line; (4) traps used (or possessed) for turtle collection must have a plate or tag attached with the name and address of the user; (5) no more than three traps may be used, mesh traps must be no less than one-inch mesh, and traps must be set to allow turtles to surface and breathe; and (6) the use of setlines is not permitted for the take of turtles.

Table 2.–Current Michigan turtle harvest regulations.

Species	Season	Minimum size (inches)	Possession limit	
			Daily	Total
Snapping turtles [a]	Jul 15–Sep 15	13" minimum carapace length	2 in combination (no more than 1 of either species)	4 in combination (no more than 2 of either species
Softshell turtles		none		
All other turtles (painted, musk, map, red-eared slider)	Open all year	none	2 in combination (no more than 1 of any one species)	4 in combination (no more than 2 of any one species)

[a] Carapace length: use a flexible tape to measure from the shell behind the turtle's head to the posterior end of the shell.

The following key harvest regulation changes were implemented: (1) commercial collection of wild turtles is now prohibited in Michigan; (2) the recreational possession seasons were shortened for snapping turtles and softshell turtles and one statewide season established from July 15 to September 15; (3) the minimum carapace size limit on snapping turtles was increased from 12 inches to 13 inches; (4) the daily possession limit on snapping and softshell turtles was reduced from three each per day to one per day of each species; (5) the total possession limit for snapping and softshell turtles was reduced to four turtles total with no more than two snapping turtles and two softshell turtles; (6) the daily possession limit on other nonprotected turtles was reduced from three per day to two per day with no more than one of any one species and a total possession limit for these species being double the daily possession limit. The recreational turtle regulations are listed in the Michigan Department Natural Resource Michigan Fishing Guide (available online at www.michigan.gov/fishingguide).

Michigan has four turtle species (Blanding's turtle, eastern box turtle, spotted turtle, and wood turtle) that are protected from all personal use or possession. Possession of state-listed threatened and endangered reptile species is prohibited without a valid scientific collector's permit and threatened/endangered permit issued through the department. For reptile species of special concern only a valid scientific collector's permit is required from the department.

Dispensation Regulations

An individual property owner may have a turtle on their private property that they perceive as a nuisance. Often these are large-bodied snapping turtles. The MDNR does not recommend the killing of turtles that are perceived as a nuisance on private property, and the translocation of turtles should be discouraged. However, in those situations where the private homeowner wants to have the turtle removed from their property there are three options. The first option involves purchasing a valid fishing license so the turtle can be legally possessed and moved to a public-owned wetland or water body. This option is limited to the regulations concerning turtles in the fishing guide (Amphibians and Reptiles www.michigan.gov/fishingguide). The second option is for those individuals who want to move turtle species that are protected by regulations that makes it unlawful for them to possess the turtle. A few examples would include the following: the turtle is smaller than the minimum size limit, the possession season is closed, or they want to possess a number greater than the possession limit allows. In this case, the individual would need to contact a private animal removal service (who will need a scientific collector's permit from the department) to have the turtle moved off their property. The third option would be for the individual to apply online for a scientific collector's permit (www.michigan.gov/dnrfishing) to legally perform the turtle translocation effort themselves instead of hiring a consultant. Each scientific collector's permit request is reviewed by the MDNR on a case-by-case basis and may or may not be granted.

It is highly recommended that all turtles being translocated from a private residence be placed near a public water body within the same general location, without delay, and be released unharmed. Scientific collector's permits will not be issued for the removal of turtles from public property under any circumstances.

Michigan Pet Trade Regulations

The Michigan Department of Agriculture and Rural Development has regulatory authority over pet trade in Michigan (www.michigan.gov/mdard). Pursuant to federal law, the turtle Health Advisory Sheet must accompany all sales of turtles smaller than four inches in shell length.

Federal Regulations

According to federal law (Title 21 CFE 1240.62, enacted in 1975), the sale of living and viable turtle eggs or live turtles smaller than four inches (carapace or shell length) is prohibited both between states and within states. However, some exemptions from this restriction apply under certain circumstances. For example, the sale of small turtles is not illegal if it is for a bona fide scientific, educational, or exhibition purposes, but not for use as pets. Other exceptions to the ban are the sale of turtles and turtle eggs not in connection with a business (e.g., limited sales between turtle fanciers have been permitted) or that are intended only as export. An exemption is only allowed if the Health Advisory Sheet accompanies the sale. This regulation applies to small turtles (under 4-inch carapace length) because these are most likely to be held for sale as children's pets, and the purpose of the ban is to protect children from turtle-born salmonellosis. This regulation is enforced by the Food and Drug Administration (FDA) in cooperation with state and local health agencies. The Health Advisory Sheet describes the potential risk to children and adults of contracting salmonellosis from handling turtles. The FDA estimates that this regulation has prevented about 100,000 cases of salmonellosis per year. However, according to their website (www.fda.gov) there has been an increase in the sale of turtles in recent years, leading the FDA to increase efforts to inform the public about salmonellosis.

Recreational Turtle Regulations in Other States

Recreational turtle harvest regulations for several surrounding states and one Canadian Province were reviewed during preparation of this report. Michigan turtle regulations are generally comparable to other neighboring agencies' turtle regulations. However, several states are currently evaluating their regulations and some have recently prohibited commercial turtle harvest.

Risk-level Categorization

A great deal of time and effort has been invested in the collection of fisheries resource data in Michigan. Through these efforts much knowledge and expertise in the management of fish populations was gained. In contrast, even though MDNR Fisheries Division has regulatory authority over amphibian and reptile management, little effort has been undertaken to assess reptile and amphibian resources. Therefore, there are huge gaps in knowledge that have hindered the process of creating regulations based upon sound, biological population information. University research conducted on turtles in Michigan and Ontario has provided limited biological information for each turtle species. Critical information is still lacking about turtle annual recruitment rates, length at age, natural mortality rates, exploitation rates, and species abundance. Managers could use this type of information to establish potential harvest limits for each species; yet this type of information could take several decades to collect for a single location. Furthermore, there is little funding for these kinds of studies. As a result of this paucity of information, each turtle species has been assigned to one of three general risk level categories (high, medium, and low) with management recommendations varying by relative risk of population decline.

High-risk Group Category

Members of this group require special protection because they reach sexual maturity at older ages, have low fecundities, are prized in the pet trade, and population trends are in decline. High-risk group species are those species listed as special concern, state-listed threatened, or state-listed endangered. Concern for these species is based on declining estimates of abundance or presence of only relict populations. Protection from harvest is an important step towards maintaining adequate numbers

of self-sustaining populations. Without harvest protection, it is believed these species would reach dangerously low population levels.

Medium-risk Group Category

Medium-risk species are those species that are considered to have elevated mortality rates. These species may reach larger body sizes that make them more susceptible to higher harvest rates compared with other smaller turtle species that are considered less desirable to harvest. These turtles may be generally abundant throughout their range, but without estimates of recreational exploitation and limited commercial harvest data to draw from, a more guarded conservation strategy must be implemented. The loss of mature adults over time has resulted in declining populations in some areas.

Low-risk Group Category

Low-risk group species are those species considered to have lower mortality rates compared to turtle species in the high- and medium-risk groups. Low-risk group species reach maturity at relatively younger ages, have relatively higher fecundity rates, and are generally smaller compared to other Michigan turtle species. These species have not been traditionally harvested for consumption so they are believed to have lower exploitation rates. Members of this group are more likely to be collected and kept as pets or used in turtle races than used as food. They are occasionally removed from the wild and held in captivity for various periods prior to being released back to the wild. This temporary captivity is considered a nonlethal use as long as it is short-term and they are not intermingled with turtles from other locations or origins. These species are generally common and populations are considered self-sustaining; nonetheless, estimates of harvest and exploitation are lacking. The many threats that turtles in general face today indicate that greater protection may be warranted to insure that future generations can enjoy these species.

Management Recommendations

Although population, abundance, and harvest information is lacking for Michigan turtle species, geographic range information and global trends in consumptive use can be reviewed to assess potential implications of exploitation and conservation needs for each species. Species with broad geographic ranges are less likely to be depleted or extirpated since exploitation tends to be geographically disproportionate for species with large ranges (Reed and Gibbons 2004). Heavy collection pressure may deplete stocks in an area; yet, adjacent areas with little or no collection pressure have the potential to help replenish exploited locations if dispersal to those areas can still occur at an adequate rate. It should be noted that this type of replenishment may take place over several decades, especially for turtles with exceptionally high ages at maturity and or low reproductive potential and clutch sizes. Range size was positively correlated with available land area, habitat breadth, diet breadth, and body size and range size variability did not differ among families or genera, instead appearing to be a species-specific trait (Hecnar 1999 as cited by Reed and Gibbons 2004). It is less likely that a species with a large range will be exploited to the point of extinction since large harvest pressure would need to be expressed throughout the entire species' range. Therefore, total geographic range data as referenced in Reed and Gibbons (2004) was used to assess personal use or exploitation for Michigan turtle species along with other biological attributes such as reproductive potential (clutch size), age at maturity, potential as food species, potential threat as trade species, and expert recommendations (J. Harding, Michigan State University, personal communication).

Estimates and statistics about recreational turtle harvest in Michigan are not available; notwithstanding, continued depletion increases the likelihood of localized extinction / extirpation. Recognizing that population data are not available, such information as life-history characteristics, trends in anthropogenic disturbances, recent trends in exports of turtles for food in Asian markets (or other consumptive uses), increased popularity of the turtle pet trade, and scientific evidence of world turtle population declines must be used to develop risk-management based recommendations. Biological attributes, likelihood of harvest, and expert opinion were all considered in the development of recommendations for each risk group category. Separate regulation options were derived for each risk level category in order to provide the best conservation strategy for each risk group.

High-risk Group

The high-risk species are species that cannot sustain any level of recreational harvest. Members of this group are Blanding's turtles, eastern box turtles, spotted turtles, and wood turtles. These species are afforded special protection due to concerns about their immediate vulnerability. The MNFI program conducts field surveys to locate and identify threatened and endangered species throughout the state and provides biological expertise to the MDNR. MNFI personnel meet with other experts every few years to review current listings and evaluate if any changes are warranted. Threatened or endangered species are provided protection under the Endangered Species Act of the State of Michigan (Part 365 of PA 451, 1994 Michigan Natural Resources and Environmental Protection Act). Species of special concern are not afforded legal protection under the Act, although they are protected by means of a Director's Order (Regulation on the Take of Reptiles and Amphibians; FO-224).

Possession of species of special concern requires a scientific collector's permit from MDNR Fisheries Division. Possession of state-listed threatened and endangered species is restricted to holders of both a scientific collector's permit and a threatened/endangered permit. Wildlife Division has the authority to issue threatened/endangered permits for the department. For more information concerning protected turtles in Michigan, see Hyde (1999) and Lee (1999a, 1999b, 2000).

Spotted turtle: Spotted turtles are uncommon to rare throughout Michigan and confined to isolated colonies with good habitat (J. Harding, Michigan State University, personal communication). Due to the life history traits, population levels, and past exploitation levels this turtle is protected in Michigan. Spotted turtles are state-listed as threatened; therefore they are protected from harvest and may not be possessed without a scientific collector's permit and threatened/endangered permit issued by Fisheries and Wildlife Division. Between November 2002 and November 2005 1,800 (12% from wild) live specimens were reported for export from the United States (Senneke 2006). This species has been sold as a pet species, threatening wild populations, and Reed and Gibbons (2004) reported that 60% of the spotted turtles for sale online as pets were collected from wild populations. The geographic range of spotted turtles is generally small and ranks as the second smallest among Michigan turtles (Reed and Gibbons 2004).

Wood turtle: Wood turtles are generally uncommon to rare; significant declines are due primarily to human activities (J. Harding, Michigan State University, personal communication). Wood turtle populations are especially sensitive to adult loss due to their limited reproductive potential. They are species of special concern; therefore they are protected from all harvest or possession without a scientific collector's permit issued by MDNR Fisheries Division. Between November 2002 and November 2005, ten live specimens were reported for export from the United States (Senneke 2006). This species has also been sold as a pet species, threatening wild populations, and Reed and Gibbons (2004) reported that 25% of wood turtles for sale online as pets were collected from wild populations. The geographic range of wood turtles is the smallest of all Michigan turtle species (Reed and Gibbons 2004).

Eastern box turtle: Eastern box turtles are locally common in a few places in Michigan with significant declines noted throughout most of their Michigan range (J. Harding, Michigan State University, personal communication). Low reproductive potential and life history traits limit this species' ability to rebound after losses of mature adults. Habitat loss has also had a negative effect on Michigan populations. Eastern box turtles are state-listed as a species of special concern and so are protected from harvest and may not be possessed without a scientific collector's permit issued by MDNR Fisheries Division. Between November 2002 and November 2005, no live specimens were reported for export from the United States (Senneke 2006). Regardless, this species has great value as a pet species, threatening wild populations, and Reed and Gibbons (2004) reported that 80% of the eastern box turtles for sale online as pets were collected from wild populations. The geographic range of eastern box turtles is larger than other protected Michigan turtle species (Reed and Gibbons 2004).

Blanding's turtle: Blanding's turtle has been eliminated in many places, but can be fairly common where suitable habitat exists (J. Harding, Michigan State University, personal communication). Due to the life history traits, population levels, and past exploitation levels these remaining individuals are protected in Michigan. Blanding's turtles are state-listed as a species of special concern and so are protected from harvest and may not be possessed without a scientific collector's permit issued by MDNR Fisheries Division. Between November 2002 and November 2005, 327 live specimens were reported for export from the United States (Senneke 2006). This species has value as a pet species, threatening wild populations, and Reed and Gibbons (2004) reported that 30% of the Blanding's turtles for sale online as pets were collected from wild populations. The geographic range of Blanding's turtles is generally small and ranks as the third smallest among Michigan turtles (Reed and Gibbons 2004).

High-risk Group Options and Recommendation

Option 1. Maintain current regulations of protection from harvest.

Option 2. Change the current regulations to allow limited harvest of this group. Commercial sale of recreationally harvested individuals would still be prohibited.

Recommendation: Option 1. The current level of protection for these species is necessary and should continue; therefore all harvest of this group should remain prohibited. Numerous threats to these species have been documented with regard to habitat loss and collection from wild as pets. These species have very low reproductive potential and their numbers are already believed to be declining. The protection afforded to these individual species may allow their numbers to increase over time resulting in their reclassification into either medium or low-risk group designations.

Medium-risk Group

Medium-risk group species are those species believed to be experiencing relatively higher adult mortality rates than low-risk group species. Medium-risk group species include the common snapping turtle and spiny softshell turtle. These species are capable of growing to larger sizes when compared to other Michigan species (Table 1). Although these species are considered common and widely distributed throughout their ranges, they are believed to be in decline in some localized populations. In most instances, increased adult turtle mortality is the direct result of human interactions including harvest, target practice, loss of suitable habitat, and "pest" control efforts due to concern for children or juvenile waterfowl. Both species have been commercially exploited in recent times and are still considered the preferred turtle species by harvesters. These species have specific individual threats, which predispose them to higher adult mortality compared to low-risk group turtle species. Several additional factors including roadway mortality, nest predation, contaminants, and disease are threatening

the sustainability of these species. When human interactions are added to the equation it is difficult to comprehend how 10% mortality has not already been exceeded in some locations, resulting in declining population numbers.

Common snapping turtle: Snapping turtles are generally common in the Great Lakes basin, but some local populations have been depleted by overharvest (J. Harding, Michigan State University, personal communication). Snapping turtles may be able to tolerate a very low level of personal harvest, but take should be limited (J. Harding, Michigan State University personal communication). This species has been traditionally harvested as food in times when the human population was lower and habitat was less modified. They are widespread and are habitat generalists. Mature snapping turtles are viewed negatively by some people, which can sometimes result in harassment, relocation, or mortality for adults as they leave wetlands in search of mates or suitable nesting habitat. Common snapping turtles are sometimes considered a nuisance by some members of the public during spring and early summer months when nesting migration increases human and turtle interactions. Because they often occupy recreational lakes, their nesting habitat has been diminished by lakeshore development. Thus, not only has adult mortality increased due to harvest and other human-induced factors, recruitment rates in highly developed lakes are probably declining.

According to Senneke (2006), approximately 635,000 live individuals were reported for export from the United States from November 2002 to November 2005, with 30% reportedly collected from the wild. They are not commonly collected for use as pets, although there has been some indication that this trend may be increasing. Reed and Gibbons (2004) estimated that 10% offered for sale as pets were collected from the wild. It is believed the minimum carapace limit of 13 inches on snapping turtles has been effective in protecting the females since males reach larger sizes (on average) than females. As a result, harvest pressure has been shifted towards males or older, larger reproducing females. Males are considered more expendable than females because it is believed that a male could mate with more than one female during each breeding cycle.

Spiny softshell turtle: This species is locally common in the western Great Lakes region, but uncommon to rare in the eastern part (J. Harding, Michigan State University, personal communication). Softshell turtles were a traditional commercially harvested food species in Michigan until the early 1990s, and this species has been specifically exploited for target practice over the years (J. Harding, Michigan State University, personal communication). Past regulations restricted the size (minimum size limit of 12 inches) of spiny softshell turtles taken for commercial and personal harvest. Though, according to Harding (personal communication 2006), softshell turtle females grow faster than males so the 12 inch minimum was later dropped in 1994 because harvest was primarily directed towards females. This species has suffered from habitat loss and elimination of nest sites, due to rampant lakeshore development. Softshell turtles are generally considered to grow faster than their hard-shelled cousins do, which makes them attractive economically for farming in Southeast Asia (Barzyk 1999). Senneke (2006) reported that nearly 84,000 live spiny softshell turtles were reported for export from the United States between November 2002 and November 2005, with 13% listed as wild caught. Due to their disposition and difficulty to maintain as pets, softshell turtles have limited value as a pet species. Reed and Gibbons (2004) did not find any spiny softshell turtles for sale as pets online. This species has the fourth largest geographical range compared to other Michigan turtles (Reed and Gibbons 2004).

Medium-risk Group Options and Recommendation

Option 1. Prohibit all harvest of this group.

Option 2. Allow limited harvest but add, “Only one of each species in possession may be alive” reducing the potential for collection by the pet trade or live Asian markets.

Option 3. Allow limited harvest with one or more options listed above.

Option 4. No change to current regulations.

Recommendation: Option 3. Allow limited harvest of this group using the existing very restrictive regulations on possession (2 per day harvest limit but no more than one of each species; four total possession limit but no more than two of each species with a shortened season length. The existing 13-inch minimum carapace limit on snapping turtles should protect larger females. The single season (July 15 – September 15) simplified the regulation overall and provided additional protection. Given the increase of human activities detrimental to turtles plus the added likelihood of these species being harvested, sustainability is questionable. Restricting possession to four total provides greater protection from collection for illegal sale to Asian markets that sell primarily live turtles. The sale of recreationally harvested turtles continues to be prohibited. These species are not believed to be in a state of decline as a whole, but there are concerns that local populations are experiencing declines. It is believed that without increased protection from exploitation, these species may reach the point of being overexploited. Both species are considered common but declining in Wisconsin (Christoffel et al. 2002). Biological evidence indicates that even a small increase in mortality rates for this group will lead to their decline. These species have similar life-history traits to Lake Sturgeon (late maturing and long lived). Regulations for Lake Sturgeon harvest are generally highly protective (e.g., one per person per season with high minimum size limits in the Michigan – Wisconsin boundary waters), and it is logical to believe that the existing greater protection is warranted for turtle species that share similar life-history traits. This group requires greater conservation protection from harvest to ensure their sustainability into the future.

Low-risk Group

Low-risk group species include the common map turtle, common musk turtle, painted turtle, and red-eared slider. These species are generally common with the exception of the red-eared slider, which has been found in a few locations and is an introduced species. Exploitation rates for these species are believed to be lower than for other species in Michigan (although this has not been proven), but turtle harvest appears to be on the rise globally. Turtles in this group are typically the species used in "turtle races"; therefore they have an increased threat of disease transmission through contact with others from different origins. The sustainability of this group is primarily affected by the general threats experienced by all turtles as mentioned previously. Their sustainability is not believed to be a current concern. Population assessment data are lacking, however. Therefore, a more conservative approach is required given the limited information currently available about populations and exploitation rates for these particular species.

Common musk turtle: Common musk turtles are locally common in the lower Great Lakes, but are declining in areas with residential development. This species has suffered from habitat loss in Michigan (J. Harding, Michigan State University, personal communication). This species has not been traditionally harvested for food in Michigan due to its size; in contrast, reports indicate they are being exported as food and sold as pets in other states (Reed and Gibbons 2004). Nearly 56,000 live specimens were reported for export from the United States between November 2002 and November 2005 with 30% reported as collected from the wild (Senneke 2006). Reed and Gibbons (2004) reported that 75% of the individuals offered for sale as pets were collected from wild populations. The average clutch size is low compared to other turtle species (Table 1) and they have the fifth smallest geographical range compared with other Michigan species (Reed and Gibbons 2004). Common musk turtles have been used as an aquarium pet. Due to the species' low reproductive potential, apparent threat to wild populations from the pet trade, and relatively small geographical range, harvest should be limited.

Common map turtle: This species has disappeared from heavily polluted urban areas but is locally common throughout the lower Great Lakes basin (J. Harding, Michigan State University, personal communication). Map turtles have suffered from habitat loss in Michigan, but do not appear to be in any threat of decline at this time. This species has not historically been collected and harvested as food. Less than 4,000 live specimens were reported for export between November 2002 and November 2005 according to Senneke (2006). This species has been sold in the pet trade and Reed and Gibbons (2004) reported that 15% of those offered for sale were of wild origin. In the United States several populations of map turtles are federally threatened, making this a candidate species for being federally-listed, state endangered, or state-listed as threatened due to several factors including loss of habitat, exposure to contaminants, and collection for the pet trade. Although map turtles have the fourth smallest geographic range compared to other Michigan turtles (Reed and Gibbons 2004), they have not been in demand as an export.

Painted turtle: Painted turtles are habitat generalists and are reasonably secure in Michigan (J. Harding, Michigan State University, personal communication). They are common to abundant throughout most of the region except the far north. This species has no traditional history of being collected and harvested as food in Michigan but has been imported for sale as a commodity recently. Painted turtles have been observed in Asian live markets in Detroit by MDNR Law Enforcement Division staff (Steven Huff, MDNR, personal communication). These specific turtles were purchased by a Michigan retailer at a market in New York City with origin of harvest in Florida. There should be concern about increased demand on these limited resources as worldwide turtle populations are depleted. A total of 136,000 painted turtles were reported for export from the United States between November 2002 and November 2005 with 53% reportedly collected from wild populations (Senneke 2006). Painted turtles have limited value in the pet trade due to their abundance, although Reed and Gibbons (2004) reported that 40% are collected from wild populations. Their geographical range is the third largest compared to other Michigan turtles (Reed and Gibbons 2004). Painted turtles are often collected by people from the wild and kept in aquariums since they are very common and easy to care for.

Red-eared slider: This species is believed to have been introduced to Michigan via pet releases (J. Harding, Michigan State University, personal communication). They are described as habitat generalists and are reasonably secure in a few areas in Michigan. They are the dominant turtle species exported from the United States with over 15,000,000 reported for export between November 2002 and November 2005 (Senneke 2006). Most of the exported turtles are produced in massive turtle farms located in the southern United States. Nonetheless, it is apparent that future demand will surpass farming production at some point and more pressure will be placed on wild populations. Red-eared sliders have been a traditional species for the pet trade, although only 10% are believed to be collected from wild populations (Reed and Gibbons 2004). They have the second largest geographical range compared with other Michigan turtles (Reed and Gibbons 2004).

Low-risk Group Options and Recommendation

Option 1. Prohibit all harvest of this group.

Option 2. Allow limited harvest of this group and implement a size-limit restriction (slot, minimum, or maximum).

Option 3. Allow limited harvest of this group and implement a change to the harvest season (currently open all year).

Option 4. No change to current regulations.

Recommendation: Option 4. Continue to allow limited harvest of this group with possession limited to two per day and no more than one per day of any one species; four total turtles may be possessed

with a year-round season. The sale of recreationally harvested turtles should continue to be prohibited. These species are typically smaller in size, which may afford them protection from harvest as table fare. Nonetheless, they should be afforded greater protection due to rampant habitat loss, roadway mortality, increased global demand for consumptive uses, disease concerns, and lack of information on exploitation and population sizes in Michigan. Risks for these species are thought to be generally lower than those of the other risk group types, but questions about sustainability still exist. As a result, greater conservation protection is warranted.

Additional Management Options

Issues like habitat protection, roadway mortality, predator management, and disease are all real threats to native turtle populations in Michigan. If warranted by dramatic changes in turtle populations, the director of the MDNR can use his/her powers under the General Provisions and Powers for the Director to prescribe protective measures. Management beyond state ownership boundaries relies upon the assistance and cooperation of private individuals to improve turtle populations. Greater public awareness of turtle population issues and involvement by the public to improve habitat and minimize mortality should be encouraged to ensure turtle populations are self-sustaining.

Habitat Protection

Habitat conservation and rehabilitation are the keys to protecting tomorrow's reptile populations; yet, a majority of the land in Michigan belongs to private owners. Resource agency staff must ensure that actions on state lands do not negatively affect turtle populations. Resource managers need to work with riparian landowners to inform them about techniques that will have lower effects on reptile communities. Cooperative efforts with township and county governments could lead to greater buffer strip protection through new zoning rules around streams and wetlands. These groups can help establish preserves as well as assist with environmental education and outreach programs. Other cooperative opportunities involve working with nongovernmental organizations such as lake associations, watershed groups, and conservancies to share information and build partnerships that would be beneficial. Private land owner awareness must be increased so they can consider the needs of reptiles in the course of their land management activities. The DNR has produced two documents that provide habitat management guidelines that will benefit amphibians and reptiles on streams (Alexander et al. 1995) and lakes (O'Neal and Soulliere 2006). Another good source of information is "Habitat Management Guidelines for Amphibians and Reptiles of the Midwest" (Kingsbury and Gibson 2002), produced by Partners in Amphibian and Reptile Conservation (PARC); this document provides a general reference for how to manage land activities for these special animals (Appendix A).

Roadway Mortality

Land and resource managers need to work together early in the planning stages of new roadway construction projects to reduce threats to turtle populations. In locations where high mortalities are recognized, managers need to try to mitigate turtle losses by construction of barriers (fencing), education of the public (signage), construction of culverts for wildlife crossings, or through creation of new nesting habitat to replace that lost due to highway construction (Jackson 1996; Jackson and Griffin 1998; Jackson 2000). MDNR should work towards identifying locations where roadway mortality is considered high and try to reduce mortality with protective measures and cooperation with other agencies and concerned citizen groups.

Predator Management

Predator management has been recognized as a viable option where predation levels have been identified to be a limiting factor (Boarman 1997). Reduction of nest predator populations has been shown to be effective and is recommended for turtle restoration efforts for declining turtle species (Engeman et al. 2005). More information is needed to identify whether predation is a factor contributing to turtle population declines in Michigan. A predator management program may need to be initiated if predators are found to be responsible for causing declines or limiting recovery of populations. The continued decline in fur harvest and the outward expansion of urbanization have allowed predator numbers to skyrocket. The MDNR should work with user groups, private citizens, and universities to encourage more assistance on this issue.

Disease

Today's global economy allows for the quick transport of wild collected turtles over state, national, and continental boundaries to locations worldwide. This increases the potential for disease transmission through pet releases. Current regulations allow turtles collected in Florida to be shipped to New York and to eventually wind up in a Detroit market to be sold alive. It is just a matter of time before a pathogen is carried from a foreign location to Michigan with negative effects to native resources.

Turtles captured and brought into captivity can negatively affect wild turtle populations if diseased animals are released into wild populations. Unnatural movements of this type can expose wild turtle populations to virulent agents that they have no protection against, potentially causing an epizootic resulting in mortality. This could lead to reduced fitness of turtle populations as they become sick or even lead to an increase in mortality as they die off. Epizootics can wipe out localized turtle populations entirely so care must be taken to reduce the threat by informing the public of the dangers of pet releases and transfers between areas. Groups or individuals that hold turtle races need to be informed and educated about the risks of exposing wild turtles to diseases and about how transplanting a few individual turtles may negatively affect local turtle populations. Informative materials should be provided to the public online and be referenced in the Fishing Guide.

Additional Research and Data Collection

Some (limited) turtle distribution information is available for each of the 10 Michigan turtle species; however, information is lacking concerning turtle population dynamics and personal-use harvest. Data is needed immediately to support a population viability analysis (PVA) for endemic turtle populations. This information would be beneficial for developing future regulation recommendations pertaining to management of Michigan turtles. There are currently four state-listed species that are afforded protection from any harvest. However, there is no mechanism in place to assess how this protection has contributed to their recovery, if at all.

Survey information is needed to better manage turtles in a sustainable manner for future generations. The first step is to develop a strategy to fund nongame assessment programs such as those needed for scientifically based turtle management. Potential sources include federal funding through the comprehensive State Wildlife Plan and legislative allocation of general funds for nongame species work. Concurrently, MDNR should start communications with members of the Amphibian and Reptile Technical Advisory Committee (ARTAC) to assist with the design and implementation of a general turtle surveying protocol. MDNR Fisheries Division will then need to determine how to implement the needed turtle surveys along with the best data management systems for these data. Databases will also need to be created to track this new information. In those instances where more in-depth research

information is needed (PVA, predator surveys, etc.), MDNR Fisheries Division will have to coordinate with universities to conduct specific studies. MDNR Fisheries Division will also need to identify and contact individuals harvesting turtles about their selective harvest pressure practices and turtle harvest in Michigan. Without this type of information, it will be difficult to assess whether turtles are being harvested in a sustainable manner.

Survival of turtle nests and hatchlings has been identified as a significant problem for certain species, such as wood turtles, where successful reproduction has not been documented for several years. Research is needed to evaluate methods for improving survival of turtle nests and juveniles.

Habitat alteration and loss is a significant threat for Michigan turtles. Research is needed to develop planning guidelines for sustainable turtle populations in urban, suburban, rural, and other areas. There is a need to increase our general knowledge about mitigating for turtle habitat loss when new construction is imminent. More collaboration with other regulatory agencies like the Department of Environmental Quality is needed when reviewing sea wall permitting requests. Additionally, more research is needed related to the development of turtle crossings and other effective ways to reduce roadway threats to turtles, especially during springtime nesting and mating events.

Education and outreach programs should be included in Michigan's turtle management strategy. A greater emphasis on turtle biology should be included as part of these programs, to better inform the public about the importance of these species. Information should be posted online to help inform the public about Michigan turtle species and to create more awareness. This would benefit turtles of special concern, since added information could potentially help alleviate pet collection of turtles from the wild or reduce disease exposure from careless turtle releases.

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Appendix A

Partners in Amphibian and Reptile Conservation

PARC is an organization interested in the worldwide conservation and protection of amphibians and reptiles and their associated habitats. Members come from a diverse network of like-minded citizens, professionals, and organizations that focus on conservation efforts regionally, nationally, and worldwide. The organization provides many resources online such as grant information or funding sources, habitat management guidelines (by region), and a regulation guideline. Using the best science available, PARC has put together a publication titled, "Model State Herpetofauna Regulatory Guidelines," that is available at no cost online (www.parcplace.org). The objective of this publication is to provide a model to assist agencies in creating or modifying their regulations regarding the collection, manipulation, possession, and sale of native and nonnative herpetofauna; and to promote consistency between adjacent states.

Michigan's regulatory processes cover many of the baseline recommendations listed in the guide. However, there are a few recommendations that could be strengthened in our regulatory processes such as regulation of the sale of native taxa, and venomous, invasive, and potentially dangerous nonnative taxa (those taxa potentially threatening native species, ecosystems, or human health).

MDNR Fisheries Division has the regulatory authority for the management of amphibians and reptiles. One area that could be improved would be to include a reporting component for the take of these animals. Currently, there is absolutely no data on how many amphibians or reptiles have been harvested recreationally. To address this key data gap, information should be requested of each fishing license purchaser about the number of reptiles or amphibians harvested in the previous year and an approximate number of each harvested when licenses are purchased. Similar questions could be added to interviews conducted by Statewide Angler Survey Program (creel census) personnel and by other monthly division angler surveys. This information could be used to assess recreational pressure on these resources. Information collected over a series of years could be used to identify harvest trends, to monitor harvest success rates (thus indicating potential herpetofauna population trends), as well as to answer other management-related questions.