SPC Journal of Environmental Sciences, 2 (1) (2020) 36-41

SPC Journal of Environmental Sciences

Website: www.sciencepubco.com/index.php/JES

Research paper

A review of distribution, threats and conservation of freshwater turtles of Ontario, Canada

Amtyaz Safi [1, 2] *, Muhammad Usman Ali Hashmi [1, 2], John Peter Smith [2]

[1] Department of Zoology (Wildlife Section), University of Karachi, Karachi-75270, Pakistan
[2] Unit # 102, 1651, Victoria Park Avenue, Scarborough, Toronto, Canada
**Corresponding author E-mail: amtyaz.safi@gmail.com*

Abstract

There are four families and eight species of freshwater turtles found in Canada, and the same families and species have also been recorded in Ontario province, all species are listed in CITES Appendices, in which six are declared as threatened species. Three families are hard shelled turtles viz Family Emydidae, Family Kinosternidae, and Family Chelydridae while Family Trionichidae is the only soft shelled turtle. Legally, all freshwater turtles in Ontario have been protected. Many efforts have been made by the Government, Non-governmental organizations and Academia for the protection and conservation of turtle population in Ontario. IUCN, WWF Canada, Ontario Wildlife Department, and Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Canadian Wildlife federation, Wildlife preservation Canada, Ontario turtle conservation center (OTCC) and some other organizations are contributing in efforts for the conservation of freshwater turtles in Ontario. But still, freshwater turtles are facing serious threats due to climatic changes and some anthropogenic activities.

Keywords: *Ontario; Freshwater Turtles; Distribution; Threats; Conservation.*

1. Introduction

Canada is a country with great varieties of freshwater habitats and also has an abundance of wetland reservoirs with almost 60% of all freshwater lakes in the world. Canada's wetland ecosystems cover approximately 1.5 million square kilometers, representing 16% of Canada's total area (equivalent to over twice the area of France). These freshwater reservoirs are very diverse and range from vast forested peat lands in the boreal zone in north to deltas, marshes and vernal pools of southern parts of the country (Messager et al. 2016; Currie et al. 2004). Despite the largest wetland reservoirs of the world's freshwater habitats, still the diversity of freshwater species is lower than other southern countries due to repeated glaciation events. Wetlands have become adversely affected by land use practices that have resulted in vegetation destruction, nutrient and toxic loading, sedimentation, and altered flow regimes areas especially in southern parts. For example, in southern Ontario, 68% of the original wetlands have been converted from their natural state to agriculture and housing schemes. Only wetlands from north remain intact originally (Environment and Climate Change, Canada, 2016 b). The high diversity of freshwater turtles and fishes are found in southern part of Ontario, particularly in the Lake St. Clair and western Lake Erie watersheds. This is a result of warmer climate compared to the rest of Canada.

The International Union for Conservation of Nature (IUCN) is the global standard for threat assessments and determination of conservation status of all species. This group augmented TFTSG Red List 2018 is the first assessment to consider the global conservation status of all species in the Testudines, at present generally recognized to include about 360 species (TTWG 2017; TTWG, unpubl. data, 2018; www.iucnredlist.org) (Table 1).

Table 1: Number of Turtle Species, by IUCN Red List Category

Number of species (356 Total) IUCN Red List category
7 Extinct (EX)
1 Critically Endangered (CR, Possibly Extinct)
63 Critically Endangered (CR)
50 Endangered (EN)
65 Vulnerable (VU)
38 Near Threatened (NT)
81 Least Concern (LC)
35 Data Deficient (DD)
16 Not Evaluated (NE)

Source: Tortoise and Freshwater Turtle Specialist Group (TFTSG) 2018.

Turtle diversity is highest in Asia, followed by North America (Buhlmann et al. 2009). Turtles and tortoises represent one of the most imperiled vertebrate groups, with 56.4% of the known species listed as critically endangered, endangered, or vulnerable (TTWG 2014). Globally, only primates have a higher percentage of threatened species (64.3%), while salamanders have a similar number (55.4%). Asia

is at the epicenter of the global turtle extinction crisis that has rapidly developed as a result of unsustainable trade (Behler 1997; van Dijk et al. 2000; Gibbons et al. 2000; Safi and Khan, 2014; Khan et al., 2015; 2016). The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international treaty signed in March 1973 and in effect since 1975 (Wijnstekers, 2003). The goal of CITES is to ensure trade does not threaten species with extinction. Specifically stated, "International cooperation is essential for the protection of certain species of wild fauna and flora against over-exploitation through international trade" (CITES 1973). Member countries signing onto CITES are called "parties." As of January 2018, there were 183 parties, representing 182 countries and the European Union as a whole. Overall, CITES ensures that international trade in wild fauna and flora is legal and sustainable (IUCN, 2018).

There are 313 recorded species of Tortoises and Fresh water Turtles presently in worldwide, In which 128 species have been included in IUCN Red List of Threatened species (Fritz and Havas, 2007; Khan et al. 2015; 2016). Economically, freshwater turtles are considered as more valuable as compared to the fisheries because of the presence of good quality of flesh and fats which are highly demanded globally for different purposes.

In Canada, provinces have jurisdiction over wildlife within their borders (on provincial and private lands), whereas the federal government has control over international trade and trade in specimens originating from federal lands. Therefore, management of freshwater turtle populations is the responsibility of both provincial and federal governments, whereas CITES authority and implementation rests solely with the federal government.

Ontario is the second largest province of Canada, covering more than 1 million square kilometers (415,000 sq. miles), an area larger than France and Spain combined. Ontario is bounded by Quebec to the east, Manitoba to the west, Hudson Bay and James Bay to the north, and the St. Lawrence River and the Great Lakes to the south. The longest east-west distance in Ontario is 1,568 kilometers (974 miles). The longest north-south distance is 1,691 kilometers (1,050 miles). The highest point is 693 meters (785 yards) above sea level, in the Timiskaming area. Manitoulin Island in Georgian Bay is the world's largest freshwater island, covering 2,766 sq. km (1,068 square miles). Ontario's many lakes, rivers and streams played a central role in the province's history and development. The Great Lakes include Lake Superior, Lake Michigan, Lake Huron, Lake Erie and Lake Ontario - combined, these lakes hold one-fifth of the world's fresh surface water. The combined shoreline of the Great Lakes is equal to about 45% of the earth's circumference. The Great Lakes Basin covers an area of 750,000 sq. Km this basin includes 8 US states, most of southern Ontario and extends into northern Ontario. More than 98% of Ontario residents live within the Great Lakes and St. Lawrence River Basin. More than 80% of Ontarians get their drinking water from the lakes. the Great Lakes and St. Lawrence River Basin supports nearly more than 75% of Canada's manufacturing, and a third of the country's employment in agriculture and food processing (Wikipedia, 2020).

There have been several studies on freshwater turtles conducted throughout Ontario province. Most of the studies focus on different parameters like population structures, home ranges, threats, habitats and general biology of Ontario's freshwater turtles (Bennett & Litzgus, 2014; Gunson, Ireland, & Schueler, 2012; Hughes & Brooks, 2006; Millar & Blouin-Demers, 2011; Paterson, Steinberg, & Litzgus, 2012; Yagi & Litzgus, 2012). These aspects provide context on how to protect freshwater turtle species' Survival, since seven of Ontario's eight freshwater turtle species are listed as species at risk by the Ministry of Natural Resources and Forestry (MNRF, 2015). Two key authors who have published several studies on freshwater turtles in Ontario are Dr. Ronald Brooks from the University of Guelph, and Dr. Jaqueline Litzgus from Laurentian University. Dr. Ronald Brooks has participated in several studies located in Algonquin Park, studying topics such as nesting migrations of snapping turtles, nest-site selection by painted turtles, and the frequency of painted turtle nest depredation (Hughes & Brooks, 2006; Obbard & Brooks, 1980; Rollinson & Brooks, 2007). Dr. Jaqueline Litzgus has participated in different studies programs related to freshwater turtles of Ontario conducted in Algonquin Park, Sudbury, Southern Ontario, and along the Trent-Severn Waterway in Ontario. Some of Dr. Jaqueline Litzgus' published studies include information regarding injury rates of freshwater turtles on recreational waterways, nest-site selection by wood turtles, habitat selection by snapping turtles, and the effects of flooding on the spatial ecology of spotted turtles of the region (Bennett & Litzgus, 2014; Paterson et al., 2012; Yagi & Litzgus, 2012). Other studies done in Ontario have taken place in the St. Lawrence Islands National Park, within coastal marshes along three Laurentian Great Lakes, in Point Pelee National Park, and at several turtle road crossing hotspots throughout Southern Ontario. Topics of study conducted in these areas include the spatial ecology, distribution, population and seasonal activity of Blanding's turtles, the relationship of road density and marsh condition to freshwater turtle assemblage characteristics, species loss and shifting population structures of turtles, and ways to identify high-risk road mortality locations and causes (Browne & Hecnar, 2007; DeCatanzaro & Chow-Fraser, 2010; Gunson et al., 2012; Millar & Blouin-Demers, 2011). Each of these studies conducted in Ontario reveal important information that guides government policy regarding land-use planning and herpetofauna conservation, thereby contributing to the protection of Ontario's eight freshwater turtle species. Turtles of some genera seldom leave the water other than when females undergo nesting migrations; for our purpose, we categorized these genera as fully aquatic. For turtles of other genera, both sexes regularly undertake terrestrial movements independently of nesting; these genera were categorized as semi-aquatic. Different researchers worked on phylogeny of some extinct terrapins globally (Karl et al., 2019; Karl and Safi, 2019).

2. Discussion

Ontario has 8 native freshwater turtle species all occur in southern Ontario. Based on absence or presence of horny scutes or scales on their carapace, freshwater turtles divide into two categories, Soft shell turtles and hard shell turtles, respectively. Soft shell turtle includes family Trionichidae which consists of only one species, Apalone spinifera, While all other seven species are hard shell turtles like: Family Emydidae (Blanding's Turtle, Emydoidea blandingii; Wood turtle, Glyptemys insculpta; Painted turtle, Chrysemys picta; Northern map turtle, Graptemys geographica; Spotted turtle, Clemmys guttata); Family Kinosternidae consistys of one species viz Eastern Musk turtle (Sternotherus odoratus); and Family Chelydridae consists of common snapping turtle (Chelydra serpentina) (Tab. 2).

Table 2: Status of Freshwater Turtles in Ontario

S. No.	Family	Scientific name	Common Name	IUCN Status	CITES Appendix III	II
1	Emydidae	Emydoidea blandingii	Blanding's Turtle	EN	-	+
2	Emydidae	Glyptemys insculpta	Wood turtle	EN	-	+
3	Emydidae	Chrysemys picta	Painted turtle	LC	+	-
4	Emydidae	Graptemys geographica	Northern map turtle	LC	+	-
5	Emydidae	Clemmys guttata	Spotted turtle	EN	-	+
6	Kinosternidae	Sternotherus odoratus	Eastern Musk turtle	LC	+	-
7	Chelydridae	Chelydra serpentina	common snapping turtle	LC	+	-
8	Trionichidae	Apalone spinifera	soft shell turtle	LC	+	-

Each of Ontario's eight native freshwater turtle species are assessed as endangered, threatened or special concern in at least one part of the country. Despite turtles' tough shells, which have helped them survive predators, traps and even mass extinctions, modern threats such as busy roadways and some other anthropogenic threats have put these prehistoric creatures in jeopardy.

WWF-Canada is working to address some of the threats facing freshwater species like turtles. The Ontario Turtle Conservation Centre – Ontario's only conservation centre dedicated to caring only for turtles – is a recipient of WWF-Canada's Go Wild Community Grants presented by TELUS. The centre admits more than 800 adult turtles for treatment and rehabilitation each year and releases over 1,000 hatchling turtles as part of their headstarting program, including these five at-risk species.

What humans have done through contributing to habitat loss, hunting, and poaching, is target adult turtles. That increased adult mortality is actually what's driving the population down. You're most likely to spot turtles in marshy areas where there is native aquatic plant life. But during nesting season, which runs from late May to early July, you'll also spot them crossing roads and in sandy or gravel areas. Spring is an important time to watch for turtles. Here's a list of common differences among Ontario's freshwater turtles:

1) Blanding's Turtle (Emydoidea blandingii)

- Unlike snapping turtles, which have yellow spots, look for a bright yellow chin and throat.
- If you spot a turtle eating on land, it might be a Blanding—most aquatic turtles feed exclusively in the water.
- They're also likely to be seen on the move; Blanding's make the largest overland movement of any Ontario turtle to move from their summer nesting spots to overwintering habitat.
- These turtles can live to be 75.
- Although Blanding's turtles generally live in shallow lakes or large wetlands around the southern portions of Ontario, Québec and Nova Scotia. In Ontario, Blanding's Turtle mainly occurs from extreme southwestern Ontario, east to Ottawa and northwest to Sault-St. Marie; however, a handful of isolated records occur as far north as Timmins district. The Ontario distribution is not continuous and there are large portions of the province with few to no records, including the area from north of Sudbury to Timmins; the area from Grey and Bruce counties south to Waterloo County and east to Lake Simcoe; extreme southeastern Ontario; and the areas west and south of Algonquin Provincial Park. Interestingly, models predicted these zones as maintaining lower habitat suitability for Blanding's Turtle (Millar and Blouin-Demers, 2012);

2) Eastern Musk Turtle (Sternotherus odoratus)

- With an upper shell that is brown with black flecking and a yellowish lower shell, these guys are easily confused with painted turtles, snapping turtles, and Blanding's turtles. However, this small turtle only reaches a maximum length of 13 cm.
- Keep an eye out for a light stripe above and below the eye on each side of the head in adult turtles.
- Generally nocturnal creatures, Eastern musk turtles also rarely swim.
- This turtle is named for the odor it emits when it's threatened, which—you guessed it—is strong and musky. It's also called "stink-pot."
- Although it was once common in southwestern Ontario, this small turtle is now listed as threatened and is primarily found along the southern edge of the Canadian Shield in Ontario and Quebec.

3) Painted Turtle (Chrysemys picta)

- Painted turtles feature distinctive black shells with dark red or orange markings. No other species native to Ontario claims these colours.
- Easily spotted on the move, painted turtles will move over large areas overland in search of nesting sites.
- With natural "antifreeze" that prevents them from freezing, these turtles can survive temperatures as low as -9C0.
- These are the only non-threatened turtle species in Ontario, but they are still susceptible to the threats that face other turtles.

4) Northern Map Turtle (Graptemys geographica)

- Named for its markings, this turtle has contour lines on its upper shell that look like a topographical map.
- They also feature a yellow spot behind their eyes. Don't confuse them with snapping turtles though; snapping turtles are larger and lack the distinctive shell markings of the map turtle.
- One of the largest threats to this turtle's pollution is water pollution. It can cause mass die-offs of mollusks, one of their primary food sources.
- USA and Canada (Canada - Ontario and Quebec)

5) Snapping Turtle (Chelydra serpentina)

- The most prehistoric-looking of all of Ontario's native species, the snapping turtle has triangular spikes along its tail.
- Most likely to be confused with musk turtles, snapping turtles are significantly larger and grow up to 47 cm long.
- Not the strongest of swimmers, these aquatic turtles are usually observed walking on the bottom of small ponds and rivers or crossing roads.
- Most Ontario turtles only lay somewhere between three and 15 eggs. The snapping turtle lays around 50.
- Canada (Manitoba, New Brunswick, Nova Scotia, Ontario, Québec, Saskatchewan) and United States.

6) Spiny Softshell (Apalone spinifera)

- As the name implies, the softshell turtle has a soft, leathery shell.
- A long snout makes this peculiar-looking creature unmistakable from its counterparts. This turtle is also known for its snorkel-like snout, a fitting feature for the highly aquatic species. It rarely travels far from the rivers and lakes of Southwestern Ontario, where remaining Canadian populations are primarily found.
- With the ability to get nearly half the oxygen they require by breathing through their skin in the water, they're able to stay submerged for up to five hours.
- The spiny softshell is threatened, which means it could quickly become endangered if the degradation of its habitat continues.
- Canada (Ontario, Québec); Mexico and United States.

7) Spotted Turtle (Clemmys guttata)

- The spotted turtle features orange-yellow markings on its limbs, neck, and legs. However, it's most clearly identifiable from the yellow spots marking its shell.
- While males have dark eyes and a dark chin, females of this species have orange eyes and a yellow chin.

- Unlike most other turtles, spotted turtles spend the summer or dry season in a state of inactivity to avoid hot dry weather.
- Its beautiful shell also makes it a popular species in the illegal pet trade.
- Not only is it one of Canada's smallest turtles, it's also endangered.

8) Wood Turtle (Glyptemys insculpta)

- With a highly sculpted upper shell, Ontario Nature calls this species "one of Ontario's most attractive turtles."
- It's also one of few turtle species in Canada that doesn't shed sections of its shell.
- The neck, chin and and front legs are a vivid orange-yellow colour.
- Like their name implies, these turtles are likely to be found in woodlands or floodplains during the summer months.
- This turtle is no dunce. They're considered extremely intelligent and have been documented using creative methods to get their food, including stamping their feet to cause earthworms to come to the surface.
- The wood turtle can be found in or along clear, slow-flowing rivers, streams and creeks, scattered throughout Nova Scotia, New Brunswick, Southern Quebec and Ontario. However, it also spends a great deal of time on land, making it a semi-terrestrial species.

2.1. Threats to turtle populations

The following threats are having the largest impact on turtle populations in general:

- Habitat Loss

Habitat loss through urbanization and land conversion to agriculture has significantly contributed to declining turtle population in Southern Ontario and other areas surrounding the Great Lakes. Habitat loss can impact turtle populations for various reasons. For example, habitat loss can lead to a reduction in turtle populations from increased predation (Mifsud, 2014). Habitat loss and conversion is important for all species. Wetlands continue to decline in Canada, and few provinces have imposed legal protection of wetlands. Shoreline development is an important threat for the Map Turtle and Spiny Softshell. Hardening of the shoreline with retaining walls, rip rap, and docks reduce the amount of habitat available for nesting, basking, foraging, and overwintering. The introduction of invasive exotic plants has resulted in a surprising source of habitat conversion for Blandings Turtle, Spiny Softshell, Spotted turtle, and Northern Map Turtle. In particular, the European Common Reed, Phragmites, has invaded wetlands and decreased habitat quality by reducing solar heat at nesting sites. Turtle habitats are being extensively degraded, destroyed and fragmented because of anthropogenic activities (Klemens, 2000). Sometime natural habitat of freshwater turtles destructed because of developmental activities and urbanization. All these sort of developmental activities although are beneficial for mankind but also hazardous to natural habitat of wild fauna.

- Nest Predation

Seven of Ontario's eight native freshwater turtle species are at risk. Wildlife Preservation Canada has been working on the problem since 2004, when they launched a research project into nesting success in two of Ontario's largest, most important turtle nesting areas. This research showed that, even though the nesting sites were in prime, protected habitat inside national and provincial parks, virtually 100% of all turtle nests were being destroyed within 48 hours of being laid. Predators of turtles such as raccoons, possums, skunks, and coyotes are habitat generalists and can adjust more easily to landscapes converted into urban or agricultural areas. For example, raccoon populations can sometimes increase in areas converted into an urban landscape because of food availability from garbage waste. In contrast, most turtle species require very specific habitats to meet their survival needs and cannot survive in an urban or agricultural landscape (Mifsud, 2014).

- Illegal Collection and Poaching for the Pet Trade

There is a thriving pet trade for turtles, and all species are traded illegally within Canada and exported outside of Canada. Ironically, as the number of turtles in a traded species decline, the price per turtle increases, making the trade more lucrative. Trade for food also occurs, although the scope of the problem is not well understood.

- Road Mortality

Road mortality is an important threat to most of the species. Turtles move across roads and the ever expanding road network is a threat to the survival of turtle species through road kill and as a barrier to movement. Even if a turtle perceives a car approaching it, there is little chance that it is capable of getting off the road quickly enough to avoid being hit.

- Boating

Another source of direct mortality for some species is boating. The turtle species that bask in the water, Spiny Softshell, Northern Map Turtle, and Eastern Musk Turtle, are vulnerable to boating mortality. Boaters may not even see turtles basking in the water and do not feel the impact of hitting them.

- Predation

Another surprising threat, listed as being important for all species except the Spotted Turtle is human-subsidized predators. These predators include species that are well adapted to human activity, such as raccoons and red fox. Because their populations thrive near human dwellings, they have become important turtle nest predators.

- Fish Hooks

Another widespread threat is the accidental hooking of turtles on fishing lines. Many freshwater turtles are opportunistic scavengers that also take live prey, making them vulnerable to getting caught on baited fishing hooks. Often anglers will simply cut the fishing line when a turtle is hooked, so the hook remains caught in the turtle. Some hooks get caught in the mouth of the turtle, which can making feeding difficult. Other hooks are swallowed and lodge in the throat or even the stomach, which can be fatal. Even if the fishing hook does not kill the turtle, there is also the risk of lead poisoning if lead sinkers are also swallowed.

- Habitat Fragmentation

Habitat fragmentation caused by roads, drainage ditches; agricultural lands, housing, and invasive species can reduce turtle populations (Mifsud, 2014; Proulx et al., 2014). Several studies have been undertaken to discover the impacts that habitat fragmentation can have on turtle populations, and how these impacts can be mitigated. Commercial sand mining from the rivers not only cause erosion but also destruct the nesting areas of the turtles. It also modifies the direction of flow of water, configuration of riverbanks and makes water more turbid. All these factors directly influence on the growth of waterweeds, on under water activities of turtles and it also has hazardous effects on health of that aquatic ecosystem. Another important factor which is influenced by sand mining in rivers is reduction in dissolved oxygen in water which ultimately results in disturbance of aquatic life.

- Climate Change

Environmental and climate changes and natural disasters are also major threats for turtle survival. Pollution, contamination of water with industrial, agricultural, or domestic waste, pesticides sprays, fertilizers, global warming, and pathogens, all serve as threat for existence of Freshwater turtles. Climatic change is also important factor for their loss. Urbanization, developmental projects, construction of dams, barrages and roads are also important reason for their decreased populations. Globally, turtle habitats are being extensively degraded, destroyed and fragmented, and where they still exist in reasonable population's turtles are being subjected to subsistence hunting as well as for collection for regional and international consumption markets, in addition to the growing international pet trade.

- Habitat Degradation

Water quality and its impact on turtle's habitat degradation from urban and agricultural pollutants is another issue that affects turtle populations (Mifsud, 2014; Tryfonas et al., 2006). Continued degradation of waterways may be the most significant environmental threat to the survival of freshwater turtles (Burgin & Ryan, 2008). All crop growing activities and major deforestation also responsible for water seepage problems, modification of waterways and canal blockage. Agricultural wastewater and pesticides usage is also disastrous to population of fresh water turtles, Khan et al., (2015; 2016) also reported pesticides threats to turtles. Industrial waste material is an important cause of reduced population of freshwater turtles. It results in disturbed breeding biology, infertility; eggs shell thinning and physiological disorders in freshwater turtles. Freshwater turtles rely on permanent water sources to forage for food and hide from predators during times of drought; however, temporary wetlands also provide habitat for foraging and shelter from predators when flooded (Cosentino et al., 2010).

2.2. Recommendations for Conservation of Freshwater Turtles

1) The legislation for conservation of turtles should be properly implemented.
2) Distribution areas and hotspots should highlight. Community based awareness should be utilized.
3) Alternate opportunities should be provided to local people to avoid fresh water turtle pet trade.
4) Major threats should be detected and resolved.
5) Habitat destruction should be discouraged.
6) Export of parts of turtles should be checked, and local markets should be monitored to minimize the use of turtles in as pet trade.
7) Raising public awareness about wildlife trade can take many paths. Workshops/Seminars should be held in public places in regular basis to identify the need to raise consumer community awareness.
8) Government and CEC might consider creating a logo, a single sentence, and a common message.
9) The Monarch Butterfly CEC awareness campaign should be used as a model. The decline in monarch butterflies has triggered interest in this species in Canada, USA and Mexico, because: a) populations are seen across all three countries, and b) there are things people can do to help conserve monarchs; for example, people can manage their small plot of garden or yard and see the benefits when the butterflies arrive.
10) A recommendation to provide aquatic habitat within the restored areas is to block off agricultural drains that remain in the marsh from before it was restored. The drains prevent the Meadow Marsh habitat areas from flooding beyond a certain depth.
11) It is recommended that suitable aquatic habitat is constructed for freshwater turtles within restored marsh areas, which reach depths that ensure a permanent water source.
12) Basking areas such as logs could be added to the ponds. The construction of ponds within restored areas of the marsh could encourage freshwater turtles to move from canal habitats to areas within the restored marsh, located away from the highway and the threats associated with it.
13) It is recommended that the speed limits could be reduced along the stretch of highway located beside the canal to help prevent road mortality.

Acknowledgements

We are very thankful to Dr. Shah for the review and support for the current review study. We would also like to thank Mr. Z. Farooqui and Mr. M. Sohaib Bhai for the time they given us to visit different wetlands of the study areas.

References

[1] Messager, M.L., Lehner, B., Grill, G., Nedeva, I. and Schmitt, O. 2016. Estimating the volume and age of water stored in global lakes using a geostatistical approach. Nature Communications, 7, 13603. https://doi.org/10.1038/ncomms13603.

[2] Currie, D.J., Mittelbach, G.G., Cornell, H.V., Field, R., Guégan, J.F., Hawkins, B.A., Kaufman, D.M., Kerr, J.T., Oberdorff, T., O'Brien, E. and Turner, J.R.G., 2004. Predictions and tests of climatebased hypotheses of broad-scale variation in taxonomic richness. Ecology letters, 7(12): 1121-1134. https://doi.org/10.1111/j.1461-0248.2004.00671.x.

[3] Environment and Climate Change Canada. 2016b. Canadian Environmental Sustainability Indicators: Extent of Canada's Wetlands. Consulted on 08/06/2017.

[4] International Union for the Conservation of Natute (IUCN). 2018. Global policy – About. At: <www.iucn.org/ theme/global-policy/about>.

[5] Turtle Taxonomy Working Group (TTWG) [van Dijk, P.P., J.B. Iverson, A.G.J. Rhodin, H.B. Shaffer, and R. Bour]. 2014. Turtles of the world, 7th edition: Annotated checklist of taxonomy, synonymy, distribution with maps, and conservation status. Chelonian Research Monographs 5(7):000.329–479.

[6] Turtle taxonomy working group [TTWG: Rhodin, A.G.J., Iverson, J.B., Bour, R., Fritz, U., Georges, A., Shaffer, H.B., and Van Dijk, P.P.]. 2017. Turtles of the World: annotated checklist and atlas of taxonomy, synonymy, distribution, and conservation status. Eight Edition. Chelonian Research Monographs 7:1–292.

[7] Turtle Extinctions Working Group (TEWG) [Rhodin, A.G.J., S. Thomson, G.L. Georgalis, H.-V. Karl, I.G. Danilov, A. Takahashi, M.S. de la Fuente, J.R. Bourque, M. Delfino, R. Bour, J.B. Iverson, H.B. Shaffer, and P.P. van Dijk]. 2015. Turtles and tortoises of the world during the rise and global spread of humanity: First checklist and review of extinct Pleistocene and Holocene chelonians. Chelonian Research Monographs 5:000e.1–66.

[8] Buhlmann, K.A., T.S.B. Akre, J.B. Iverson, D. Karapatakis, R.A. Mittermeier, A. Georges, A.G.J. Rhodin, P.P. van Dijk, and J.W. Gibbons. 2009. A global analysis of tortoise and freshwater turtle distributions with identification of priority conservation areas. Chelonian Conservation and Biology 8:116–149. https://doi.org/10.2744/CCB-0774.1.

[9] Behler, J.L. 1997. Troubled times for turtles. In: Van Abbema, J. (ed.). Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles – An International Conference. New York: New York Turtle and Tortoise Society.

[10] Van Dijk, P.P., B.L. Stuart, and A.G.J. Rhodin (eds.). 2000. Asian turtle trade: Proceedings of a workshop on conservation and trade of freshwater turtles and tortoises in Asia, Phnom Penh, Cambodia, 1–4 December 1999. Chelonian Research Monographs No. 2. Chelonian Research Foundation, Lunenburg, Mass. 164 pp.

[11] Gibbons, J.W., D.E. Scott, T.J. Ryan, K.A. Buhlmann, T.D. Tuberville, B.S. Metts, J.L. Greene, T. Mills, Y. Leiden, S. Poppy, and C.T. Winne. 2000. The global decline of reptiles, déjà vu amphibians. BioScience 50:653–666. https://doi.org/10.1641/0006-3568(2000)050[0653:TGDORD]2.0.CO;2.

[12] Safi, A. and Khan, MZ. 2014. Distribution and current population status of freshwater turtles of district of Charsadda of Khyber Pakhtunkhwa, Pakistan. Journal of Zoology Studies. 1(4):31-38.

[13] Khan, MZ., Safi, A., Fatima, F., Ghalib, SA., Hashmi, MUA., Khan, IS., Siddiqui, S., Zehra, A. and Hussain, B. 2015. An Evaluation of Distribution, Status and Abundance of Freshwater Turtles in Selected areas of Sindh and Khyber Pakhtunkhwa Provinces of Pakistan. Canadian Journal of Pure and Applied Sciences. 9(1):3201-3219.

[14] Khan, M. Z., Kanwal, R., Ghalib, S.A., Fatima, F ., Zehra, A., Siddiqui,S. Yasmeen, G., Safi, A., Hashmi, M.U.A., Hussain, B., Iqbal, M.A., Manzoor, U. and Ullah, U. 2016. A review of distribution, threats, conservation and status of freshwater turtles in Sindh. Canadian Journal of Pure and Applied Sciences. 10 (3): 3997 – 4009.

[15] Khan et al., Safi A, Ghalib SA and Kanwal R. 2016. Population status, distribution and conservation of freshwater turtles of peshawar valley, khyber pakhtunkhwa, Pakistan. Canadian Journal of Pure and Applied Sciences. 10 (1): 3732 – 3750.

[16] Wijnstekers, W. 2003. The evolution of CITES: A reference to the Convention on International Trade in Endangered Species of Wild Flora and Fauna. 7th Edition. Geneva, Switzerland: CITES Secretariat. 588 pp.

[17] Commission for Environmental Cooperation (CEC). 2017. Sustainable Trade in Turtles and Tortoises: Action Plan for North America. Montreal, Canada: Commission for Environmental Cooperation, 60 pp.

[18] Fritz, U. and Havas, P. 2007. Checklist of Chelonians of World. Vertebrate Zoology. 57(2)149-368.

[19] Gunson, K., Ireland, D., & Schueler, F. (2012). A tool to prioritize high-risk road mortality locations for wetland-forest herpetofauna in southern Ontario, Canada. North-Western Journal of Zoology, 8(2), 409-413. Retrieved from http://biozoojournals.3x.ro/nwjz/index.html

[20] Bennett, A., & Litzgus, J. (2014). Injury rates of freshwater turtles on a recreational waterway in Ontario, Canada. Journal of Herpetology, 48(2), 262-266. https://doi.org/10.1670/12-161.

[21] Hughes, E., & Brooks, R. (2006). The good mother: Does nest-site selection constitute parental investment in turtles? Canadian Journal of Zoology, 84, 1545-1554. doi:10.1139/Z06 148.

[22] Millar, C., & Boulin-Demers, G. (2011). Spatial ecology and seasonal activity of Blanding's turtles (Emydoidea blandingii) in Ontario, Canada. Journal of Herpetology, 45(3), 370378. https://doi.org/10.1670/10-172.1.

[23] Paterson, J., Steinberg, B., & Litzgus, J. (2012). Generally specialized or especially general? Habitat selection by snapping turtles (Chelydra serpentina) in central Ontario. Canadian Journal of Zoology, 90, 139-149. https://doi.org/10.1139/z11-118.

[24] Yagi, K., & Litzgus, J. (2012). The effects of flooding on the spatial ecology of spotted turtles (*Clemmys guttata*) in a partially mined peatland. Copeia, 2, 179-190. https://doi.org/10.1643/CE-11-106.

[25] Obbard, M., & Brooks, R. (1980). Nesting migrations of the Snapping Turtle (Chelydra serpentina). Herpetologica, 36(2), 158-162. Retrieved from http://www.jstor.org/stable/3891480

[26] Browne, C., & Hecnar, S. (2007). Species loss and shifting population structure of freshwater turtles despite habitat protection. Biological Conservation, 138, 421-429. https://doi.org/10.1016/j.biocon.2007.05.008.

[27] Rollinson, N., & Brooks, R. (2007). Marking nests increases the frequency of nest depredation in a northern population of painted turtles (Chrysemys picta). Journal of Herpetology, 41(1), 174-176. https://doi.org/10.1670/0022-1511(2007)41[174:MNITFO]2.0.CO;2.

[28] DeCatanzaro, R., & Chow-Fraser, P. (2010). Relationship of road density and marsh condition to turtle assemblage characteristics in the Laurentian Great Lakes. Journal of Great Lakes Research, 36, 357-365. https://doi.org/10.1016/j.jglr.2010.02.003.

[29] Karl HV, Safi A and Philippen HD. 2019. Evidences of Cheloniophagy by Early Hominid (*Homo erectus*) during Middle of Pleistocene from Central Java (Indonesia), with an Updated List of Trinil's Testudines, and a Redescription of *Duboisemys isoclina* (Dubois, 1908). International Journal of Zoology Studies. 4 (6):73-84.

[30] Karl HV and Safi A. 2019. *Desmemys bertelsmanni* (Wegner, 1911) (Testudines: Pleurosternidae) - a valid taxon of a Mesozoic river turtle based on the rediscovery of type material from the Wealden fazies of North Rhine-Westphalia, Germany. Documenta naturae communications. 3: 45-61.

[31] www.wikipedia.org

[32] Mifsud, D. (2014). A status assessment and review of the herpetofauna within the Saginaw Bay of Lake Huron. Journal of Great Lakes Research Supplement, 40, 183-191. Retrieved from https://doi.org/10.1016/j.jglr.2013.09.017.

[33] Proulx, C., Fortin, G., & Blouin-Demers, G. (2014). Blanding's turtles (Emydoidea blandingii) avoid crossing unpaved and paved roads. Journal of Herpetology, 48(2), 267-271. https://doi.org/10.1670/12-176.

[34] Tryfonas, A., Tucker, J., Brunkow, P., Johnson, K., Hussein, H., & Lin, Z. (2006). Metal accumulation in eggs of the red-eared slider (Trachemys scripta elegans) in the Lower Illinois River. Chemosphere, 63, 39-48. https://doi.org/10.1016/j.chemosphere.2005.07.080.

[35] Burgin, S., & Ryan, M. (2008). Comparison of sympatric freshwater turtle populations from an urbanized Sydney catchment. Aquatic Conservation: Marine and Freshwater Ecosystems, 18, 1277-1284. https://doi.org/10.1002/aqc.945.

[36] CEC. 2019. Trinational Trade and Enforcement Training Workshop to Support the Legal and Sustainable Trade in Turtles and Tortoises. Report. Montreal, Canada: Commission for Environmental Cooperation. 2019. 84 pp.

[37] Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2007. COSEWIC assessment and update status report on the Wood turtle (Glyptemys insculpta) in Canada. Ottawa: Committee on the Status of Endangered Wildlife in Canada. Vii + 42 pp.

[38] Cosentino, B., Schooley, R., Phillips, C. (2010). Wetland hydrology, area, and isolation influence occupancy and spatial turnover of the painted turtle, Chrysemys picta. Landscape Ecology, 25, 1589-1600. https://doi.org/10.1007/s10980-010-9529-3.