PROPOSED

Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the Wood Turtle (*Glyptemys insculpta)* in Canada

Wood Turtle

2016

Government of Canada
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For copies of the recovery strategy, or for additional information on species at risk, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk (SAR) Public Registry[1].

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[1] http://www.registrelep-sararegistry.gc.ca

Preface

The federal, provincial and territorial government signatories under the Accord for the Protection of Species at Risk (1996)[2] agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c. 29) (SARA), the federal competent ministers are responsible for the preparation of recovery strategies for listed Extirpated, Endangered and Threatened species, and are required to report on progress within five years after the publication of the final document on the SAR Public Registry.

The Minister of the Environment and Minister responsible for the Parks Canada Agency is the competent minister under SARA for the Wood Turtle and has prepared this recovery strategy in accordance with section 37 of SARA. To the extent possible, it has been prepared in cooperation with the Department of National Defence, the Ontario Ministry of Natural Resources, the Ministère des Forêts, de la Faune et des Parcs du Québec (MFFP), the Department of Natural Resources of New Brunswick, the Nova Scotia Department of Natural Resources, and the Kitigan Zibi Anishinabeg First Nation, and any others as per section 39(1) of SARA.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Environment Canada and the Parks Canada Agency, or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of the Wood Turtle and Canadian society as a whole.

This recovery strategy will be followed by one or more action plans that will provide information on recovery measures to be taken by Environment Canada, the Parks Canada Agency and other jurisdictions and/or organizations involved in conservation of the species. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations

The recovery strategy sets the strategic direction to arrest or reverse the decline of the species, including identification of critical habitat to the extent possible. It provides all Canadians with information to help take action on species conservation. When the recovery strategy identifies critical habitat, there may be future regulatory implications, depending on where the critical habitat is identified. SARA requires that critical habitat identified within federal protected areas be described in the *Canada Gazette*, after which prohibitions against its destruction will apply. For critical habitat located on federal lands outside of federal protected areas, the Minister of Environment must either make a statement on existing legal protection or make an order so that the prohibition against destruction of critical habitat applies. For critical habitat located on non-federal lands, if the Minister of Environment forms the opinion that any portion of critical habitat is not protected by provisions in or measures under SARA or other Acts of Parliament, and not effectively protected by the laws of the province or territory, SARA requires that the Minister recommend that the Governor in Council make an order to extend the prohibition against destruction of critical habitat to that portion. The discretion to protect critical habitat on non-federal lands that is not otherwise protected rests with the Governor in Council.

[2] www.sararegistry.gc.ca/approach/strategy/default_e.cfm

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Executive Summary

Although the Wood Turtle (*Glyptemys insculpta*) is strongly associated with year-round flowing streams, it is the most terrestrial of Canada's freshwater turtles. It was listed as a Threatened in Schedule 1 of the *Species at Risk Act* (SARA) in 2010.

The Canadian population of the Wood Turtle is estimated to be between 6000 and 12 000 adults. Local populations are mostly small, rarely exceeding 100 individuals, with the number of adults likely declining at a rate of > 10% in three generations. Although no quantitative habitat trend is available, there is a decline in area and quality of habitat over much of the species' range.

Road network and agricultural practices are the most serious threats to Wood Turtle. Other threats include illegal collection as pets and for consumption, residential and commercial development, subsidized predation, forestry practices, off-road vehicles, water management, sand and gravel pit operation as well as pollution and sediment input. Wood Turtle populations are highly vulnerable to any increases in mortality rates of adults or older juveniles because of the species' long-term reproductive success strategy (e.g., delayed sexual maturity, slow reproductive rate).

Recovery of the Wood Turtle is considered feasible. The long-term population and distribution objectives (i.e., ~ 50 years) is to ensure the viability of local populations in watersheds where the Wood Turtle currently occurs in Canada. To work toward achieving the long-term population and distribution objectives, three specific medium-term objectives (i.e., ~ 10-15 years) have been identified. Broad strategies and general approaches to achieve these objectives are set out in the section on Strategic Direction for Recovery.

Wood Turtle critical habitat is partially identified in this recovery strategy. Critical habitat is identified based on two criteria: habitat occupancy and habitat suitability. The Minister of the Environment, on the advice of COSEWIC, has restricted the release of information that relates to the location of the Wood Turtle or its habitat (SARA, s. 124). Wood Turtle critical habitat is therefore presented at the 1:250 000 scale so as not to compromise this sensitive information. A schedule of studies has been included to complete critical habitat identification, and examples of activities likely to destroy the critical habitat are provided.

One or more Wood Turtle action plans will be posted before 2021 on the Species at Risk Public Registry.

Recovery Feasibility Summary

Under subsection 41(1) of SARA, the competent minister must determine whether the recovery of the listed wildlife species is technically and biologically feasible. Although it is acknowledged that, as with many other species, there is some degree of uncertainty in the application and net efficiency of threat avoidance or mitigation and recovery techniques, recovery is determined to be feasible according to the following four criteria used by Environment Canada:

1. Individuals of the wildlife species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance.

Yes. Individuals capable of reproduction as well as young turtles leaving the nest have been observed in several local populations in all provinces where the species occurs (see section 3.2). There are also local populations of Wood Turtle in all provinces where the species occurs that are likely to persist in the wild. In addition, distribution of the Wood Turtle is continuous between southeastern Canada and northeastern United States, and some exchanges do occur at specific locations.

2. Sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration.

Yes. Although habitat loss and degradation is affecting several local populations, suitable habitat remains available throughout the Canadian range and is likely sufficient for the recovery of the majority of local Wood Turtle populations. Further suitable habitat could also be made available through habitat management or restoration.

3. The primary threats to the species or its habitat (including threats outside Canada) can be avoided or mitigated.

Yes. Mitigation or avoidance of mortality (or collection) as well as habitat loss and degradation is possible through implementation of best management practices and habitat conservation or restoration. Threats can also be mitigated through outreach, legislation and enforcement (e.g., *Convention on International Trade in Endangered Species of Wild Fauna and Flora, Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act*).

4. Recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable time frame.

Yes. Possible recovery techniques include habitat management and restoration, implementation of compatible cropping practices (e.g., height and timing of mowing), protection of nesting sites, disturbance management, head-starting programs, and road mortality mitigation structures (e.g., road fencing).

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1. COSEWIC* Species Assessment Information

Date of Sssessment: November 2007

Common Name (population): Wood Turtle

Scientific Name: *Glyptemys insculpta*

COSEWIC Status: Threatened

Reason for Designation: This species is declining across much of its range, and occurs in small, increasingly disjunct populations. It is more terrestrial than other freshwater turtles, which makes it extremely vulnerable to collection for the pet trade. It has a long-lived life history typical of turtles, so that almost any chronic increase in adult and juvenile mortality leads to a decrease in abundance. Such increased mortality is occurring from increased exposure to road traffic, agricultural machinery and off-road vehicles, collection for pets, commercial collection for the pet trade, and, perhaps, for exotic food/medicines. Increased level of threat is associated with new or increased access to the species' range by people.

Canadian Occurrence: ON, QC, NB, NS

COSEWIC Status History: Designated Special Concern in April 1996. Status re-examined and designated Threatened in November 2007.

* Committee on the Status of Endangered Wildlife in Canada.

1. Species Status Information

Canada has approximately 30% of the global distribution of the Wood Turtle (COSEWIC 2007). In March 2010, the species was listed as Threatened[4] on Schedule 1 of the *Species at Risk Act* (SARA) (S.C. 2002, c. 29). In Ontario, the species has been listed as Endangered[5] under the *Endangered Species Act, 2007* (S.O. 2007, c. 6) since 2008. It is also designated as a Specially Protected Reptile under the Ontario *Fish and Wildlife Conservation Act* (S.O. 1997, c. 41). In Quebec, it is listed as Vulnerable[6] under the *Act Respecting Threatened or Vulnerable Species* (R.S.Q., c. E-12.01) since 2005. In Nova Scotia, it has been listed as Vulnerable[7] under the *Endangered Species Act* (Acts of 1998, c. 11) since 2000, but has recently been uplisted to Threatened[8]. In New Brunswick, the species is listed as Threatened[9] under the new *Species at*

[4] Threatened (SARA): a species likely to become an endangered species if nothing is done to reverse the factors leading to its extirpation or extinction.
[5] Endangered: a native species facing imminent extinction or extirpation.
[6] Vulnerable: a species for which survival is precarious even if extinction is not anticipated.
[7] Vulnerable: a species of special concern due to characteristics that make it particularly sensitive to human activities or natural events.
[8] Threatened: a species likely to become endangered if the factors affecting its vulnerability are not reversed.

Risk Act (2013). The International Union for the Conservation of Nature (IUCN) assessed the Wood Turtle as Endangered in 2010. NatureServe (2014) conservation ranks for Canada and the United States are presented in Table 1.

Table 1: NatureServe conservation ranks for Wood Turtle

Global rank (G)	National rank (N)	Subnational rank (S)
G3	Canada (N3)	S2: Ontario, Quebec; S3: New Brunswick, Nova Scotia
	United States (N3)	SH: District of Columbia; S1: Iowa, Ohio; S2: Minnesota, New Jersey, Rhode Island, Virginia, West Virginia; S2S3: Michigan; S3: Connecticut, Massachusetts, New Hampshire, New York, Vermont, Wisconsin; S3S4: Pennsylvania; S4: Maine, Maryland

1: Critically Imperiled; 2: Imperiled; 3: Vulnerable; 4: Apparently Secure; 5: Secure; H: Possibly Extirpated

The Wood Turtle is also listed in Part 1 of Schedule to the *Wild Animal and Plant Trade Regulations*, made under the *Wild Animal and Plant Protection and Regulation of International and Interprovincial Trade Act* (S.C. 1992, c. 52) (WAPPRIITA), which controls the trade of species listed under the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES).

2. Species Information

This section is primarily a synthesis of the information reported in COSEWIC (2007). Most descriptive information originates from COSEWIC (2007). Primary sources of information are given for ecological or behavioral information.

3.1 Species Description

The Wood Turtle is a medium-sized semi-aquatic turtle (16-25 cm adult carapace [upper shell] length), with adults weighing about 1 kg. Males are slightly larger than females, with a broader head. The species has a broad, low carapace ranging from grayish-brown to yellow in colour. Each scute (plates on the shell) has pyramidal concentric ridges (growth lines), giving the carapace a sculptured appearance. The plastron (bottom shell) does not have a hinge and is yellow with black blotches on the outer posterior corners of its scutes; it is flat in adult females and juveniles but concave in mature males. The skin is generally brown but the legs and neck often have orange, yellow or reddish colouring. There is little published information on the longevity of Wood Turtles, but they are known to live over 50 years in the wild (Reference removed[10]). Wood Turtles do not reach maturity until 11 to 22 years of age ([Reference removed]; Walde et al. 2003). Unlike most other turtle species, the temperature during incubation does not determine the sex of an individual (Ewert and Nelson 1991). Females lay

[9] Threatened: a wildlife species that is likely to become an endangered species if nothing is done to reverse the factors leading to its extirpation.

[10] Due to the vulnerability of the species to illegal collection, specific references providing sensitive information have been removed from this version of the recovery strategy. See *References* section.

clutches of 1-20 eggs (the average is 8-12), though there may be years in which they do not breed.

3.2 Population and Distribution

The Wood Turtle is found only in eastern North America, from Nova Scotia westward through New Brunswick, Quebec, Ontario and Minnesota, and southward to Virginia, West Virginia and Maryland. Its distribution, as shown in Figure 1, is discontinuous (COSEWIC 2007).

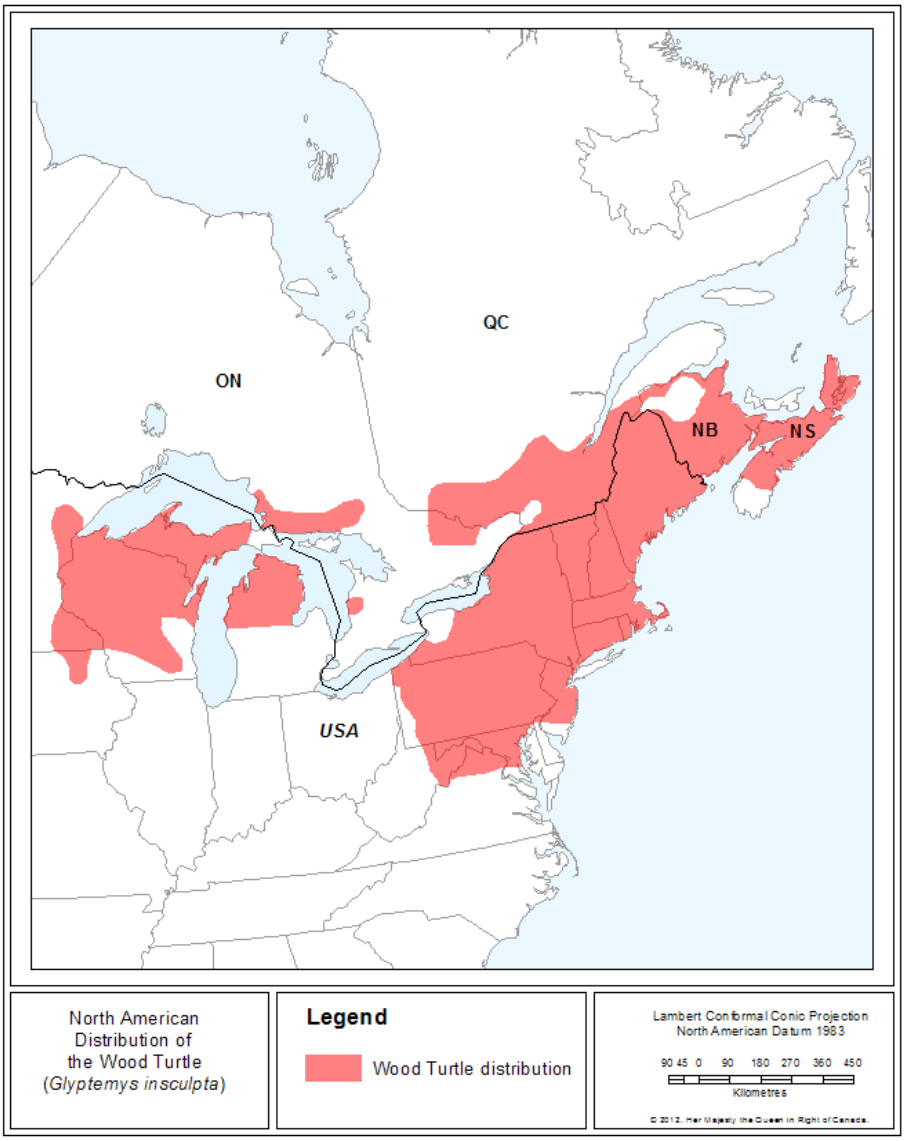


Figure 1: Distribution of the Wood Turtle in North America (based on COSEWIC 2007)

The extent of occurrence[11] has remained relatively unchanged since the mid-20th century, i.e., approximately 500 000 km^2. The known area of occupancy[12] had been estimated at between 1051 and 1752 km^2 (COSEWIC 2007). Search effort since 2007 led to an increase in the estimated area of occupancy, with the discovery of several new locations occupied by the species in Quebec (Centre de données sur le patrimoine naturel du Québec [CDPNQ] 2014), New Brunswick and Nova Scotia (AC CDC 2014). According to COSEWIC (2007), no quantitative habitat trend is available, but there is a decline in area and quality of habitat over much of the Wood Turtle's range.

The entire Canadian population was estimated between 6000 and 12 000 adult individuals by COSEWIC (2007), with local populations[13] being mostly small, rarely exceeding 100 individuals. The current estimate, based on the sum of provincial estimates (Table 2) is roughly the same.

The number of adults is likely declining at a rate > 10% in three generations (COSEWIC 2007). In Ontario, few streams inhabited by Wood Turtle have been studied long enough to identify trends, but one stream in southern Ontario declined by approximately 70% during the 1993-2002 period ([References removed]; Mitchell *et al.* 1997) and have not yet recovered (J. Crowley, pers. comm. 2014). Another stream located in central Ontario may have declined by 30-50% during the 1990-2005 period ([Reference removed]; R. Brooks, pers. comm. 2005, *in* COSEWIC 2007). In Quebec, the population trend has been assessed for 11 streams on the basis of quantitative analysis (e.g., Reference removed) and expert opinions; it is declining in nine and stable in two (J. Jutras, pers. comm. 2005, *in* COSEWIC 2007). In New Brunswick and Nova Scotia, there are no published data on population trends. This lack of information can be partially explained by the substantial resources required to obtain traditional quantitative population trends. Genetic approaches have recently been tested successfully in the state of Michigan to infer population declines for Wood Turtle (Willoughby *et al.* 2013).

Table 2 shows that Wood Turtle records are distributed among 145 watersheds (comprising records from all available sources [e.g., Conservation Data Centers [CDCs], unreported studies]). CDCs (Atlantic Canada Conservation Data Centre [AC CDC] 2014; CDPNQ 2014; Ontario Natural Heritage Information Centre [NHIC][14] 2011) presently hold 404 element occurrences (EO).[15] The EO rank, which is one way of expressing viability (probability of persistence) of the local population, has been determined in Ontario and more recently in Quebec. Very few EOs from those provinces show excellent viability.

[11] The area included in a polygon without concave angles that encompasses the geographic distribution of all known populations of a species (COSEWIC 2010).
[12] The area within the extent of occurrence that is occupied by the species (COSEWIC 2010).
[13] A *local population* for Wood Turtle in Canada is defined as a discrete interbreeding population in a distinct watershed.
[14] The Natural Heritage Information Centre (NHIC) is the CDC for Ontario.
[15] An element occurrence is an area of land and/or water in which a species or natural community is, or was, present (NatureServe 2014).

Table 2. Numbers of individuals, element occurrences, and watersheds where Wood Turtle is reported per province

Province	Estimated[a] number of adult individuals	Number of element occurrences	Number and scale of watersheds[b] where records are reported	Reference
Ontario	~ 1100	56 (33 extant; 1 extirpated; 22 historic)	22 Ontario tertiary watersheds Mean size = 4068 ± 1645 km²	Ontario Wood Turtle Recovery Team (2010); NHIC (2011); J. Crowley, pers. comm. (2014)
Quebec	2000-2500	125	33 Quebec hydrological sheet lines Mean size = 4859 ± 3648 km²	[Reference removed]; COSEWIC (2007); CDPNQ (2014); Y. Dubois, pers. comm. (2014)
New Brunswick	>1000	101	55 New Brunswick secondary watersheds Mean size = 686 ± 1268 km²	COSEWIC (2007); AC CDC (2014); unpublished data compiled by CWS-AR (2014)
Nova Scotia	2000-7000	122	35 Nova Scotia primary watersheds Mean size = 1267 ± 547 km²	COSEWIC (2007); AC CDC (2014); M. Pulsifer, pers. comm. (2014); unpublished data compiled by CWS-AR (2014)
TOTAL	~6100->11 600	404	145	

[a] Please note that estimates come from different calculation techniques. There are more uncertainties related to the estimates for the Atlantic Provinces given that limited quantitative surveys have been conducted This is reflected in the wide ranging estimates.

[b] In the four provinces where Wood Turtle is present in Canada, watersheds are delineated at several scales (or levels). The most appropriate one has been selected in each province based on the species' needs. For more information, see "Definition and relevance of the *local population* concept for the Wood Turtle" below.

Definition and relevance of the *local population* concept for the Wood Turtle

In Canada, all Wood Turtles are presently considered to belong to one overall *population*. COSEWIC (2007) examined the relevance of separating this *population* in finer designatable management units[16] and concluded that it would not be appropriate at this time. Nevertheless, Wood Turtle genetic studies performed in Ontario (Fridgen et al. 2012) and Quebec (References removed) demonstrated that, in some cases, genetic differences observed between inhabited streams are large enough for associated populations to be considered as distinct management units.[17] This information, which is crucial to the development of this strategy, tends to indicate that the Canadian *population* is composed of multiple *local populations*, which seems to be the most appropriate unit for recovery planning. Until now, no studies have been performed to specifically define or delineate *local* Wood Turtle *populations* in Canada. On the basis of the available ecological information (section 3.3 and COSEWIC 2007), we define a *local population* for Wood Turtle in Canada as a discrete interbreeding population in a distinct watershed.

[16] Based on the criteria for assigning such units (see COSEWIC Operations and Procedures Manual, Appendix F5, Nov. 2007).

[17] Management units are recognized as populations with significant divergence of allele frequencies at nuclear or mitochondrial loci, regardless of the phylogenetic distinctiveness of the alleles (Moritz 1994).

Watershed scale, shown in Table 2, was selected on the basis of the information available in section 3.3 (Movement). Further studies will help verify or refine this approach.

3.3 Needs of the Wood Turtle

General habitat and biological needs

As an ectotherm,[18] the Wood Turtle is highly dependent on climatic conditions (see "Limiting factors" at the end of this section). Analyses performed by Dubois *et al.* (2009) indicated that the spatial distribution, temporal activity patterns, and semi-terrestrial lifestyle of Wood Turtles are shaped by their thermal biology.

Wood Turtles are generally found in forested landscapes. Although they make significant use of terrestrial habitats, they require water frequently (often on a daily basis) and for several vital functions throughout their life cycle (Reference removed). The Wood Turtle is virtually always associated with clear freshwater streams[19] and associated floodplains[20]. It prefers streams with a year-round current, ranging from creeks (as little as 1 m wide) to medium-sized rivers (rarely up to 75 m). Streams used by the species are usually meandrous with frequent oxbows[21], and the riverbeds are generally sandy or gravely-sandy, sometimes cobbly. Wood Turtles were previously thought to be strictly associated with freshwater environments with salinity up to 0.1 ppm (Reference removed), but a recent study in New Brunswick showed that 12 individuals used brackish water and estuaries with salinity up to 30 ppm for several months, and even nested in associated habitat (Reference removed). However, these observations were made for the short term, and further studies will be needed to confirm that the Wood Turtle can live, survive and reproduce in brackish environments in the long term. Wood Turtles may also use bogs, marshy pastures, beaver ponds, oxbows, riparian and shrub areas, meadows, hay and agricultural fields, and utility rights-of-way.

Overwintering

To avoid freezing, Wood Turtles overwinter in underwater hibernacula from October to April, or for shorter periods under milder climates. At one site in Ontario, Wood Turtles overwintered at a mean water depth of 91.2 ± 34.8 cm (N = 61 observations) and within a mean distance of 124.4 cm from the shore (Greaves and Litzgus 2008). Overwintering may occur in numerous microhabitat types (e.g., buried in mud, under overhanging banks, resting on the bottoms of stream pools) (source references in Ultsch 2006). Most individuals overwinter in the main stream with which they are associated, but can overwinter in a variety of conditions, including small streams (~ 1 m wide) that may be located several kilometres from the main stream (Reference removed). A recent study (Reference removed) conducted in Nova Scotia also reported adults overwintering in small numbers in oxbows and marsh outlets. Hibernacula have also been reported in lakes near stream outlets (Reference removed). Until early 2010's , the general

[18] It relies on the heat available in its environment to control its internal body temperature.
[19] In this document, stream is defined as a body of water that moves under gravity to progressively lower levels, in a relatively narrow but clearly defined channel on the surface of the ground.
[20] Floodplains occur in river valleys adjacent to stream channels and are prone to periodic flooding. The habitats, vegetation, and hydrologic regime of floodplains are strongly influenced by watershed size, gradient, and channel morphometry (New Hampshire Fish and Game Department 2005).
[21] Meander of a river that has since been cut off of the main stem, creating a free-standing body of water.

consensus was that hibernating Wood Turtles required a stable, high concentration of dissolved oxygen to survive ([References removed]; Ultsch 2006), effectively limiting the Wood Turtle to stream habitats (Greaves and Litzgus 2008). Observations of successful overwintering in hibernacula with moderate (6.0-9.0 ppm) to low (<3.0 ppm) dissolved oxygen concentrations may suggest that other factors also come into play (Reference removed). Wood Turtles may overwinter alone, communally with conspecifics or with other turtle species. Greaves (2007) reported no fine-scale site fidelity in one inhabited stream in Ontario. Site fidelity probably does not occur in lotic environments for this long-lived species because streams are turbulent and stochastic, leading to changes in the configuration of potential overwintering sites over time (Greaves 2007). However, (Reference removed) did observe fine-scale fidelity in 13 out of 23 individuals tracked for two consecutive winters in Nova Scotia that returned to within 0-2 m of the previous year's location, in lentic, thus more stable, environments. [Reference removed] also reported some degree of site fidelity linked with structural elements present in the stream. Turtles hibernated for nine consecutive years sheltered by a hemlock log until it was swept away in a flash flood. These observations support the aforementioned hypothesis that overwintering site fidelity is dependent on habitat structure stability.

Mating

Wood Turtles mate throughout the active season (April to October, or a longer period under milder climate), but most commonly in spring and fall. Mating generally occurs in water, usually shallow water zones (Reference removed). Males typically remain near the water, while females are often reported farther from streams (References removed).

Thermoregulation

During the active season, regulation of body temperature imposes constraints on habitat use by Wood Turtles. Individuals take advantage of higher average temperatures and greater basking opportunities offered by terrestrial habitats during the day, and regularly use the stream as a thermal refuge at night (Dubois *et al.* 2009). This is especially true at the beginning (pre-nesting period) and end of the active season (pre-overwintering period), and explains why Wood Turtles stay in closer proximity to water and may use banks extensively to bask during those periods. During the summer, while remaining in the vicinity of streams, Wood Turtles become more terrestrial (e.g., Reference removed). More information on terrestrial habitat use during the active season is provided in the "Movements" sub-section below. Outside the aquatic habitat, turtles rely heavily on edges between forest and open habitats (e.g., grassland) or where canopy cover is low (e.g., alder tickets, shrubland), which allow access to solar radiation ([Reference removed]; Compton *et al.* 2002; Dubois *et al.* 2009).

Nesting

Female Wood Turtles generally lay their eggs from late May to mid-June (with some records going as late as the first week of July, M. Pulsifer, pers. comm. 2013) in open, sunny areas in fairly moist but well-drained sandy or gravelly soil ([Reference removed]; NatureServe 2014). Sun exposure is crucial, as females will select sites based on soil temperature (Reference removed). [Reference removed] reported that when the slope of nest sites exceeded 20, southerly aspects were clearly favoured (ESE-SW). Females have been shown to exhibit high nest-site fidelity (Reference removed). The nests are typically dug on beaches, riverbanks or other open areas. Wood Turtles also nest in clearings created by humans, such as gravel pits, road and railway embankments, utility rights-of-way, agricultural fields, pastures and old fields. Distance

between aquatic habitat and nesting sites may vary greatly depending on site availability. Studies on Wood Turtle in Canada show a maximum distance ranging from 150 to 700 m, and usually from 10 m to 50 m ([Reference removed]; Ernst 2001; Steen et al. 2012). In Canada, hatchlings generally emerge from late August or early September to early October, sometimes as late as late October (M. Pulsifer, pers. comm. 2013).

Hatchlings

In Canada, it is unlikely that hatchlings overwinter in the nest (COSEWIC 2007). A study by (Reference removed) showed that hatchlings could remain in terrestrial habitats following emergence for up to several weeks, where they foraged and grew. The authors suggested that the movement to water may be driven by the need to hibernate. Telemetry data from (Reference removed) showed that habitat selection by hatchlings was similar to that of adults, either terrestrial or aquatic.

Foraging

Wood Turtles are opportunistic omnivores at all life stages, feeding primarily on vegetable matter (e.g., berries, tender leaves), mushrooms and invertebrates (e.g., earthworms, slugs) (Pope 1967; Harding and Bloomer 1979). Many important food items are found in deciduous and mixed forests, which are used primarily during the summer months (post-nesting period up to pre-overwintering period), while floodplain habitats (e.g., alder thickets) still remain widely used during this period ([Reference removed]; Compton *et al.* 2002) and are reported to be often prime foraging habitat (Ontario Wood Turtle Recovery Team 2010). There seems to be a high spatial correspondence between thermoregulation and foraging habitats. According to some authors, prime habitats (e.g., alder thickets, openings in the streamside canopy) are selected to balance thermoregulatory and foraging needs ([Reference removed]; Compton *et al.* 2002). However, there is a need for a better understanding of Wood Turtle foraging habitat use and requirements (e.g., time and spatial partitioning).

Movement (commuting and dispersal)[22]

Wood Turtles may use several habitat types while moving across their home range[23]. In addition to the habitat types discussed earlier in this section, several occurrences reported in provincial CDCs suggest that individuals may use lakes, or portions of lakes, for their movements. Terrestrial movements have been observed more than 600 m away from a stream, although they are generally more restricted (Ontario Wood Turtle Recovery Team 2010). In most of the telemetry studies performed in Ontario (OMNR, unpublished data from three study sites), Quebec ([References removed]; Robillard 2009; Y. Dubois, unpublished data) and Nova Scotia (Tingley *et al.* 2009), 95% of records occurred within 200 m of a stream. In Ontario, Quebec and New Brunswick telemetry studies[24] (N=3308 records), composite average distance to the water is 46 m (standard deviation: 72 m). In one telemetric study performed in New Brunswick, the

[22] Commuting refers to short-distance movements within the home range in order to complete different life processes (e.g., mating, foraging), while dispersal refers to long-distance movements related to emigration of individuals.

[23] The area needed by an animal to complete its normal activities (Burt 1943).

[24] M. Arvisais (Quebec, Mauricie; Arvisais 2000), P.A. Wesley (Ontario, Algoma district; Wesley 1996), Y. Dubois (Québec, Estrie), D. Masse (Parks Canada Agency; Quebec), Y. Robitaille (Quebec, Mauricie), Éric Tremblay (Parks Canada Agency, New Brunswick), K. Trochu (Quebec, Outaouais; Trochu 2004).

highest probability (69%) of finding Wood Turtles was at a distance of 0–10 m from a stream between May 1 and July 1, while the highest probability (50%) was at distances greater than 50 m from a stream between July 2 and October 1 (Reference removed). For the October–November period, 90% of the available telemetry locations in Quebec[25] are within 62 m of a stream. Female Wood Turtles often travel larger distances from the stream than males ([Reference removed]; OMNR, unpublished data from three study sites). There is a need for a better understanding of terrestrial movements partitioned by sex and by life cycle activities, notably by females during the post-nesting period (July-September), when they may potentially make significant use of habitat more than 200 m from the stream. The distances travelled along streams are, however, much greater, with several reports up to 6 km, and sometimes exceeding 12 km (Wesley and Brown, unpublished manuscript). [Reference removed]reported average maximum travelling distances of 185 m from the stream and 715 m along the stream for Wood Turtles in Vermont.

The largest home range values for Wood Turtle, based on the 95% convex polygon method, have been reported in Quebec and Ontario as averaging between 24 and 28 ha, with an observed maximum of 132 ha (References removed). Other studies have reported much smaller values, averaging around 7 ha (see source references in NatureServe 2014). Due to Wood Turtles' tendency to follow streams, their home range typically has an elongated shape. Wesley and Brown (unpublished data) and [Reference removed] calculated the home range length along streams in Ontario and Quebec to be 1.1 to 4.3 km, with a mean value around 2.1 km. Home range sizes vary in response to many factors, including distance to nesting and hibernation sites and habitat productivity (Reference removed).

In Canada, local Wood Turtle populations are defined at the watershed scale, as individuals will move extensively along streams but rarely move between streams, even when separated only by a few kilometres (e.g., Reference removed). The maximum reported movement between two streams for an individual moving inland is 4.2 km (Parks Canada Agency – Atlantic, unpublished data). The observed population genetic distinctness among several streams is likely a reflection of low vagility[26] and high home range fidelity (COSEWIC 2007). For example, in a long-term study (>15 years) on two Ontario streams less than 5 km apart,[27] no turtle was ever recorded using both streams (Reference removed). Genetic studies performed in Quebec also highlight that genetic exchanges were very limited between two groups of individuals located 20 km apart[27] (Reference removed). On the other hand, two streams situated 100 km apart[27] showed no significant genetic differences along with high genetic exchanges between individuals (Reference removed). Those results tend to demonstrate that there is variability throughout the Wood Turtle's range.

Limiting factors

The Wood Turtle is a long-lived species that has a long-term reproductive success strategy based on delayed sexual maturity (11-22 years) and a low reproductive rate (i.e., very few hatchlings reach the adult stage). Those attributes lead local Wood Turtle populations to be highly

[25] M. Arvisais (1996-1997; Mauricie), Y. Dubois (2003-2004; Estrie), K. Trochu (2000-2001; Outaouais), D. Masse – Parks Canada Agency (1994-2012; Quebec).
[26] The ability of an organism to move about freely and migrate.
[27] Following the hydrological network.

vulnerable to any increases in mortality rates of adults or older juveniles ([References removed]; Compton 1999). Compton's (1999) modeling study suggests that the removal of two adults annually would lead to the extirpation of a population (n ~ 100 adults) within 80 years.

Because the Wood Turtle is an ectotherm, its distribution is highly dependent on climatic conditions (e.g., temperature, precipitation), even at the landscape scale (Iverson *et al.* 1993; McKenney, pers. comm. 2006; Ultsch 2006). At northern latitudes, such as those found in Canada, energy accumulation is probably limited by the short active season (Congdon 1989). The number of thermal units required to complete egg incubation is particularly limiting at such latitudes and has a greater impact on the species' distribution (Compton 1999).

Streams used by Wood Turtles are dynamic systems where potential increases in extreme events may limit growth, abundance or distribution. For example, [Reference removed] reported evidence that stochastic flood events may lead to the displacement of adult Wood Turtles, resulting in elevated mortality rates, and that displaced individuals mate and nest in the year following displacement at rates well below average. Flash floods may also destroy existing nesting sites (and kill eggs/neonates) and remove structural elements that created good overwintering conditions (Reference removed). However, those stochastic events may also be beneficial (e.g., may help create suitable nesting sites, mechanism of population connectivity) (References removed).

3. Threats

Threats to the Wood Turtle may vary regionally and locally across its distribution within Canada. The information presented in Table 3 is an overall assessment of threats to the Wood Turtle in Canada. Where information is available on the significance of the threat at the local scale, additional information is provided in the threat description section.

4.1 Threat Assessment

Threats are presented in Table 3 under their main threat category. When a given threat applies to more than one category, further information is provided in the threat description section.

Table 3: Threat Assessment Table

Threat	Level of Concern[a]	Extent	Occurrence	Frequency	Severity[b]	Causal Certainty[c]
Accidental mortality						
Road networks	High	Widespread	Current	Seasonal	High	High
Agricultural practices	High	Widespread	Current	Seasonal	Moderate	High
Off-road vehicles	Low	Local	Current	Seasonal	Low	Medium
Sand and gravel pits	Low	Local	Current	Seasonal	Unknown	Low
Biological resource use						
Illegal collection as pets and for consumption	Medium-High	Local	Current	Seasonal	Moderate	Medium
Habitat loss or degradation						
Residential and commercial development	Medium	Local	Current	Continuous	Low	High
Forestry practices[d]	Medium	Widespread	Current	Recurrent	Moderate	Low
Water management	Low	Local	Current	Continuous	Low	Medium
Pollution and sediment input	Low	Local	Current	Continuous	Unknown	Low
Changes in ecological dynamics or natural processes						
Subsidized predation[e]	Medium	Widespread	Current	Seasonal	Moderate	Medium

[a] Level of Concern: signifies that managing the threat is of (high, medium or low) concern for the recovery of the species, consistent with the population and distribution objectives. This criterion considers the assessment of all the information in the table.

[b] Severity: reflects the global population-level effect (high: very large population-level effect, moderate, low, unknown).

[c] Causal certainty: reflects the degree of evidence that is known for the threat (high: available evidence strongly links the threat to stresses on population viability, medium: there is a correlation between the threat and population viability e.g., expert opinion, low: the threat is assumed or plausible).

[d] Assessment of forestry practices excludes the forestry road network that is taken into account in the above “road networks” threat.

[e] Subsidized predation: occurs when human activity alters resource availability, leading to an increase in the predator population and subsequent predation levels.

4.2 Description of Threats

This section describes the threats outlined in Table 3, emphasizes key points, and provides additional information. Although threats are listed individually, an important concern is the long-term cumulative effect of such a variety of threats on local Wood Turtle populations. It should be noted that most of these threats apply only during the active season (generally April to October) since they lead to direct mortality or injury. Moreover, exposure increases in periods in which Wood Turtle movements increase (e.g., nesting, when some females have been known to move several kilometres between overwintering and nesting sites in the spring). Among the mechanisms through which threats can impact Wood Turtle populations, isolation through habitat loss is of special concern, as it leads to a breakdown
dynamics and limits the possibility of rescue effect[28].Threats such as road networks, agricultural practices, forestry practices and residential and commercial development can all contribute to further isolate remaining populations. Threats are listed in order of decreasing level of concern.

Road networks
Wood Turtle mortality and injuries resulting from the development of road networks throughout the species' distribution, including road widening and increased traffic volume and speed, represent the main adverse effect of road networks. Given that individuals spend much time on land during summer, and considering that they are relatively slow when travelling through terrestrial habitat, collision probabilities are high if roads are present in riparian habitat, especially moderate- and high-traffic roads (References removed). Adult females are more vulnerable for several reasons: they travel longer distances overland to nest, they can be attracted by gravel roads or shoulders of roads or bridges to nest, and they regularly use terrestrial habitat more intensively than males during the post-nesting period (see section 3.3). Some studies have shown that, for some North American freshwater turtle species, populations in high-road-density landscapes had male-biased sex ratios resulting from increased mortality in females (Steen and Gibbs 2002; Steen *et al.* 2006). Increased mortality of adult females is especially harmful to Wood Turtle populations, owing to the species' long-term reproductive strategy (References removed). Hatchlings originating from roadside nests are also more likely to be killed (Reference removed). In Southern Ontario, locations where Wood Turtle populations have been extirpated coincide with areas of high road density (Crowley 2006). In a Quebec local population that was tracked using telemetry, reproductive females faced a road mortality rate of 4.75%, adding to a natural mortality rate of 10.7% (Reference removed).

High-traffic roads are particularly dangerous for crossing turtles, but smaller, less-travelled roads can also result in frequent collisions if they are located near high-quality habitat. Forest harvesting is usually supported by a tentacular road network that can become a significant mortality factor for some Wood Turtle populations (References removed). The nature of such roads, i.e., built from loose aggregates, may offer more nesting opportunities, which in turn may result in higher nest destruction probabilities and increased mortality in young turtles.

[28] Rescue effect is the process by which a wildlife species may move through its range in such a way that it mitigates Canadian extirpation or population decline.

In addition to causing direct mortality, roads also remove suitable habitat, alter adjacent areas, change hydrologic patterns, and subdivide populations. Highways with heavy traffic or built in such a way as to make it impossible for turtles to cross are considered barriers to movement (NatureServe 2014). Expansion of road networks near occupied streams and rivers, including bridges, may create new nesting locations; however, these are likely to act as ecological traps because of the increased collision risk associated with such locations. In addition, they facilitate public access to areas that were once remote, thus increasing other threats, such as illegal collection as pets and for consumption (Reference removed).

Agricultural practices

During the active season, riparian and terrestrial habitats are important for the Wood Turtle as they should provide suitable foraging, thermoregulation, nesting and commuting habitats. Riparian and terrestrial habitats of several local populations throughout Canada, especially in southern Ontario and Quebec, are used for agricultural purposes, mainly annual and perennial production. A threat analysis of Wood Turtle element occurrences in Quebec showed that agricultural lands covered between 43 and 98% of turtle habitat for nine streams located south of the St. Lawrence River (Reference removed). Local Wood Turtle populations that are exposed to agricultural machinery (e.g., mowers) show unsustainable levels of mortality and mutilation ([Reference removed]; Saumure and Bider 1998; Saumure et al. 2007; Tingley et al. 2009). Areas used for extended periods (e.g., staging habitat surrounding nesting or overwintering sites) would be of particular concern for the Wood Turtle (M. Elderkin, pers. comm. 2013). Although Saumure and Bider (1998) did not find a significant difference in mutilation rates between males and females in populations sampled in agricultural settings, females and juveniles were under-represented in their captures, which may indicate a bias in threat-related mortality and possibly in mutilation rates if sampling could have been balanced. Mutilation may reduce mobility and thus reduce foraging efficiency, while shell damage may directly inhibit or restrict growth (Saumure and Bider 1998). Moreover, the prolonged stay of hatchlings in terrestrial habitat following emergence might also increase the risk of mutilation or death inflicted by farm machinery (Reference removed). Besides collisions, there are also reports of Wood Turtles being buried alive during ploughing and following the collapse of severely eroded banks along hay fields (Saumure et al. 2007).

While direct effects of agricultural practices on Wood Turtle individuals are relatively well documented (e.g., collisions), quantitative data are somewhat lacking on indirect effects through habitat degradation, modification or loss. COSEWIC (2007) reports that the species' habitat is declining over much of its historic range in Canada, and that agricultural practices have been playing a significant role in this situation. Row cropping is believed to lead to habitat loss. According to Saumure and Bider (1998), removal of vegetation cover increases soil temperature and promotes desiccation which can, in turn, reduce foraging opportunities for Wood Turtle as a result of changes in plant growth and invertebrate numbers. Drainage associated with row cropping also promotes desiccation. Agricultural practices may also impair water quality (e.g., increased sedimentation, pollution) (see *Pollution and sediment input* threat). Strictly in terms of terrestrial habitat needs, Kaufmann (1992) suggested that certain agricultural practices might benefit Wood Turtles by providing a mixture of different food and cover types (e.g., hayfields). However, such increased foraging opportunities may turn into an ecological

trap[29] for turtles by attracting them into habitats where they are subject to collision (e.g., Saumure and Bider 1998; Saumure *et al.* 2007). This could also be true for increased nesting opportunities in agricultural fields (R. Saumure, pers. comm. 2006 *in* COSEWIC 2007). Specific studies are needed to determine the full range of indirect effects coming from agricultural practices (e.g., assess the extent to which agricultural lands create ecological traps).

Illegal collection as pets and for consumption

Freshwater turtles, prized as food, traditional medicine remedies and pets, are under threat due to overuse in many parts of the world (Bodie 2001). Wood Turtles are extremely vulnerable to collection because of their attractive appearance, terrestrial habits, and low capacity to evade capture when on land (COSEWIC 2007). This information was integrated in the assessment of this threat in Table 3. Collection as pets does not directly cause mortality, but removes adults from the population which, given the species' limiting factors (section 3.3), may greatly reduce recruitment. Nesting sites are especially vulnerable as the high site fidelity shown by females facilitates collection ([Reference removed]; Walde *et al.* 2007). Eggs may also be collected for incubation and trade. Even casual collection for use as pets, when added to the cumulative effects of other threats, may lead to population declines. Collection, especially for pet trade, may cause rapid and severe damage to local populations. It was most likely the cause of one drastic decline in Ontario, where the adult local population dropped by 70% following one or two poaching events after the location of this population was made public (J. Crowley, pers. comm. 2014). Casual collection by people living near Wood Turtle streams is also reported (References removed) sometimes in significant numbers (n=29 Wood Turtles exhibiting captivity signs (e.g., drilled hole in the carapace), Walter Bertacchi, pers. comm. 2013). In Connecticut, two populations were extirpated within 10 years following a protected area being opened to human recreation (e.g., hiking, fishing) (Garber and Burger 1995). According to COSEWIC (2007), collection for consumption may be a growing threat in Canada. Little information is available on this topic at the present time.

Residential and commercial development

Residential and commercial development, especially in terms of residential and cottage lot development, appears to be a widespread threat. Such development can destroy or alter habitat and reduce habitat connectivity permanently (e.g., urbanized shore). Increased local human activity may also sustain higher local populations of predators, such as raccoons (see *Subsidized predation* section), and often results in increased risks of illegal collection as pets (COSEWIC 2007). Also, residential and commercial development often comes with further development of local road networks, which is a major threat to the Wood Turtle. Shoreline stabilization associated with waterfront development can also destroy turtle habitat, e.g., overwintering habitat. In the province of Quebec, nearly half of the rivers with Wood Turtle populations have some degree of residential development within the element occurrence (Reference removed). According to NatureServe (2014), urbanized shores where no appropriate aquatic habitat is available for dispersal constitute barriers to movement.

[29] Effects of an attractive sink leading to maladaptive habitat selection. A sink is a habitat that will be colonized or used by individuals but in which mortality exceeds benefits gained.

Subsidized predation

Anthropogenic development of the landscape, which has increased subsidized feeding opportunities[30], along with a decline in trapping activities, have increased the population of Wood Turtle predators, such as the Common Raccoon (*Procyon lotor*), Coyote (*Canis latrans*), Striped Skunk (*Mephitis mephitis*) and Red Fox (*Vulpes vulpes*) (References removed). According to available information, a major adverse effect of subsidized predation is death or mutilation of adult Wood Turtles above what could be considered a natural predation rate due to increased opportunistic predator population density. Mutilations may reduce individual mobility and thus reduce foraging efficiency (Saumure and Bider 1998). In 2004-2005, a few raccoons killed at least 15 adult Wood Turtle females at an important nesting site in Quebec, and it was estimated that that particular segment of the local population suffered a 50% predation rate on adults in a single year (Reference removed). In New Brunswick, over a three-year period (2005-2007), an average of 82% (out of 57 individuals) showed signs of attempted predation and the mortality rate was 15%, all due to predation (Red Foxes, raccoons and River Otters [*Lutra Canadensis*]) (Reference removed). Raccoons, skunks and foxes also dig up and eat eggs, resulting in high levels of nest failure. Egg predation is considered to be a major threat to turtle populations (Reference removed), as it can significantly reduce recruitment and affect the population age structure (Congdon *et al.* 1983). Nest predation rates as high as 70-100% have been documented in several turtle species (Reference removed). [Reference removed] documented in one instance a Wood Turtle nest predation rate of 88.2% in an Ontario inhabited stream. Other authors have also reported significant nest predation rates in other Canadian populations ([Reference removed]; Harding and Bloomer 1979). Quantitative information detailing the proportion of nest failure due to predators in Canada is lacking, but the intensity of subsidized predation is likely to increase with level of human activity (e.g., agricultural landscapes, residential and commercial development).

Forestry practices

Most of the local Wood Turtle populations in Canada are located in forested landscapes where forestry practices may take place. Aside from forestry road networks, which are considered a major threat to Wood Turtles (see *Road network* threat) (COSEWIC 2007), the direct effects of other forestry practices on Wood Turtles are poorly known. Forestry practices involving heavy machinery (e.g., harvesting, scarification) can kill and harm individuals. At the present time, there are no reported cases in the literature but it is much harder to retrace turtles struck by forest machinery than those struck on roads or in cropland. Because of the nature of this threat, direct effects are likely to occur only 2-4 times every 100 years within a specific area, when actual harvesting or other forestry practices take place (J. Crowley, pers. comm. 2014). As with agricultural practices and road networks, direct impacts caused by forestry practices occur during the Wood Turtle active season when individuals are using terrestrial habitat. In the last decade, special management practices have been established in Wood Turtle habitat located on provincial public lands in Ontario, Quebec and Nova Scotia (see section 6.1), allowing very few practices during the active season.

[30] Subsidized feeding opportunities refer to food resources made available through human activity (e.g., landfills, road kills, etc.).

Indirect effects due to forestry practices are also largely unknown. Arvisais (2000) found that areas of recent clear-cuts (≤ 10 years old) were avoided by Wood Turtles. On the other hand, Wood Turtles used regenerating stands (> 10 years old) ([Reference removed]; Arvisais 2000). Arvisais (2000) reports that clear-cutting may potentially temporarily eliminate important food items (e.g., mushrooms) and shelter (e.g., shrub cover). Kaufmann (1992) suggests that some small-scale forest clearing may be beneficial. Expert opinion suggests that harvesting would have to occur at such a small scale (e.g., < 1 hectare [100 m X 100 m]) that it would not affect the integrity of the soil and water drainage patterns (Wesley 2006). In addition, given the habitat needs of Wood Turtles (average home range as small as 7 ha, edge species), beneficial clearing would probably be of less than 1 hectare (J. Crowley, comm. pers. 2013). Other indirect effects are mostly speculative (i.e., expert opinion). Forestry practices may remove (e.g., creation of log landings) or alter (e.g., changes in forest composition) suitable terrestrial habitat. Clear-cutting may contribute to the flooding of streamside nests and increase sedimentation of streams inhabited by the species (COSEWIC 2007). If clear-cutting is followed by land conversion, these effects could be permanent. Historically, logging drives were suspected to have destroyed a large amount of Wood Turtle habitat and impacted populations, the effects of which may still be reflected in the current abundance and distribution of the species (M. Elderkin, pers. comm. 2005 *in* COSEWIC 2007). In Quebec, dams that were formerly used to facilitate logging drives still reduce the availability of traditional nesting sites (Reference removed). Established special management practices discussed previously also allow for habitat conservation (e.g., riparian strips, stream crossings).

Off-road vehicles

COSEWIC (2007) summarizes several personal communications reporting direct adverse effects of off-road vehicles on Wood Turtles, notably the destruction of nests and adult mortality and injuries. Off-road vehicle traffic in Wood Turtle habitat increases in summer when water levels drop, allowing access to crossings and thus exposing riverbanks to off-road vehicles. In Ontario, a segment of a local population showing a slow decline is located in an area open to all-terrain vehicle (ATV) traffic and increasing recreational use. In other provinces, anecdotal information indicates increased ATV traffic in nesting areas. Some characteristics of Wood Turtle nesting habitat (open sandy/gravely) are especially valued by ATV enthusiasts, which may lead to nest destruction. Increased access to Wood Turtle habitats may also potentially lead to casual illegal collection.

Water management

Disturbances to stream and riparian habitats, such as channelization, damming and dredging, are all potentially detrimental activities for the Wood Turtle (Buech and Nelson 1997). Any alterations to a stream that increase spring and fall flooding can have direct detrimental effects on adults, juveniles and hatchlings. Wood Turtles that occupy river stretches downstream from dams can experience mortality and nest destruction (Norden 1999). A study of Wood Turtles in Maine found that approximately 25% of the nests found were flooded because of dam releases (Compton 1999). Mortalities and injuries to Wood Turtles were also observed recently in Massachusetts following a spring flood; turtles were swept downstream and suffered injuries from colliding with rocks in the stream and from being buried in sediment (Reference removed). There are also reports of Wood Turtles that have been buried alive in Quebec during shoreline stabilization operations (Saumure *et al.* 2007).

Water management may also lead to habitat loss and degradation. Dams alter the flow of streams, and the impoundment of water for regulated release may reduce natural erosion processes that create or maintain nest sites. Dams or ineffective culverts under roadways may also contribute to impeding the movement of turtles, fragmenting populations and reducing gene flow (New Hampshire Fish and Game Department 2005). According to the New Hampshire Fish and Game Department (2005), channelization of streams may also alter stream flow by increasing water velocity, causing sections of the river to be unusable for the Wood Turtle. Dredging may cause sediment loading in rivers and degradation of water quality. Changes in river morphology can also potentially alter prey composition and availability (Bodie 2001). Additionally, the use of rip-rap along shorelines may reduce the availability of food and cover vegetation.

Sand and gravel pits

Wood Turtles are known to nest in gravel pits ([Reference removed]; Walde *et al.* 2007) where females are attracted by suitable bare ground, potentially exposing them to direct mortality (e.g., collision, burial), injuries or illegal collection. Sand and gravel substrates used for nesting by the Wood Turtle are also sought and exploited by humans, especially for road construction. This threat may be particularly significant in managed forested landscapes because of the need for road material as the forest road network is built (J. Crowley, pers. comm. 2013). As well, recreational activities within old pits and quarries may also destroy nests (see *Off-road vehicles* threat). At the present time the severity of this threat is unknown since quantitative data are lacking.

Pollution and sediment input

Wood Turtles are believed to be sensitive to several forms of water pollution (Ernst 2001; NatureServe 2014; Lesbarrères *et al.* 2014). Harding and Bloomer (1979) observed declines in Wood Turtle populations in New Jersey following spraying of pesticides in the 1950s and 1960s. Although empirical studies showing both individual and population-level effects of pollutants on the Wood Turtle are lacking, such effects have been demonstrated on other turtle genera (Mitchell and Klemens 2000; Bodie 2001). Several industrial-based contaminants were detected in Snapping Turtle eggs in the Great Lakes basin, and abnormal embryo development increases with exposure to polychlorinated aromatic hydrocarbons ([Reference removed]; Van Meter *et al.* 2006). Studies have shown that Snapping Turtle and Yellow-blotched Map Turtle (*Graptemys flavimaculata)* are affected by water pollution (Mitchell and Klemens 2000; Shelby-Walker *et al.* 2009). Because Wood Turtles feed on land for part of the year, they may accumulate less of some forms of pollutants than most aquatic turtle species (Burger and Garber 1995). Although water pollution is unlikely to be a serious threat to most Wood Turtle populations in Canada, some populations living in watersheds more exposed to pesticides or industrial pollution could be significantly impacted.

Inputs of sediments and organic matter through erosion and runoff can also alter water quality and habitat structure to the detriment of the Wood Turtle. Significant sediment inputs through erosion, runoff or discharges can alter river morphology. Siltation of deep pools has been linked to the decline of several turtle species (see Bodie 2001) and could degrade Wood Turtle overwintering habitat by exposing individuals to freezing. Inputs of organic matter and nutrients can increase water turbidity and reduce dissolved oxygen content in slow-moving rivers, which

could affect respiration in winter. The extent to which such conditions could affect the Wood Turtle is unknown.

Potential threats

Invasive plants are a potential threat, with floodplain habitats being particularly vulnerable to the spread of invasive plants because the frequent disturbances from flooding create opportunities for such plants to establish in the nutrient-rich soils characteristic of floodplains (New Hampshire Fish and Game Department 2005). Within one local population in Quebec, a stream segment has been invaded by Japanese Knotweed (*Fallopia japonica*) (Y. Dubois, pers. comm. 2013).

4. Population and Distribution Objectives

The long-term population and distribution objectives (~ 50 years) are to ensure the viability[31] of local populations[32] in watersheds[33] where the Wood Turtle currently occurs in Canada.

To work toward achieving the long-term population and distribution objectives, the following specific medium-term objectives (~ 10-15 years) have been identified:

1. Increase population abundance in streams where the Wood Turtle is declining.
2. Throughout the Canadian range, maintain and if possible increase available suitable habitat, and reduce or mitigate threats that may be causing population declines.
3. Throughout the Canadian range determine either baseline abundance or trend information for streams inhabited by the Wood Turtle with unknown abundance and population trend.

COSEWIC (2007) indicated that the Wood Turtle is declining across much of its Canadian range and that there is a decline in area and quality of habitat over much of this range. Some inhabited streams are located in relatively pristine environments, but the situation rapidly deteriorates in streams that are subject to threats and ever-increasing isolation between suitable habitat. Currently, declines have been confirmed in almost all streams assessed in Ontario and Quebec. To recover Wood Turtle in Canada, it is imperative to reverse the declines by addressing threats to the species in order to increase population abundance and suitable habitat availability where necessary or possible. In addition, some focus should also be given to maintaining connectivity within local populations, mainly through watercourses, as rescue effect may play a role in the persistence of the species in stream segments with low recruitment. This long-lived species has specific ecological requirements, complex life cycle needs, and a limited ability to compensate for the loss of individuals through reproduction or through recruitment from adjacent local populations. As a result, active broad strategies and general approaches undertaken on several fronts over a long period of time and sometimes over large regions (e.g., watershed) will be required to achieve these long- and medium-term objectives. Baseline abundance or trend

[31] A local population that is sufficiently abundant and well adapted to its environment for long-term persistence (in the face of demographic, genetic and environmental stochasticities, plus natural catastrophes) without significant ongoing management and investment of resources.
[32] As defined in section 3.2.
[33] As defined in section 3.2.

information are necessary in order to evaluate whether both medium- and long-term objectives are met.

5. Broad Strategies and General Approaches to Meet Objectives

6.1 Actions Already Completed or Currently Underway

Provincial governments have been involved in Wood Turtle conservation since the mid-1980s. They have undertaken and funded many projects such as: targeted surveys for the species; studying the severity of and/or mitigating threats; soliciting observations/encouraging public reporting of sightings; educating landowners and/or the public on species identification, threats, and stewardship options. The Government of Canada has been funding projects related to Wood Turtle conservation through the Habitat Stewardship Program (HSP) and Aboriginal Fund for Species at Risk (AFSAR) since 2001 and the Interdepartmental Recovery Fund (IRF) since 2004. At the national scale, the Canadian Herpetological Society is the main non-profit organization devoted to the conservation of amphibians and reptiles, including turtles, through promoting and supporting scientific research and conservation projects, facilitating collaboration, and advancing public understanding of native herpetofauna. Several academic institutions as well as non-profit organizations devoted to natural habitat and biodiversity conservation are also key contributors to Wood Turtle recovery.

The following non-exhaustive list provides examples of Wood Turtle conservation initiatives completed or underway.

Ontario

- The Ministry of Natural Resources has published a provincial recovery strategy for the Wood Turtle (Ontario Wood Turtle Recovery Team 2010).
- The Government of Ontario has developed a final Government Response Statement and a final Habitat Regulation for Wood Turtles under the *Endangered Species Act, 2007*.
- The Government of Ontario is developing guidelines for forestry activities in regulated Wood Turtle habitat.
- Since the mid-1980s several studies have taken place in Ontario investigating habitat selection (e.g., over-wintering, nesting), movements, population genetics and threats (see specific references in section 10).
- An intensive head-starting[34] program is underway for a southwestern Ontario local population that was considered non-viable due to intensive poaching, habitat degradation and other threats.
- Several habitat stewardship projects have been conducted by non-governmental and governmental organizations (e.g., structures to reduce access to roads,creation and restoration of nesting sites).

[34] Refers to captive hatching of turtles and rearing them through a vulnerable life stage in an environment free from predators.

- One property containing Wood Turtle habitat has been acquired by the Nature Conservancy of Canada, and a number of such properties are now protected under Ontario's Living Legacy, which seeks to increase the area of parks and protected areas.
- Monitoring work has been initiated, and a monitoring protocol based on the presence or absence of the species is under development (OMNR in prep.).
- Surveys for the species have been conducted on federal lands under the Interdepartmental Recovery Fund.
- The Department of National Defence (DND) has conducted Wood Turtle studies and management on Ontario DND sites.
- The Ontario Ministry on Natural Resources (OMNR) has drafted a survey protocol for the Wood Turtle, which is available on request.
- The Ontario Reptile and Amphibian Atlas, developed by Ontario Nature, is collecting occurrence records of reptiles and amphibians, including Wood Turtle, to expand our knowledge of the distribution of these species in Ontario

Quebec

- Nearly 28 km² (~ 5%) of element occurrences are located within protected area (S. Pelletier, pers. comm. – CDPNQ 2013).
- A provincial recovery team for five species of turtle, including the Wood Turtle, was established in 2005. It has published a recovery plan (Reference removed), which is currently being updated.
- An update of recovery implementation (Reference removed) reports 71 activities completed or underway during the period 2005-2011, in four categories: knowledge acquisition; conservation of habitats and populations; outreach and communication; and recovery planning and funding.
- The Ministère des Ressources Naturelles du Québec[35] established forest management protection measures to protect the Wood Turtle and its habitat on public land (Reference removed). Nearly a third of element occurrences are on provincial public land (CDPNQ 2014).
- Since the early 1990s, several studies have been conducted on the species' ecology, population dynamics, population genetics and threats (see specific references in section 10).
- An atlas of potential Wood Turtle habitats in Quebec has been produced (Giguère *et al.* 2011).
- Several habitat stewardship projects have been conducted in many regions by non-governmental and governmental organizations since 2005. For example 4 km² of element occurrences located in cropland benefit from special management practices (e.g., mower blade height agreements). Properties containing Wood Turtle habitat have also been acquired.
- Several surveys have been conducted in many administrative regions since 2005 to expand the knowledge on the species' distribution. Population monitoring is also underway in some stream segments across the province.

[35] Now called the Ministère des Forêts, de la Faune et des Parcs.

- A protocol to estimate population size using the capture-mark-recapture method has been developed and tested (Bernier and Mazerolle, in preparation).
- A head-starting program has been implemented in one local population to increase its viability (Reference removed).
- The MFFP is currently designating Wood Turtle habitat as wildlife habitat for a Threatened or Vulnerable species under the *Act respecting the conservation and development of wildlife* (2002, c. 82, s.1).
- The *Atlas of Amphibians and Reptiles of Québec*, developed by the Société d'histoire naturelle de la vallée du Saint-Laurent, is collecting records of amphibians and reptiles, including Wood Turtle, to expand our knowledge of the distribution of these species in Quebec.

<u>New Brunswick</u>

- Concentrated efforts to increase Wood Turtle sightings by naturalists with the New Brunswick Museum, have expanded the number of known occurrences.
- Pilot projects on threat identification and stewardship have been initiated on three watersheds representing three different contexts: agricultural landscape, forestry-dominated area, region with high number of outdoor recreational activities (e.g., angling, hunting and canoeing).
- Initial work on implementing the coordinated monitoring strategy for Wood Turtle in the Northeastern United States (Jones *et al*. 2013).
- DND has conducted Wood Turtle studies and management on New Brunswick DND sites.
- Measures to address potential threats and mitigation measures have been drafted at one New Brunswick DND site ([References removed]).
- The New Brunswick Department of Natural Resources is currently drafting a recovery strategy for Wood Turtle in New Brunswick.
- Several habitat stewardship projects have been conducted by non-governmental and governmental organizations.
- Radio-telemetry studies were performed to gather information on habitat use and population characteristics (References removed).

<u>Nova Scotia</u>

- The Nova Scotia Department of Natural Resources has prepared a stewardship plan (MacGregor and Elderkin 2003) for use by individuals and stakeholders who may have an impact on the species. The main objectives of the document are: research and monitoring, information collection and sharing, capacity building, stewardship and education, and habitat management.
- The Nova Scotia Department of Natural Resources has developed special management practices, notably for forestry and agricultural practices (Nova Scotia Department of Natural Resources 2012).
- Surveys and public interviews were performed for various watersheds, including one containing one of the largest Wood Turtle populations in Canada (MacGregor and Elderkin 2003).

- Radio-telemetry studies on habitat use ([Reference removed]; Tingley *et al.* 2009, 2010) and studies on population dynamics ([References removed]; Coulombe 2007) have been conducted.
- A major series of studies initiated by the provincial government is currently underway to increase the understanding of the impacts of highways, bridges and overpasses in Wood Turtle watersheds.
- Several habitat stewardship projects have been conducted by non-governmental and governmental organizations.
- The Nova Scotia Nature Trust has secured lands for the Wood Turtle through the 12 percent protected areas initiative.
- Wood Turtle habitat conservation and management are an integral part of the Provincial Environmental Assessment process.

First Nations communities

- Inventories are being conducted on Anishinabeg traditional territory.
- Wood Turtles have been monitored since 2005 on Anishinabeg traditional territory (2005-2012).
- One Anishinabeg community has provided technical training to other First Nation communities for surveying and monitoring the Wood Turtle (2010-2011).
- One Anishinabeg community studied habitat use by the Wood Turtle in forested and agricultural areas using telemetry and investigated juvenile Wood Turtles dispersal patterns (2011-2012).

6.2 Strategic Direction for Recovery

As demonstrated in section 6.1, provincial governments have been planning and implementing recovery strategies, approaches and measures for several years. Thus, the broad strategies and the research and management approaches discussed in this section are drawn largely from provincial recovery planning documents ([Reference removed]; MacGregor and Elderkin 2003; Ontario Wood Turtle Recovery Team 2010; Ontario Ministry of Natural Resources 2013; New Brunswick Department of Natural Resources, in prep.). To work toward achieving the population and distribution objectives, six broad strategies for recovery have been established. Research and management approaches are recommended for each one (Table 4).

Table 4: Recovery Planning Table

Threat or Limitation[a]	Broad Strategy for Recovery	Priority[b]	General Description of Research and Management Approaches
All threats	Reduction of adult mortality, injury and illegal collection	Urgent	- Protect Wood Turtle individuals through legislation and regulation tools. - Continue to develop and implement reduction and mitigation techniques (e.g., best management practices) to address threats to individuals. - Develop a federal/provincial strategy to address illegal collection as pets and for consumption.
1, 2, 4, 6, 8, 9, 10	Conservation, management and restoration of habitat	Urgent	- Conserve or manage Wood Turtle habitat through legislation, regulation, administrative and stewardship tools. - Continue to develop and implement reduction and mitigation techniques (e.g., best management practices) to address threats to habitat where required and at a relevant scale. - Promote an integrated habitat management approach at the watershed scale. - Determine habitat restoration needs in streams where Wood Turtle habitat is declining.
All threats	Communication and outreach	Necessary	- Develop and implement communication strategies appropriate to reduce adult mortality, reduce threats and conserve habitat. - Encourage the transfer and archiving of information and tools, including Traditional Ecological Knowledge (TEK). - Improve and maintain cooperation between stakeholders. - Promote research initiatives on the species.
All threats	Improvement of recruitment	Necessary	- Document recruitment needs in streams where the Wood Turtle is declining or where viability is deemed to be compromised.

Threat or Limitation[a]	Broad Strategy for Recovery	Priority[b]	General Description of Research and Management Approaches
	where needed		- Improve recruitment (where needed) in streams where the Wood Turtle is declining or where viability is deemed to be compromised.
Knowledge gaps	Surveying and monitoring	Necessary	- Develop and implement provincial monitoring plans. - Develop and promote the appropriate use of standardized protocols (e.g., data collection, handling, marking) and databases. - Improve the knowledge on local populations (e.g., abundance, suitable habitat size, threats, key habitats). - Prioritize and conduct targeted surveys.
Knowledge gaps 2, 3, 5, 6, 7, 8, 9, 10	Research	Necessary	- Verify the extent of local populations and most appropriate recovery scale. - Determine minimal habitat and population requirements to ensure local population viability (e.g., suitable habitat size, number of mature individuals). - Determine the full range of adverse effects (e.g., indirect effects, knowledge gaps) from identified threats as well as potential threats (including at the watershed scale). - Refine knowledge of habitat needs (e.g., females foraging habitat, brackish water) in order to develop a better understanding of spatial and temporal use.

[a] Threats or limitations: 1) Road networks, 2) Agricultural practices, 3) Illegal collection as pets and for consumption, 4) Residential and commercial development, 5) Subsidized predation, 6) Forestry practices, 7) Off-road vehicles, 8) Water management, 9) Sand and gravel pits, and 10) Pollution and sediment input.

[b] "Priority" reflects the degree to which the broad strategy contributes directly to the recovery of the species or is an essential precursor to an approach that contributes to the recovery of the species.

6.3 Narrative to Support the Recovery Planning Table

Considering the Wood Turtle's reproductive strategy (see section 3.3), maintaining the highest adult survival rate, especially for females, remains the primary need of the species to achieve recovery. Unfortunately, some biological traits of the species (i.e., terrestrial habits, use of bare ground to nest, use of edges between forested and open spaces) make it very vulnerable to many human activities (e.g., transportation, agriculture, illegal collection). As a result, it is deemed urgent to undertake a particularly proactive integrated approach with land owners and land users to limit threats on adult Wood Turtles. Such approaches should focus primarily on the specific spatial and temporal scales where most of the adult mortality and illegal collection occurs. Habitat conservation, management and restoration is another key strategy since it contributes to maintaining, improving or creating suitable habitat, and to reducing adult mortality (i.e., reducing threat severity). Habitat conservation and restoration should focus primarily on the aquatic, riparian and terrestrial zones identified as critical habitat (see section 7) where most of the adults are found. The area delineated as critical habitat defines a key 'conservation zone' for this species, i.e., the areas within which recovery efforts focussed on reducing adult mortality and threats and on habitat management need to occur. Habitat management is also necessary at a larger scale (e.g., watershed) in order to minimize some threats affecting the Wood Turtle (e.g., pollution and sediment input). The habitat conservation and management approaches must be implemented via an integrated approach engaging various stakeholders (e.g., land owners, land users, land planners, non-government organizations, governments). In many cases, there are watershed level planning or stewardship programs in place. It will be important to take advantage of these larger scale programs where possible. Considering the large numbers of stakeholders engaged in the recovery of the Wood Turtle as well as the wide spectrum of threats affecting it, specific communication and outreach approaches are necessary. Along with the approaches already discussed, it will also be necessary in some streams where viability is unlikely to improve recruitment. Several knowledge gaps have been highlighted in sections 2, 3 and 4. It is necessary to fill those gaps through a wide range of specific studies to ensure the completion of the long-term population and distribution objectives. Along with approaches highlighted in Table 4, some knowledge gaps will also be filled via the schedule of studies to complete critical habitat identification (Table 6). Finally, to achieve the recovery of the species, it will be important to implement the broad strategies concurrently, particularly those addressing threats to adults, conservation, management and restoration of habitat, and improvement of recruitment.

7. Critical Habitat

Section 41(1)(*c*) of SARA requires that recovery strategies include an identification of the species' critical habitat to the extent possible, as well as examples of activities that are likely to result in its destruction. Section 41(1)(*c.1*) also requires the inclusion of a schedule of studies to complete the identification of critical habitat, where available information is inadequate, which is the case for the Wood Turtle.

7.1 Identification of the Species' Critical Habitat

Wood Turtle critical habitat is partially identified in this recovery strategy. A schedule of studies has been included to outline the studies required to complete identification of critical habitat for the species (section 7.2). Critical habitat for the Wood Turtle is identified to the extent possible, based on the best available information. More precise boundaries may be mapped, and additional critical habitat may be added in the future if additional research supports the inclusion of areas beyond those currently identified. The area identified as critical habitat may differ from the area identified as habitat under provincial regulations.

Wood Turtle critical habitat is identified herein based on two criteria: habitat occupancy and habitat suitability (includes suitable habitat for all aspects of the life cycle). Critical habitat is subdivided according to life cycle considerations (e.g., nesting, overwintering).

7.1.1 Habitat Occupancy

The habitat occupancy criteria for the Wood Turtle can be met under two circumstances:

1. When a minimum of two distinct Wood Turtle individuals have been observed in any year within the last 40 years (see below, an indicator of site quality),

OR

2. When a single individual has been observed in multiple years within the last 40 years (an indicator of site fidelity).

Nesting records automatically meet the first criterion, because two individuals are needed to produce a viable embryo. Site fidelity is considered because Wood Turtles were shown to exhibit high fidelity to their home ranges and nesting sites (see section 3.3).

The 40-year[36] period represents the approximate generation time for a Wood Turtle (COSEWIC 2007). The large time window allows for inclusion of local populations that likely persist but for which Wood Turtle individuals may not have been detected in recent years. It also increases the confidence that a site will likely contribute to the maintenance of a local Wood Turtle population.

[36] The 1974-2013 period has been used in this recovery strategy to identify critical habitat. When more critical habitat is identified in a subsequent action plan or an amended recovery strategy, the period will be adjusted to correspond to the year of the new identification.

For the same reason of increasing confidence, records that cannot be reliably associated with a feature (i.e., stream segment, nesting site, overwintering site) are excluded from critical habitat identification. A cartographic analysis of each record, based on data accuracy, distance to the water, and its description must be performed to qualify.

Records being considered for the identification of critical habitat include:

- Data from all valid sources;
- Sightings, telemetry studies, nest site and overwintering site observations;
- Dead individuals and observations in non-suitable habitat (e.g., paved roads).

Critical habitat is not identified for locations where survey efforts made in the last decade did not confirm Wood Turtle persistence or habitat use and/or where extirpation is considered likely. Distance threshold between records to fulfill the criteria is provided in section 7.1.2.

7.1.2 Habitat Suitability

Wood Turtle is a habitat generalist displaying considerable variation in terrestrial habitat use across its range (see COSEWIC 2007 for specific references). However, because of the rarity of some habitat types that are essential during specific phases of its life cycle (i.e., nesting and overwintering) as well as some of its ecological traits (e.g., reproductive strategy), nesting and overwintering habitats are addressed separately from other, more general, habitat.

Habitat suitability refers to conditions in which individuals can carry out any of the components of their life cycle (i.e., overwintering, mating, thermoregulation, nesting, foraging) as well as their movements. Suitable habitat can be described as a habitat mosaic, in which specific biophysical attributes can be associated with life processes and species' needs. Within the area of suitable habitat, the biophysical attributes required by the Wood Turtle will vary over space and time with the dynamic nature of ecosystems. In addition, particular biophysical attributes will be of greater importance to turtles at different points in time. The concept of suitable habitat recognizes that certain biophysical attributes do not need to be immediately adjacent to each other, as long as they remain connected so that individuals can move between them easily to meet all of their biological needs and respond to disturbance. The biophysical attributes of suitable habitat for the Wood Turtle as well as the specified distance determining the extent of suitable habitat are detailed in Table 5, while the biophysical attributes used for each component of the life cycle are shown in Figure 2. That information is specific to Wood Turtle and is based on the species' biological and behavioural requirements (see section 3.3 for specific references).

Nesting habitat

Given the nature of factors limiting the Wood Turtle (e.g., long-term reproductive success strategy, climatic conditions – see section 3.3), nest site availability and selection are likely to be especially important for local population persistence ([Reference removed]; Congdon *et al.* 1983; Horne *et al.* 2003; Wesley 2006). Finding nesting sites with incubation temperatures that promote successful hatching is essential in the thermally limited, northern portion of the Wood Turtle's range (Compton 1999; Shine 1999). Rarity of optimal nesting sites may explain the long-distance pre-nesting movements reported for females in several Canadian local populations (e.g., [Reference removed]; Walde *et al.* 2007), as well as the strong nest site fidelity and

frequent communal nesting exhibited by Wood Turtles (e.g., 63 females were reported in the vicinity of a single nesting area in a multi-year study – Walde *et al.* 2007).

Specific criteria: Confirmed nesting sites are identified as critical habitat irrespective to the distance to the stream. The entire feature presenting suitable nesting habitat (see biophysical attributes of beaches, riverbanks or other bare ground areas in Table 5) is identified, as well as a 200-m staging habitat around nesting habitat. The 200-m value for staging habitat was selected on the basis of Walde *et al.* (2007), who showed that more than 50% of females in a local population were present within 200 m of the nesting site in the days preceding nesting. Within this extent critical staging habitat corresponds to the biophysical attributes of streams, adjacent waterbodies, wetlands, grassland, shrubland and deciduous and mixed forests (Table 5).

Overwintering habitat

At northern latitudes such as those in Canada, overwintering represents a key component of a turtle's life cycle because individuals undergo extremely long dormancy/low mobility periods (nearly half of their life) (COSEWIC 2007). Overwintering site availability is an important predictor of Wood Turtle occurrence since the species is restricted to stream reaches presenting numerous potential overwintering sites (Wesley 2006). Therefore, the species may show fidelity to river stretches presenting availability of overwintering sites (Reference removed). Limited availability of optimal overwintering sites may explain the long-distance movements reported in several Canadian local populations (e.g., [References removed]; Walde *et al.* 2007), site fidelity and occasional communal overwintering (Gregory 1982). Overwintering habitat primarily includes lotic environments (e.g., streams), but may also include non-riverine environments (e.g., oxbow, marshes, vernal pools).

Specific criteria: Confirmed overwintering sites are identified wherever they are located (no maximal distance to the stream). A 150-m radius area is identified around each valid record (section 7.1.1). The 150-m distance is used to account for spatial accuracy of records. It also accounts for staging areas in the vicinity of the hibernacula. The Wood Turtle is also known to move very short distances during the overwintering period, with a maximum of 10 m reported by Greaves and Litzgus (2008). Within the 150-m extent critical overwintering habitat corresponds to the biophysical attributes of main stream, adjacent waterbody and wetland (Table 5).

Thermoregulation, foraging and mating habitats

Although essential to the survival of the Wood Turtle, the availability of thermoregulation (outside overwintering period) and foraging habitats appears to be less limiting than nesting and overwintering habitats given the short distance movements reported to balance thermoregulation and foraging needs (Kaufmann 1992; Compton *et al.* 2002), as well as to meet thermoregulation needs during pre- and post-overwintering periods (References removed). Those short-distance movements tend to demonstrate that thermoregulation and foraging habitats are available in several areas of the home range. The availability of mating habitat does not appear to be limiting for the Wood Turtle as it requires small areas of shallow water during a short period of the year.

Specific criteria: Given that there is no available information on the minimum area of habitat that is required for those life cycle activities, it was decided using a precautionary approach to identify a functional habitat that meets thermoregulation, foraging and mating needs throughout

the home range. This functional habitat will also include the vast majority of potential nesting and overwintering habitats, which is important considering that few precise locations are known. Functional habitat for the Wood Turtle corresponds to the entire width of a suitable stream (up to its high water mark (HWM)) closest to the location of any valid record (section 7.1.1) as well as adjacent suitable aquatic, wetlands and terrestrial habitats located within 200 m on either side of the stream[37] and having a length extending 2000 m upstream and downstream of the record (resulting in a total site length of 4000 m). Adjacent sites are merged if they spatially overlap. The distances used to set the functional habitat boundaries are based on current knowledge of the species' needs (see section 3.3 for specific references). The 2000-m site length is based on the mean average home-range length along streams recorded in local Wood Turtle populations in Quebec and Ontario (~ 2.1 km). The 200 m distance on either side of a stream corresponds to an extent that captures 95% of Wood Turtle records of most local populations in Ontario, Quebec and Nova Scotia studied by telemetry. This distance could be refined once a better understanding of terrestrial movements partitioned by sex and by life cycle activities is obtained. Within those extents critical habitat corresponds to all of the biophysical attributes identified in Table 5.

Movement (commuting and dispersal) habitat

Maintaining the natural habitat linkages available to the Wood Turtle promotes the species' persistence. Such linkages provide access to resource patches (i.e., commuting) and allow for immigration and emigration (i.e., dispersal), thereby promoting rescue effect and increased gene flow and helping to maintain genetic diversity and species resilience in the face of environmental stressors.

Specific criteria: To allow short-distance movements needed to complete the Wood Turtle life cycle (commuting movement – see section 3.3), connectivity is ensured by functional habitat (as described above). To allow long-distance movements such as immigration or emigration (dispersal movement – see section 3.3), connectivity is ensured by the aquatic feature of streams and waterbodies (Table 5) that are permeable to Wood Turtles (no barriers to movement).[38] Where two records occur within a continuous water system and are separated by a maximum distance of 6000 m, the entire aquatic feature (up to the HWM) located between the two observations is considered critical habitat. This distance is based on three times the average home range length along streams (~ 2.1 km), which is equivalent to the separation distance between element occurrences recommended by NatureServe (2002).

Unsuitable habitat

Any man-made structure (e.g., houses, wharves, urban areas), any habitat type that does not correspond to the biophysical attributes of suitable habitat (Table 5), or any habitat type that is recognized as an ecological trap (i.e., roads and shoulders) is considered unsuitable habitat. At the present time, active cropland and active sand and gravel pits are presumed to be ecological traps thus considered as unsuitable habitat, except for nesting sites at streams where the Wood Turtle local population is declining. The best available information indicates that declines are

[37] Measured landward from the high-water mark.

[38] Barriers to Wood Turtle movements include busy highways or highways with obstructions such that turtles rarely if ever cross successfully; untraversable topography (e.g., cliffs); urbanized areas lacking aquatic or wetland habitat; large impoundments or lakes (NatureServe 2012).

known to occur in disturbed landscapes (e.g., [Reference removed]; COSEWIC 2007) where Wood Turtles rely heavily on anthropogenic habitats for nesting (i.e., little to no availability of natural suitable nesting habitat) (J. Crowley, pers. comm. 2014). Because of the increased importance of nesting habitat for Wood Turtle (i.e., low availability), it is deemed necessary to identify known nesting sites that fall within active cropland and sand and gravel pits as critical habitat when the local population of Wood Turtles at these streams is already in decline. Those habitats are likely required to achieve the population objective through the recruitment of new individuals. For those sites, special management practices will have to be implemented in order to minimize the likelihood of them being ecological traps. Further work is needed to confirm this inclusion and to assess the extent to which active cropland and active sand and gravel pits are ecological traps (Table 6).

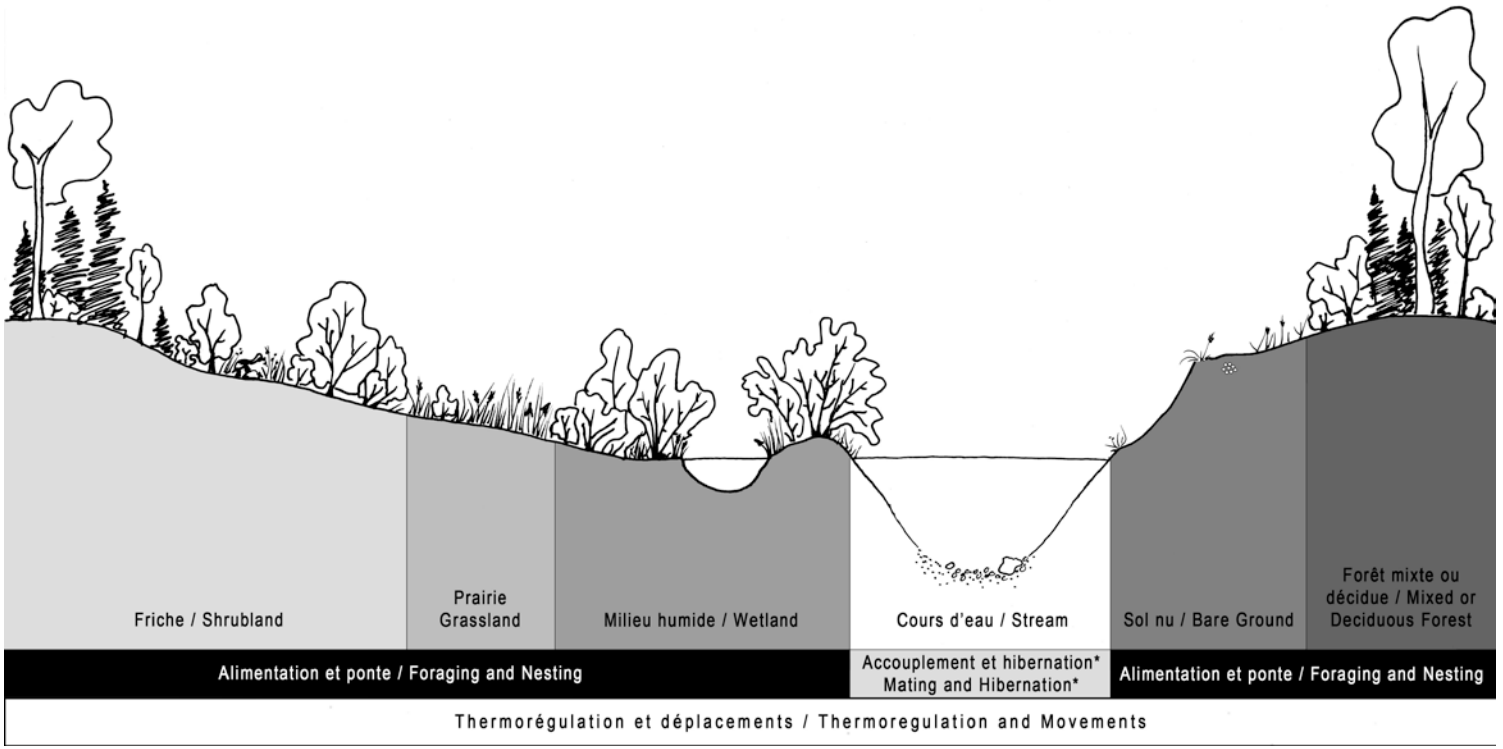
Table 5: Descriptions of biophysical attributes and physical extent for suitable Wood Turtle habitat types

Habitat type	*Biophysical attribute*	*Physical extent*[39]
Main stream[40]	▪ Creek, stream or river (including intervening lake ≤ 10 ha), AND ▪ Clear freshwater or brackish water (up to a maximal salinity of 30 ppm), AND ▪ Year-round flowing current, AND ▪ Does not freeze to the bottom, AND ▪ Sandy or gravelly or cobble riverbed	Aquatic habitat up to the high water mark (HWM), extending 2000 m upstream and downstream from a record and extending up to a maximum of 6000 m between two records
Adjacent waterbody	▪ Main stream tributary, OR ▪ Lake (up to 9-m deep), OR ▪ Pond	Aquatic habitat up to the HWM located in the 200 m terrestrial zone from the main stream
Wetland	▪ Alder thicket and alder swale, OR ▪ Swamp, OR ▪ Bog, OR ▪ Wet meadow, OR ▪ Beaver pond, OR ▪ Oxbow / perennial pool OR ▪ Vernal pool	From main stream HWM up to 200 m[41], except for confirmed overwintering sites where the site plus a 150 m radius is identified wherever they occur
Grassland	Areas dominated by native grasses, sedges family (i.e., Cyperaceae), other grasslike plants, or forbs with less than 10% of shrub or tree cover	From main stream HWM up to 200 m
Shrubland	Areas dominated by shrubs with scattered forbs and grass-like plants, including: - Utility rights-of-way, OR - Abandoned agricultural fields, OR - Reverting gravel or sand pits[42]	From main stream HWM up to 200 m
Deciduous and mixed	Areas dominated by trees: - Deciduous forest stands[43] (≤ 25% coniferous cover), OR	From main stream HWM up to

[39] In reference to the location where the biophysical attributes have to occur to be included as critical habitat.
[40] If it is demonstrated with specific data that a particular portion of a lake > 10 ha is used by Wood Turtles (except for nesting), this portion of the lake is considered a main stream.
[41] The entire feature of beaver pond, oxbow, perennial pool or vernal pool is identified even if it is exceeding the 200 m zone.
[42] Refers to a gravel or sand pit that is no longer in use and is returning to a natural state (e.g., shrub lands).

Habitat type	*Biophysical attribute*	*Physical extent*[39]
forest	- Mixed forest stands (25%-75% coniferous cover)	200 m
Beaches, riverbanks or other bare ground areas*	▪ Sparse or no vegetation throughout incubation period, AND ▪ Receiving full to partial sunlight, AND ▪ Sandy or gravelly substrate, AND ▪ Fairly moist but well-drained substrate	From main stream HWM up to 200 m; except for confirmed nesting habitat that is identified wherever it occurs

[43] A community of trees possessing sufficient uniformity in composition, age, arrangement or condition, to be distinguishable from the forest or other growth on adjoining areas. Size may vary from one to hundreds of hectares.



*primary mating and overwintering habitat types are shown. Those activities may also occur in wetlands where there is presence of water

Figure 2: Biophysical attributes of the Wood Turtle critical habitat for each life cycle activity and movement

7.1.3 Application of the critical habitat criteria

Critical habitat for the Wood Turtle corresponds to the biophysical attributes (Table 5) within the areas of suitable habitat (section 7.1.2) meeting the occupancy criteria (section 7.1.1). Critical habitat for the Wood Turtle is identified in 73 watersheds[44] across the Canadian range: 12 in Ontario, 20 in Quebec, 23 in New Brunswick and 18 in Nova Scotia. Application of the criteria specifically identifies 191 units[45] as containing critical habitat for the Wood Turtle, totalling 1050 km^2: 35 in Ontario (188 km^2); 71 in Quebec (427 km^2); 51 in New Brunswick (246 km^2) and 34 in Nova Scotia (189 km^2). The Minister of the Environment, on the advice of COSEWIC, has restricted the release of information that relates to the location of the Wood Turtle or its habitat (SARA, s. 124) due to the vulnerability of the species to illegal collection. Wood Turtle critical habitat is therefore presented at the 1:250 000 scale (national topographic maps system,[46] Appendix A) so as not to compromise this sensitive information. More detailed information on the location of critical habitat to support protection of the species and its habitat may be requested on a need-to-know basis by contacting Environment Canada's Recovery Planning section at ec.planificationduretablissement-recoveryplanning.ec@canada.ca.

7.2 Schedule of Studies to Identify Critical Habitat

The available information is not sufficient to fully identify critical habitat for the Wood Turtle. Indeed, critical habitat is identified in 73 watersheds while Wood Turtle records are known for 145 watersheds. Some of those watersheds are likely to hold local Wood Turtle populations, but critical habitat cannot currently be identified because the data are spatially imprecise or cannot be reliably associated with a feature. Moreover, several records not fulfilling the occupancy criterion (e.g., single records) come from watersheds where critical habitat is already identified (but in different areas). Due to lack of confidence in the data, it was not possible at this point to identify critical habitat even if those individuals most likely contribute to the overall viability of the local population. Also, identified critical habitat is likely insufficient along a proportion of streams where threats to habitat are significant (e.g., agricultural landscapes). Indeed, nesting habitat is recognized as the most limiting habitat for the Wood Turtle and it is likely that the identified critical habitat does not currently provide enough suitable nesting habitats in streams where threats are significant and where trend information is unavailable, since many anthropogenic nesting sites are excluded from critical habitat because they are presumed to be ecological traps (i.e., active cropland, active sand and gravel pits). To identify where additional critical habitat would be required, an assessment of suitable nesting habitat size should be performed in local populations where threats to habitat are significant. Concurrently, research is needed to determine if and to what extent active cropland and active sand and gravel pits can contribute to local populations under certain conditions. It is also imperative to assess the extent to which active cropland, as foraging and thermoregulation habitats, are ecological traps and if they can contribute to the recovery of the Wood Turtle under certain conditions. An assessment

[44] As defined in section 3.2.
[45] Georeferenced polygons representing the maximum extent of critical habitat at a particular location.
[46] The national topographic maps system is a standardized national grid system that indicates the general geographic areas containing critical habitat, for land use planning and/or environmental assessment purposes.

of suitable foraging and thermoregulation habitat size should be performed for local populations located within agricultural landscapes.

Table 6. Schedule of studies

Description of Activity	Rationale	Timeline
Confirm habitat occupancy in locations where only a single observation of the Wood Turtle is available or where records are too old, spatially imprecise or cannot be associated with specific features (stream segment, nesting site, overwintering site).	This activity is needed to identify critical habitat in watersheds not currently containing CH and to complete critical habitat in watersheds where CH units are already identified. Survey needs should be prioritized provincially based on: habitat suitability, proximity of identified critical habitat and record characteristics (e.g., years, spatial precision).	2025
Assess suitable habitat size (i.e., nesting, foraging and thermoregulation) in local populations where threats to habitat are significant, and determine where suitable habitat is likely insufficient.	This activity is needed to determine local populations where identified critical habitat is potentially insufficient to meet the population and distribution objectives, thus where critical habitat must be added.	2020
Assess the extent to which active cropland and active sand and gravel pits are ecological traps and, if possible, determine conditions where they may contribute to maintaining local population.	This activity is needed to determine whether active cropland and active sand and gravel pits can qualify as critical habitat for local populations that are not currently declining.	2020

7.3 Activities Likely to Result in the Destruction of Critical Habitat

Understanding what constitutes destruction of critical habitat is necessary for the protection and management of critical habitat. Destruction is determined on a case-by-case basis. Destruction would result if part of the critical habitat were degraded, either permanently or temporarily, such that it would not serve its function when needed by the species. Destruction may result from a single or multiple activities at one point in time or from the cumulative effects of one or more activities over time (Government of Canada 2009).

Critical habitat for the Wood Turtle may be destroyed by any alteration that adversely modifies any biological, chemical or physical feature to the extent that individuals can no longer use its environment for any of its life processes, including overwintering, mating, thermoregulation, nesting, foraging or moving. Within the critical habitat boundary, activities that ultimately alter the structure and composition of the stream and adjacent suitable waterbodies, wetlands and suitable terrestrial habitats (Table 5) can destroy Wood Turtle critical habitat. Given the importance of overwintering and nesting habitats (section 7.1.2 – Critical habitat suitability), primarily due to their low availability, special attention is required for these two life processes. Dispersal corridors (movement habitat) are less likely to be impacted by activities, because they include only aquatic features. In those corridors, it is most important to maintain habitat

permeability (i.e., no barriers to movement allowing access to adjacent suitable habitat) and, as a result, certain activities would not be as likely to result in destruction as long as sufficient habitat permeability is maintained. Activities taking place outside the critical habitat are also less likely to result in the destruction of critical habitat. Destruction could result from either a single activity conducted once at any time of year or from the cumulative effects of one or more activities carried out over time.

Listed below are examples of activities that could result in the destruction of critical habitat. The activities described in Table 7 are neither exhaustive nor exclusive and have been guided by the threats assessed and described in section 4 (Threats). For some activities, the identification of thresholds may lead to the refinement or more precise description of the aspects of an activity that is likely to destroy critical habitat.

Table 7: Examples of Activities Likely to Result in Destruction of Critical Habitat for the Wood Turtle

Description of Activity	Description of Effect	Details of Effect
1. Construction of road infrastructure (e.g., roads, bridges, culverts)	Construction of roads (paved, gravel or dirt surfaces) and bridges may cause permanent destruction (loss) or degradation of nesting, thermoregulation and foraging habitat(s). Roads and culverts may also fragment or isolate suitable habitat, precluding access to resource areas.	Roads may also act as ecological traps attracting Wood Turtles, especially adult females, which become at risk of collision. Roads built for vehicles that significantly increase the likelihood of fatal collisions (i.e., trucks, cars) are of the highest concern. Existing roads are not included in the description of critical habitat and therefore the continuation of maintenance activities on the road bed (including road side) are not likely to result in destruction of critical habitat. This activity links to the following threat(s) (refer to section 4 for additional information): • Road networks (high level of concern [LOC]).
2. Deforestation and forest alteration (e.g., residential and/or industrial and/or commercial development; habitat conversion to crop land; forestry roads, clear-cutting, commercial felled trees stacking area	Activities leading to deforestation (i.e., permanent removal of the forest/shrub cover) may cause permanent destruction (loss) or degradation of nesting, thermoregulation and foraging habitat. They may also fragment or isolate suitable habitat, precluding access to resource areas. Activities leading to forest alteration (e.g. cutting, scarification, drainage) may result in temporary or permanent destruction (loss) or degradation of nesting, thermoregulation and foraging	This activity links to the following threat(s), refer to section 4 for additional information: • Road networks (high LOC); • Agricultural practices (high LOC); • Residential and commercial development (medium LOC); • Forestry activities (medium LOC); • Sand and gravel pits (low LOC).

Description of Activity	Description of Effect	Details of Effect
creation, quarry creation)	habitat(s). They may also fragment or isolate suitable habitat, precluding access to resource areas. Clear-cutting areas greater than 1 ha could result in the temporary degradation of habitat by reducing food and shelter availability and changing the integrity of soil and water drainage patterns (Wesley, 2006).	
3. Complete or partial drainage or filling of wetlands	Complete or partial draining or filling of wetlands (e.g., alder thickets, beaver ponds, oxbows) may cause temporary or permanent destruction (loss) or degradation of overwintering, thermoregulation and foraging habitats. It may also fragment or isolate suitable habitat, precluding access to resource areas.	Drainage of wetlands outside of the critical habitat boundary could also result in the destruction of critical habitat. This activity links to the following threat(s) (refer to section 4 for additional information): • Road networks (high LOC); • Agricultural practices (high LOC); • Residential and commercial development (medium LOC).
4. Shoreline and streambed alteration (e.g., re-profiling, dredging, bottom substrate / woody debris removal, tillage or logging adjacent to stream, borrow pit operation, placement of material or construction of structures)	Activities leading to alteration of the structure and composition of the shoreline and streambed may result in temporary or permanent destruction (loss) or degradation of nesting, overwintering, thermoregulation or foraging habitat(s). Extended shoreline hardening (e.g. riprap, concrete walls) may also fragment or isolate suitable habitat, precluding access to resource areas. Changes in bathymetry and shoreline morphology can remove (e.g., erosion) or cover (e.g., siltation) preferred substrates. Changes in water depths and flow patterns can result in sections of river becoming unsuitable for the Wood Turtle (e.g., channelization may increase water velocity to an extent that it is no longer suitable). Placing materials (e.g., rocks, concrete blocks) or constructing structures in water or along shorelines reduces habitat availability (e.g., the footprint of the infill or structure is lost). Activities such as tillage and logging, when conducted too close to the stream, can cause riverbank erosion and result in loss of overwintering sites.	Conducting such activities upstream of the critical habitat boundary could also result in the destruction of critical habitat. This activity links to the following threat(s) (refer to section 4 for additional information): • Road networks (high LOC); • Agricultural practices (high LOC); • Residential and commercial development (medium LOC); • Forestry practices (medium LOC); • Sand and gravel pits (low LOC); • Pollution and sediment input (low LOC).

Description of Activity	Description of Effect	Details of Effect
5. Hydrological alteration Activities related to water management (e.g., construction of dam, creation of water impoundments > 10ha, dam operation)	Activities leading to alteration of hydrology may result in temporary or permanent destruction (loss) or degradation of nesting, overwintering, thermoregulation or foraging habitat(s). Dams and large impoundments may also fragment suitable habitat and preclude commuting and dispersal movements. High water levels can temporarily or permanently saturate nesting substrates, thereby affecting the possibility of successfully using the site. Conversely, recurrent low water levels can promote the growth of vegetation on nesting sites, preventing their use for egg laying. Impoundment of water and regulated releases may reduce natural erosion processes that create or maintain nest sites. Hydrological modifications can also result in water depth and flow rates that are outside the range required for successful overwintering (e.g., low water levels that expose turtles to freezing). Stabilization of water levels may permanently diminish floodplain habitat availability (e.g., wetlands) upon which the Wood Turtle relies for thermoregulation and foraging.	If these activities were to occur outside the bounds of critical habitat, it could result in destruction of critical habitat if the water levels/flows that contribute to critical habitat suitability are not maintained. There is an increased likelihood that such activities could result in the destruction of critical habitat during the overwintering and nesting periods. The timing of peak flows is important during the nesting period and the timing of low flows / water depth is important during overwintering. Destruction can result when activities modify these parameters to a point where overwintering and nesting requirements are not met. This activity links to the following threat(s) (refer to section 4 for additional information): • Water management (low LOC).
6. Sediment loading (e.g., removal of riparian vegetation, runoff from agriculture, forest harvesting, or development)	Activities leading to sediment loading can result in temporary or permanent destruction (loss) or degradation of overwintering habitat. Sedimentation can modify stream structure (e.g., siltation of pools used for overwintering, siltation of preferred substrate types) and may lead to reductions in dissolved oxygen levels so that overwintering would be physiologically more difficult or permanently compromised.	If these activities were to occur outside the bounds of critical habitat, it could result in the destruction of critical habitat, particularly during the overwintering period where sediment loading events are likely to modify critical habitat characteristics to a point where the species' requirements are not met. This activity links to the following threat(s) (refer to section 4 for additional information): • Road networks (high LOC); • Agricultural practices (high LOC); • Residential and commercial development (medium LOC); • Forestry practices (medium LOC); • Water management (low LOC); • Pollution and sediment loading (low LOC).

8. Measuring Progress

The performance indicators presented below provide a way to define and measure progress toward achieving the population and distribution objectives.

The performance indicators are provided as national guidelines to gauge the successful implementation of the recovery strategy.

Short-term performance indicators (15 years):

a. Population abundance has been increased in streams where the Wood Turtle is declining.
b. Available suitable habitat has been maintained or increased throughout the Canadian range
c. Threats that may be causing population decline have been reduced throughout the Canadian range.
d. Number of streams inhabited by the Wood Turtle with either baseline abundance information or appropriate trend index has increased.

Long-term performance indicators (50 years):

a. Number of local populations having a favourable viability estimate or other appropriate index has increased.

9. Statement on Action Plans

One or more Wood Turtle action plans will be posted before 2021 on the Species at Risk Public Registry.

10. References

Due to the vulnerability of the species to illegal collection, specific references providing sensitive information have been removed from this version of the recovery strategy. To support protection of the species and its habitat, the exhaustive list of references may be requested on a need-to-know basis by contacting Environment Canada's Recovery Planning section at ec.planificationduretablissement-recoveryplanning.ec@canada.ca.

[AC CDC] Atlantic Canada Conservation Data Centre. 2014. Element occurrence report for the wood turtle. http://www.accdc.com/.

Arvisais, M. 2000. Caractérisation et sélection d'habitats à l'intérieur des domaines vitaux chez la tortue des bois (*Clemmys insculpta*) au nord de son aire de répartition, Québec, Canada. Master of Science thesis, Université du Québec à Trois-Rivières, Canada. 150 pp.

Arvisais, M., E. Lévesque, J.-C. Bourgeois, C. Daigle, D. Masse and J. Jutras. 2004. Habitat selection by the wood turtle (*Clemmys insculpta*) at the northern limit of its range. Canadian Journal of Zoology 82: 391-398.

Bertacchi, W. 2013. Pers. comm. Ministère des Forêts, de la Faune et des Parcs du Québec, Direction de la gestion de la faune du Bas-Saint-Laurent – Secteur faune.

Bodie, J.R. 2001. Stream and riparian management for freshwater turtles. Journal of Environmental Management 62: 443-455.

Brooks, R.J. pers. comm. 2005. Professor, Department of Zoology, University of Guelph, Guelph, Ontario.

Buech, R.R. and M.D. Nelson. 1997. Conservation of Wood Turtles in Minnesota. pp. 15-21 in J.J. Moriarty and D. Jones (eds). Minnesota's Amphibians and Reptiles: Their Conservation and Status. Lanesboro, MN: Serpent's Tale Natural History Book Distributors.

Burger, J. and S.D. Garber. 1995. Risk assessment, life history strategies, and turtles: Could declines be prevented or predicted? Journal of Toxicology and Environmental Health 46: 483-500.

Burt, W.H. 1943. Territoriality and home range concepts as applied to mammals. Journal of Mammalogy 24: 346-352.

[CDPNQ] Centre de données sur le patrimoine naturel du Québec. 2012-2014. Element occurrence report for the wood turtle. http://www.cdpnq.gouv.qc.ca/.

Compton, B.W. 1999. Ecology and conservation of the Wood Turtle (*Clemmys insculpta*) in Maine. Master of Science thesis, University of Maine, 91 pp.

Compton, B.W., J.M. Rhymer and M. McCollough. 2002. Habitat selection by wood turtles (*Clemmys insculpta*): an application of paired logistic regression. Ecology 83: 833-843.

Congdon, J.D., D.W. Tinkle, G.L. Breitenbach and R.C. Van Loben Sels. 1983. Nesting ecology and hatching success in the turtle *Emydoidea blandingii*. Herpetologica 39: 417-429.

Congdon, J.D. 1989. Proximate and evolutionary constraints on energy relationships of reptiles. Physiological Zoology 62: 356-373.

[COSEWIC] Committee on the Status of Endangered Wildlife in Canada. 2007. COSEWIC assessment and update status report on the Wood Turtle (*Glyptemys insculpta*) in Canada. http://www.sararegistry.gc.ca/document/dspDocument_e.cfm?documentID=1658.

[COSEWIC] Committee on the Status of Endangered Wildlife in Canada. 2010. COSEWIC's Assessment Process and Criteria.

Coulombe, M. 2007. The Reproductive Ecology of the Wood Turtle (*Glyptemys insculpta*) at the North-Eastern Limit of its Range. B.Sc. Honours thesis. Department of Biology, St. Francis Xavier University, Antigonish, Nova Scotia.

Crowley, J.F. 2006. Are Ontario Reptiles on the Road to Extinction? Anthropogenic Disturbance and Reptile Distributions Within Ontario. M.Sc. thesis, University of Guelph.

Crowley, J.F. 2013-2014. Pers. comm. Ontario Ministry of Natural Resources, Species at Risk Branch.

Dubois, Y. 2014. Pers. comm. Ministère des Forêts, de la Faune et des Parcs du Québec, Direction des maladies de la faune et de la biodiversité.

Dubois, Y., G. Blouin-Demers, B. Shipley and D. Thomas. 2009. Thermoregulation and habitat selection in wood turtles (*Glyptemys insculpta*): chasing the sun slowly. Journal of Animal Ecology 78: 1023-1032.

Elderkin, M. pers. comm. 2013. Nova Scotia Department of Natural Resources – Wildlife Division.

Ernst, C.H. 2001. An overview of the North American turtle genus *Clemmys Ritgen,* 1828. Chelonian Conservation and Biology 4: 211-216.

Ewert, M.A. and C.E. Nelson. 1991. Sex determination in turtles: diverse patterns and some possible adaptive values. Copeia 1991: 50-69.

Fridgen, C., L. Finnegan, L., Reaume, C., Cebek, J., Trottier, J. and P.J. Wilson. 2012. Conservation Genetics of Wood Turtle (*Glyptemys insculpta*) Populations in Ontario, Canada.

Garber, S.D. and J. Burger. 1995. A 20-yr study documenting the relationship between turtle decline and human recreation. Ecological Applications 5(4): 1151-1162.

Giguère, S., M.-J. Côté and C. Daigle. 2011. Atlas des habitats potentiels de la tortue des bois (*Glyptemys insculpta*) au Québec. Environnement Canada, Service canadien de la faune – Région du Québec; ministère du Développement durable, de l'Environnement et des Parcs – Direction du patrimoine écologique et des parcs; ministère des Ressources naturelles et de la Faune – Direction de l'expertise sur la faune et ses habitats, Québec. Unpublished report. 21 pp. + 66 maps.

Government of Canada. 2009. *Species at Risk Act* Policies, Overarching Framework [Draft]. *Species at Risk Act* Policy and Guideline Series. Ottawa (ON): Environment Canada. 38 pp.

Greaves, W.F. 2007. A Cold and Harsh Environment: Demography and Spatial Ecology of a Northern Population of Wood Turtles (*Glyptemys insculpta*). Master of Science thesis, Laurentian University, Sudbury (ON). 176 pp.

Greaves, W.F. and J.D. Litzgus. 2008. Chemical, thermal, and physical properties of sites selected for overwintering by northern wood turtles (*Glyptemys insculpta*). Canadian Journal of Zoology 86: 659-667.

Gregory, P.T. 1982. Reptilian hibernation. In C. Gans, F.H. Pough (*eds*), Biology of the Reptilia. Academic Press, NY.

Harding, J.H. and T.J. Bloomer. 1979. The wood turtle, *Clemmys insculpta* ... a natural history. Herpetological Bulletin of the New York Herpetological Society 15: 9-26.

Horne, B.D., R.J. Brauman, M.J.C. Moore and R.A. Seigel. 2003. Reproductive and nesting ecology of the yellow-blotched map turtle, *Graptemys flavimaculata*: Implications for conservation and management. Copeia 4: 729-738.

Iverson, J.B., C.P. Balgooyen, K.K. Byrd and K.K. Lyddan. 1993. Latitudinal variation in egg and clutch size in turtles. Canadian Journal of Zoology 71: 2448-2461.

Jones, M.T., L.L. Willey, T.S.B. Akre, C. Castellano and P.R. Sievert. 2013. Draft Coordinated Monitoring Strategy for Wood Turtles (*Glyptemys insculpta*) in the Northeastern United States. Massachusetts Cooperative Fish and Wildlife Research Unit, Northeast Wood Turtle Working Group, Amherst, MA, 16 pp.

Kaufmann, J.H. 1992. Habitat use by wood turtles in central Pennsylvania. Journal of Herpetology 26: 315-321.

Lesbarrères, D., S.L. Ashpole, C.A. Bishop, G. Blouin-Demers, R.J. Brooks, P. Echaubard, P. Govindarajulu, D.M. Green, S.J. Hecnar, T. Herman, J. Houlahan, J.D. Litzgus, M.J. Mazerolle, C.A. Paszkowski, P. Rutherford, D.M. Schock, K.B. Storey and S.C. Lougheed. 2014. Conservation of herpetofauna in northern landscapes: Threats and challenges from a Canadian perspective. Biological Conservation 170: 48-55.

MacGregor, M.K. and M.F. Elderkin. 2003. Protecting and Conserving Wood Turtles: A Stewardship Plan for Nova Scotia. Nova Scotia Department of Natural Resources, Wildlife Division, Biodiversity Program. 23 pp.

McKenney, D. 2006. Pers. comm. Email correspondence on the bioclimatic model for the Wood Turtle in northeastern North America. Natural Resources Canada, Canadian Forest Service, Great Lakes Forestry Centre, Sault Ste. Marie (ON).

Mitchell, J., S.R. de Solla and R.J. Brooks. 1997. Survey and monitoring study for the Wood Turtle (*Clemmys insculpta*) in Ontario. Dept. of Zoology, University of Guelph.

Mitchell, J.C. and Klemens, M.W. 2000. Primary and secondary effects of habitat alteration. *In* Klemens, M.W. *editor*. Turtle conservation. Smithsonian Institution Press, Washington, D.C., 334 pp.

Moritz, C. 1994. Defining "evolutionarily significant units" for conservation. Trends Ecol Evol 9:373-375.

Natural Heritage Information Centre [NHIC]. 2011. Element occurrence report for the wood turtle. Peterborough (ON): Ontario Ministry of Natural Resources.

NatureServe. 2002. Element occurrence data standard. 201 pp. http://www.natureserve.org/prodServices/eodata.jsp

NatureServe. 2014. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. http://www.natureserve.org/explorer [accessed September 2014].

New Hampshire Fish and Game Department. 2005. Appendix A: Species profile: Wood Turtle. *In*: New Hampshire Wildlife Action Plan.

Norden, A.W. 1999. Flood induced winter mortality of wood turtles (*Clemmys insculpta* Le Conte) in Maryland. The Maryland Naturalist 43: 3-4.

Nova Scotia Department of Natural Resources. 2012. Vulnerable Wood Turtle (*Glyptemys insculpta*) special management practices. http://www.gov.ns.ca/natr/wildlife/habitats/terrestrial/pdf/SMP_Wood_Turtles.pdf [accessed July 2013].

Ontario Ministry of Natural Resources. 2013. Wood Turtle Ontario Government Response Statement. 4 pp.

Ontario Wood Turtle Recovery Team. 2010. Recovery Strategy for the Wood Turtle (*Glyptemys insculpta*) in Ontario. Ontario Recovery Strategy Series. Prepared for the Ontario Ministry of Natural Resources. vi + 25 pp.

Pelletier, S. 2013. Comm. pers. from CDPNQ element occurrences. Ministère des Forêts, de la Faune et des Parcs, Secteur de la faune et des parcs, Québec.

Pope, C.H. 1967. Turtles of the United States and Canada. New York (NY): Alfred A. Knopf. 337 pp.

Pulsifer, M. 2013. Pers. comm. Nova Scotia Department of Natural Resources, eastern region.

Robillard, M. 2009. Étude d'une population de tortues des bois (*Clemmys insculpta*) en milieu agroforestier dans la région des Outaouais. Rapport présenté à l'Université du Québec à Rimouski. 26 pp.

Saumure, R.A. and J.R. Bider. 1998. Impact of agricultural development on a population of Wood Turtles (*Clemmys insculpta*) in southern Québec, Canada. Chelonian Conservation and Biology 135: 37-45.

Saumure, R.A., T.B. Herman and R.D. Titman. 2007. Effects of haying and agricultural practices on a declining species: The North American wood turtle, *Glyptemys insculpta*. Biological Conservation 135: 565-575.

Shelby-Walker, J.A., C.K. Ward and M.T. Mendonça. 2009. Reproductive parameters in female yellow-blotched map turtles (*Graptemys flavimaculata*) from a historically contaminated site vs. a reference site. Comparative Biochemistry and Physiology A – Molecular and Integrative Physiology 154: 401-408.

Shine, R. 1999. Why is sex determined by nest temperature in many reptiles? Trends in Ecology and Evolution 14: 186-189.

Steen, D.A. and J.P. Gibbs. 2004. Effects of roads on the structure of freshwater turtle populations. Conservation Biology 18: 1143-1148.

Steen, D.A., M.J. Aresco, S.G. Beilke, B.W. Compton, E.P. Condon, C. K. Dodd, Jr., H. Forrester, J.W. Gibbons, J.L. Greene, G. Johnson, T.A. Langen, M.J. Oldham, D.N. Oxier, R.A. Saumure, F.W. Schueler, J.M. Sleeman, L.L. Smith, J.K. Tucker and J.P. Gibbs. 2006. Relative vulnerability of female turtles to road mortality. Animal Conservation 9: 269-273.

Steen, D.A, J.P. Gibbs, K.A. Buhlmann, J.L. Carr, B.W. Compton, J.D. Congdon, J.S. Doody, J.C. Godwin, K.L. Holcomb, D.R. Jackson, F.J. Janzen, G. Johnson, M.T. Jones, J.T. Lamer, T.A. Langen, M.V. Plummer, J.W. Rowe, R.A. Saumure, J.K. Tucker, and D.S. Wilson. 2012. Terrestrial habitat requirements of nesting freshwater turtles. Biological Conservation 150: 121-128.

Tingley, R., D.G. McCurdy, M.D. Pulsifer and T.B. Herman. 2009. Spatio-temporal differences in the use of agricultural fields by male and female wood turtles (*Glyptemys insculpta*) inhabiting an agri-forestry matrix. Herpetological Conservation and Biology 4: 185-190.

Tingley, R., T.B. Herman, M.D. Pulsifer, D.G. McCurdy and J.P. Stephens. 2010. Intra-specific niche partitioning obscures the importance of fine-scale habitat data in species distribution models. Biodiversity Conservation 19: 2455-2467.

Ultsch, G.R. 2006. The ecology of overwintering among turtles: where turtles overwinter and its consequences. Biological Reviews 81: 339-367.

Van Meter, R.J., J.R. Spotila and H.W. Avery. 2006. Polycyclic aromatic hydrocarbons affect survival and development of common snapping turtle (*Chelydra serpentina*) embryos and hatchlings. Environmental Pollution 142: 466-475.

Walde, A.D., J.R. Bider, C. Daigle, D. Masse, J.-C. Bourgeois, J. Jutras and R.D. Titman. 2003. Ecological aspects of a Wood Turtle, *Glyptemys insculpta*, population at the northern limit of its range in Québec. Canadian Field-Naturalist 117: 377-388.

Walde, A.D., J.R. Bider, D. Masse, R.A. Saumure and R.D. Titman. 2007. Nesting ecology and hatching success of the Wood Turtle, *Glyptemys insculpta*, in Québec. Herpetological Conservation and Biology 2: 49-60.

Wesley, P.A. and J.R. Brown. Implications of habitat degradation for a northern population of Wood Turtles (*Glyptemys insculpta*), unpublished manuscript.

Wesley, P.A. 2006. Local and regional scale habitat selection by Wood Turtles (*Glyptemys insculpta*) in Ontario. Master's thesis, Department of Integrative Biology, University of Guelph, Ontario.

Willoughby, J.R., M. Sundaram, T.L. Lewis and B.J. Swanson. 2013. Population decline in a long-lived species: the Wood Turtle in Michigan. Herpetologica 69(2): 186-198.

Appendix A: Critical Habitat for the Wood Turtle in Canada

TABLE A. 1:250,000 National Topographic System (NTS) map sheets identified as containing critical habitat for the Wood Turtle (*Glyptemys insculpta*) in Canada. Critical habitat occurs where the criteria described in section 7.1 are met.

Province	1:250 000 NTS Number	1:250 000 NTS[1] square coordinates[2]	
		Longitude	Latitude
New Brunswick	021G	-68.00000	45.00000
New Brunswick	021I	-66.00000	46.00000
New Brunswick	021J	-68.00000	46.00000
New Brunswick	021N	-70.00000	47.00000
New Brunswick	021O	-68.00000	47.00000
New Brunswick	021P	-66.00000	47.00000
New Brunswick	022B	-68.00000	48.00000
Nova Scotia	011D	-64.00000	44.00000
Nova Scotia	011E	-64.00000	45.00000
Nova Scotia	011F	-62.00000	45.00000
Nova Scotia	011K	-62.00000	46.00000
Nova Scotia	021A	-66.00000	44.00000
Nova Scotia	021H	-66.00000	45.00000
Ontario	030M	-78.00000	43.00000
Ontario	031D	-78.00000	44.00000
Ontario	031E	-78.00000	45.00000
Ontario	031F	-76.00000	45.00000
Ontario	040P	-80.00000	43.00000
Ontario	041A	-80.00000	44.00000
Ontario	041I	-82.00000	46.00000
Ontario	041J	-84.00000	46.00000
Ontario	041K	-86.00000	46.00000
Ontario	041N	-86.00000	47.00000
Ontario	041O	-84.00000	47.00000
Quebec	021E	-72.00000	45.00000
Quebec	021L	-72.00000	46.00000
Quebec	021N	-70.00000	47.00000
Quebec	031F	-77.50000	45.75000
Quebec	031G	-76.00000	45.25000
Quebec	031H	-74.00000	45.00000
Quebec	031I	-74.00000	46.00000
Quebec	031J	-76.00000	46.00000

Province	1:250 000 NTS Number	1:250 000 NTS[1] square coordinates[2]	
Quebec	031K	-78.00000	46.00000
Quebec	031O	-76.00000	47.00000
Quebec	031P	-74.00000	47.00000

[1] For further information on the NTS, see http://www.nrcan.gc.ca/earth-sciences/geography-boundary/mapping/topographic-mapping/10339.

[2] For further information on location of provided map number, see http://atlas.gc.ca/site/english/toporama/index.html?center=2470752.0755315,1595288.2272616&zoom=2 (click on toggle NTS Grid).

Appendix B: Effects on the Environment and Other Species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*[47]. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or any of the Federal Sustainable Development Strategy's[48] (FSDS) goals and targets.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below in this statement.

The Wood Turtle's needs are met by a wide variety of habitats centered on streams as well as riparian habitats. Riparian habitats play a major role in regulating stream hydrology by: dissipating stream energy with their meandering curves and vegetation, which contributes to a slow streamflow and reduced risk of flood damage and soil erosion; providing natural irrigation by extending seasonal or perennial flows of water, which also allows the transfer of nutrients from terrestrial vegetation into the aquatic food webs; helping regulate water temperature by means of the shade created on the stream; filtering many pollutants in the water that are transported by runoff, resulting in better-quality water; reducing suspended matter in water, which is trapped and accumulated on the bank; and providing wildlife habitats and corridors, thus enabling increased biodiversity.

Several other species at risk may be found in Wood Turtle habitat, including birds (King Rail [*Rallus elegans*] and Prothonotary Warbler [*Protonotaria citrea*]), fishes (Lake Chubsucker [*Erimyzon sucetta*], Spotted Gar [*Lepisosteus oculatus*], Pugnose Shiner [*Notropis anogenus*], Channel Darter [*Percina copelandi*] and Eastern Sand Darter [*Ammocrypta pellucida*]), turtles (Blanding's Turtle [*Emydoidea blandingii*], Snapping Turtle [*Chelydra serpentina*]), snakes (Eastern Foxsnake [*Pantherophis gloydi*] and Milk Snake [*Lampropeltis triangulum*]), and invertebrates (Skillet Clubtail [*Gomphus ventricosus*]). Those examples do not represent an exhaustive list. Given that specific needs may differ for all of these species, management actions should recognize the potential for synergistic recovery actions. Wherever possible, natural ecosystem processes should be maintained and allowed to evolve without human interference, because these are the processes to which species are adapted.

The possibility that the present recovery strategy inadvertently generates negative effects on the environment and on other species was considered. The majority of recommended actions are non-intrusive in nature, including surveys and outreach. We conclude that the present recovery strategy is unlikely to produce significant negative effects.

[47] http://www.ceaa.gc.ca/default.asp?lang=En&n=B3186435-1
[48] www.ec.gc.ca/dd-sd/default.asp?lang=En&n=F93CD795-1