PROPOSED

Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the Tiger Salamander (*Ambystoma tigrinum*) (Great Lakes Population) in Canada

Tiger Salamander (Great Lakes population)

January 2009

Parks Canada Parcs Canada

Canada

About the *Species at Risk Act* Recovery Strategy Series

What is the *Species at Risk Act* (SARA)?

SARA is the Act developed by the federal government as a key contribution to the common national effort to protect and conserve species at risk in Canada. SARA came into force in 2003, and one of its purposes is *"to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity."*

What is recovery?

In the context of species at risk conservation, **recovery** is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed and threats are removed or reduced to improve the likelihood of the species' persistence in the wild. A species will be considered **recovered** when its long-term persistence in the wild has been secured.

What is a recovery strategy?

A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets goals and objectives and identifies the main areas of activities to be undertaken. Detailed planning is done at the action plan stage.

Recovery strategy development is a commitment of all provinces and territories and of three federal agencies — Environment Canada, Parks Canada Agency, and Fisheries and Oceans Canada — under the *Accord for the Protection of Species at Risk*. Sections 37–46 of SARA (www.sararegistry.gc.ca/approach/act/default_e.cfm) outline both the required content and the process for developing recovery strategies published in this series.

Depending on the status of the species and when it was assessed, a recovery strategy has to be developed within one to two years after the species is added to the List of Wildlife Species at Risk. Three to four years is allowed for those species that were automatically listed when SARA came into force.

What's next?

In most cases, one or more action plans will be developed to define and guide implementation of the recovery strategy. Nevertheless, directions set in the recovery strategy are sufficient to begin involving communities, land users, and conservationists in recovery implementation. Cost-effective measures to prevent the reduction or loss of the species should not be postponed for lack of full scientific certainty.

The series

This series presents the recovery strategies prepared or adopted by the federal government under SARA. New documents will be added regularly as species get listed and as strategies are updated.

To learn more

To learn more about the *Species at Risk Act* and recovery initiatives, please consult the SARA Public Registry (www.sararegistry.gc.ca).

Recovery Strategy for the Tiger Salamander (*Ambystoma tigrinum*) (Great Lakes population) in Canada [PROPOSED]

January 2009

Recovery of this species is considered not technically or biologically feasible at this time.

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Additional copies:

Additional copies can be downloaded from the SARA Public Registry (www.sararegistry.gc.ca).

Cover illustration: Photo by Dr. James P. Bogart of a male Tiger Salamander from Kelleys Island, Erie County, Ohio, U.S.A, located in the western basin of Lake Erie, collected by Leslie A. Lowcock on March 25, 1985 (catalogue number JPB10674).

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DECLARATION

Under the *Accord for the Protection of Species at Risk* (1996), the federal, provincial, and territorial governments agreed to work together on legislation, programs, and policies to protect wildlife species at risk throughout Canada. The *Species at Risk Act* (S.C. 2002, c.29) (SARA) requires that federal competent ministers prepare recovery strategies for listed Extirpated, Endangered and Threatened species.

The Minister of the Environment presents this document as the recovery strategy for the Tiger Salamander (Great Lakes population), as required under SARA. It has been prepared in cooperation with the jurisdictions responsible for the species, as described in the Preface.

The recovery of the Tiger Salamander (Great Lakes population) in Canada is considered neither appropriate, nor technically, nor biologically feasible at this time. The existence of such a population in Canada, even historically, is questionable and remains unconfirmed. If a population did exist at one time, it has since been extirpated. There are neither clear candidates for translocation, nor appropriate habitat available, nor are effective mitigation or recovery techniques currently known.

This feasibility determination will be re-evaluated, as warranted, in response to changing conditions and/or knowledge.

AUTHORS

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STRATEGIC ENVIRONMENTAL ASSESSMENT STATEMENT

A strategic environmental assessment (SEA) is conducted on all *Species at Risk Act* recovery strategies, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals* (2004). 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.

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 their intended benefits. Environmental effects, including impacts to non-target species, and the environment, were considered during recovery planning. The SEA is incorporated directly into the strategy, and is also summarized below.

Due to the lack of evidence to confirm the presence, past or present, of a Great Lakes population of the Tiger Salamander in Canada, and because recovery is regarded as neither appropriate nor feasible, no further recovery action is contemplated at this time. Accordingly, this recovery strategy will have no effect on the environment.

RESIDENCE

SARA defines residence as: *"a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating"* **[SARA Subsection 2(1)]**.

Residence descriptions, or the rationale for why the residence concept does not apply to a given species, are posted on the SARA public registry:
www.sararegistry.gc.ca/sar/recovery/residence_e.cfm

In the case of an extirpated species for which the recovery strategy does not recommend its repatriation into the wild in Canada, the prohibition pertaining to the damage or destruction of residence does not apply [SARA S33].

PREFACE

This recovery strategy deals with the recovery of the Great Lakes population of the Tiger Salamander. In Canada, the Tiger Salamander (*Ambystoma tigrinum*) currently ranges from British Columbia, across Alberta and Saskatchewan, to Manitoba. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC in press) treats the Tiger Salamander as three separate populations, or designatable units, based on geographic distribution: 1) the Great Lakes population (Extirpated - Ontario), 2) the Southern Mountain population (Endangered – British Columbia), and 3) the Prairie/Boreal population (Not at Risk – Alberta, Saskatchewan, and Manitoba). Both the Great Lakes and Southern Mountain populations are listed on Schedule 1 of the *Species at Risk Act*.

Under the *Species at Risk Act*, Parks Canada Agency is the responsible jurisdiction for the Great Lakes population of the Tiger Salamander, and has led recovery strategy development. The document has benefitted from the valuable input of Environment Canada, the Province of Ontario and peer reviewers.

The determination that recovery is not feasible, including the justification, was examined as part of the review process for the recovery strategy. The final decision and wording of the determination were the responsibility of Parks Canada Agency, and took account of the comments received.

EXECUTIVE SUMMARY

The Great Lakes population of the Tiger Salamander (*Ambystoma tigrinum*), until 2008, was considered to belong to one of six subspecies of Tiger Salamanders, the Eastern Tiger Salamander (*A. t. tigrinum*). This recovery strategy will follow this taxonomic arrangement. One of the largest terrestrial salamanders in the world, adults average 18 to 21 cm in total length. They have yellow spots, blotches, or vertical streaks marking a dark brown, green or black back, and an olive-yellow belly with pale, yellow blotching. Clusters of pigmented eggs hatch in a month, developing into silvery gray larvae, 9 to 17 mm in total length. Metamorphosis may take two to five months, with sexual maturity reached in two to five years.

The Eastern Tiger Salamander ranges from Long Island, New York southward along the Atlantic coastal plain; westward along the Gulf of Mexico to southeastern Louisiana; and then northward from Alabama through much of lower Michigan. It ranges unevenly through many of the states north and east of that core range, but is absent from most of the Appalachian uplands and the lower Mississippi River delta region. Small, isolated populations occur elsewhere, including one or more of the Ohio islands in western Lake Erie.

The Great Lakes population is considered extirpated from Ontario, and, therefore, Canada, although it may never have existed there. Its occurrence in Canada is based on a single accepted specimen of questionable origin, reported to have been collected in 1915 at Point Pelee. Pelee Island specimens are unconfirmed, as are other specimens and reports from Ontario. Genetic testing cannot be used to verify their identity, and the Tiger Salamander genetic complement has not been found. Eastern Tiger Salamanders, located in extreme southeastern Manitoba, are part of the not-at-risk Prairie/Boreal population. Although they are genetically similar to Ohio and Indiana Eastern Tiger Salamanders, they are also genetically not unlike the Gray Tiger Salamander of the Great Plains.

The Eastern Tiger Salamander's habitat requirements and threats in Canada are hypothesized based on populations in the United States. The exact collection location and habitat of the Canadian specimen are unknown, and threats, if a population existed, can only be surmised.

Recovery of the Great Lakes population of the Eastern Tiger Salamander in Canada is considered neither biologically nor technically feasible at this time, nor is it considered appropriate. The historical existence of this population in Canada is questionable. It is hypothesized that the specimen may have originally been captured in the United States, or it may have been a stray from one of the western Lake Erie islands and therefore, potentially, a hybrid. Notwithstanding this, adjacent populations are considered neither appropriate nor secure enough to serve as a source of translocated individuals. Suitable breeding habitat does not appear to be available, or easily established to minimize threats. Existing terrestrial areas present pesticide contamination and road mortality threats, and shoreline erosion threatens to introduce predaceous fishes to the only potentially suitable and available breeding habitat. Repatriation attempts elsewhere have had limited success, largely due to the Eastern Tiger Salamander's fidelity to breeding sites, and their high rate of egg mortality. Furthermore, given that Tiger Salamanders have not been present in the region for at least 90 years, if they were ever present, other organisms may now fill their ecological niche. This feasibility determination will be re-evaluated, as warranted, in response to new information. It is recommended that field investigators be encouraged to report possible sightings, that confirmation be sought where possible and that C. A. Campbell's specimen be genetically tested to rule out that it is different from hybrid, non-Tiger Salamander specimens already analyzed from the same site.

Critical habitat cannot be defined, at this time, due to the uncertainty surrounding the existence of this population in Canada, even historically, and the lack of habitat and location specificity associated with the only accepted record. Habitat needs in the United States may not apply in Canada.

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1.1 Species Assessment Information from COSEWIC

Date of Assessment:	November 2001
Common Name (population):	Tiger Salamander (Great Lakes population)
Scientific Name:	*Ambystoma tigrinum*
COSEWIC Status:	Extirpated
Reason for Designation:	This salamander was last seen in southern Ontario in 1915 at Point Pelee. Despite repeated inventories over the last 80 years, it has not been seen since that time.
Canadian Occurrence:	Ontario
COSEWIC Status History:	Last seen in Ontario in 1915. Designated Extirpated in November 2001. Assessment based on a new status report.

1.2 Description

The Great Lakes population of the Tiger Salamander, a mole salamander in the family Ambystomatidae, was, until 2008, considered to belong to one of six subspecies of Tiger Salamanders (*Ambystoma tigrinum*), the Eastern Tiger Salamander (*A. t. tigrinum*) (Green 1825, Crother 2000). Recent mitochondrial DNA, allozyme[1], and fine-scale morphological investigations strongly suggest that the Eastern Tiger Salamander is a species separate from the other forms (Shaffer and McKnight 1996, Irschick and Shaffer 1997, Powell *et al.* 1998). Based on these findings, the Eastern Tiger Salamander, including the Great Lakes population, is now considered to be a species (*A. tigrinum*) distinct from the five remaining former subspecies, now collectively recognized as *A. mavortium*. This taxonomic arrangement has only recently received acceptance in the *Scientific and Standard English Names of Amphibians and Reptiles of North America North of Mexico* (Crother 2008). This checklist is the standard followed by the three major herpetological societies in North America, as well as NatureServe, and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Oldham pers. comm. 2008). This recovery strategy, however, will follow the former taxonomic arrangement recognized at the time of COSEWIC's designation, which also makes it easier to follow discussions related to the species (Tiger Salamander), subspecies (Eastern Tiger Salamander), and population (Great Lakes) levels.

The Tiger Salamander is one of the largest terrestrial salamanders in the world. It reaches a total length of 30 to 35 cm, although it more often measures between 18 and 21 cm (Behler and King 1998, Petranka 1998). Smith (1949) recorded an Eastern Tiger Salamander measuring 33 cm in total length. Colouration, form, and life history vary across the range of the Tiger Salamander in North America, and it is on this basis that the six previously recognized subspecies were identified. Terrestrial, adult, Eastern Tiger Salamanders typically have a dull black to deep brown or dark green ground colour on their back, with lighter olive to yellow spots, blotches, or vertical streaks, and an olive-yellow belly marked with irregular, pale, yellow blotches

[1] An allozyme is any of the forms of an enzyme that are determined by the different forms of a gene at a single genetic location. Different allozymes are responsible for the inheritance of different genetic traits.

(Dunn 1940, Pope 1964, Vogt 1981, Conant and Collins 1991, Petranka 1998). These spots increase in number with age in most areas, and are as prevalent on the top of the salamander's body as on its sides (Dunn 1940).

Male and female Tiger Salamanders differ only slightly, with females showing less lateral compression than males. Females also have shorter tails in proportion to their body length, and shorter vents. The male's vent swells during the breeding season (Pope 1964).

Clusters of pigmented eggs, 10 to 12 mm in diameter, are attached to twigs or stems of emergent plants, 30 cm or more below the surface of the water. Each egg mass contains 18 to 110 eggs, the average number of which varies geographically. An average cluster of eggs measures approximately 5.5 cm by 7 cm (Pope 1964, Vogt 1981, Petranka 1998), and requires a month or more to incubate, depending on water temperature.

Upon hatching, Tiger Salamander larvae are silvery gray, and have broad snouts, three pairs of conspicuous, feathery gills, broad, dorsal fin membranes, and lack the fleshy protrusions, or balancers, found in other mole salamander larvae. Gill rakers[2], numbering from 19 to 20 on the anterior face of the third arch, can be used to help distinguish Eastern Tiger Salamanders from the other five subspecies (Dunn 1940). Larval Eastern Tiger Salamanders vary in total length from 9 to 17 mm (Petranka 1998). Paired blotches on their upper surface tend to darken with age, and a greenish colouration may appear along the outer surface of the gills (Petranka 1998, Schock 2001). Front limbs develop first, shortly after hatching, followed by the hind appendages (Schock 2001). Juveniles develop adult colouration and patterning during, or within one month of, metamorphosis (Engelhardt 1916, Webb and Roueche 1971). The gills, along with the dorsal and caudal fin membranes, are absorbed during metamorphosis, the latter of which may remain visible as a dark line down the centre of the back for a short period of time (Schock 2001).

The time from hatching through transformation to the terrestrial form varies from two to five months in the Eastern Tiger Salamander, depending on food availability, climate, density, and seasonal time of pond drying. Populations in New York, Michigan, and Indiana take approximately two to three, three, and three and a half months respectively to metamorphose (Ruthven *et al.* 1928, Bishop 1941, Wilbur and Collins 1973, Sever and Dineen 1978, Petranka 1998). A minimum of three to seven months of water availability is, therefore, needed for the entire process to occur, from pairing and mating, through egg incubation and hatching, larval development and transformation, to the emergence of juveniles in their terrestrial form. Eastern Tiger Salamander larvae are even known to overwinter in permanent ponds before transforming (Brandon and Bremer 1967). The time to reach sexual maturity also varies from population to population, based on climate and genetic factors (F. R. Cook pers. comm. 2008). However, larvae typically reach sexual maturity in two years for males, and three to five years for females (Wilbur and Collins 1973, Petranka 1998).

Cannibalistic larvae, which are rare in the Eastern Tiger Salamander, are believed to develop in response to high larval densities, especially when there are large variations in larval size (Gehlbach 1969, Collins *et al.* 1980, Pfennig *et al.* 1991). These individuals have broad, flattened

[2] Gill rakers are stiff projections, found along the inner margin of the structures supporting the gills of fishes, which help prevent food and other particles from being carried into the gills.

heads and enlarged teeth on the roof of their mouth that allow them to catch and eat salamander larvae that can be almost equal to them in size (Schock 2001). A neotenic morph, which reaches sexual maturity without undergoing metamorphosis into the terrestrial form, may also occur, although, again, they are not common in the Eastern Tiger Salamander (Petranka 1998). These forms remain in the water throughout adulthood, in areas where water is guaranteed year-round, likely representing an adaptation to terrestrial habitats that become dry and inhospitable for much of the year. Neotenic morphs can reach very large sizes (350 mm and more in total length), and occasionally may be cannibalistic.

1.3 Populations and Distribution of the Eastern Tiger Salamander

1.3.1 North American

The Eastern Tiger Salamander ranges from Long Island, New York along the Atlantic coastal plain southward to northern Florida; westward along the Gulf of Mexico to southern Mississippi and southeastern Louisiana; then northward through Alabama, Tennessee, western Kentucky, Indiana and much of Lower Michigan. They also range unevenly through Wisconsin and Illinois to Iowa, northeastern Kansas, extreme eastern Nebraska, and southeastern South Dakota, northward to Minnesota, and extreme southeastern Manitoba. It is absent from most of the Appalachian uplands, and the lower Mississippi River delta region. A large, disjunct population exists in eastern Texas, with smaller, isolated populations in Missouri, northern Arkansas, extreme southeastern Kansas, Michigan's Upper Peninsula, and Ohio, including Kelleys Island, in western Lake Erie (Conant and Collins 1991, Petranka 1998, Frost 2007, Figure 1). While Tiger Salamanders were reported from Ohio's South Bass and Middle Bass Islands between 1940 and 1966 (Langlois 1964, Downs 1989, King *et al.* 1997), they have not been reported since then. It has been suggested that they have been eliminated from these islands as a result of habitat destruction (Downs 1989, King *et al.* 1997, J. P. Bogart pers. comm. 2008).

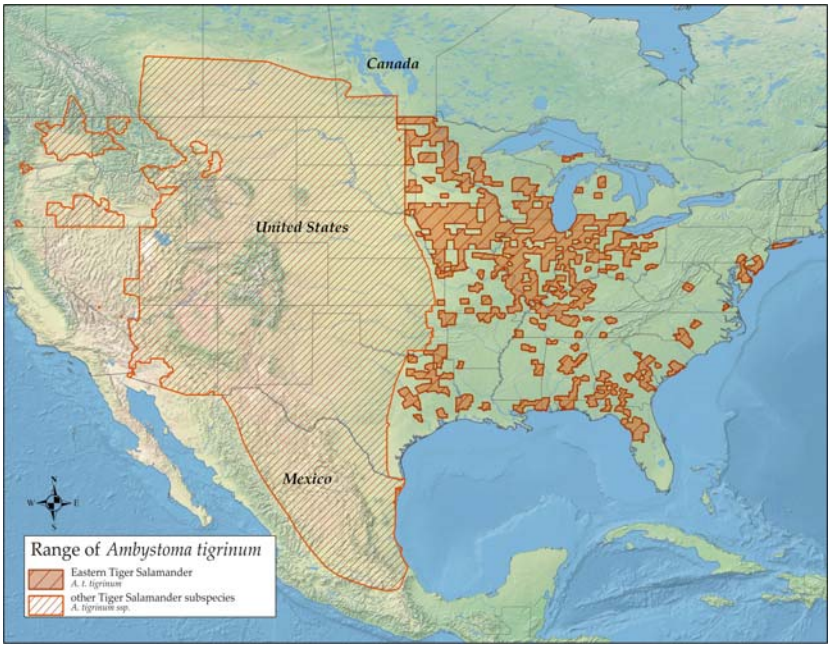

Figure 1. Distribution of the Eastern Tiger Salamander (modified from IUCN *et al.* 2006).

The Great Lakes population of the Tiger Salamander, a COSEWIC-designated unit, based on geographic distribution of the species, is considered extirpated from Ontario and, therefore, from Canada. A similar designation does not exist in the United States.

1.3.2 Canadian

COSEWIC's designation of a Great Lakes population of the Tiger Salamander in Canada is based on a single, adult specimen, housed at the Canadian Museum of Nature (CMNAR 623[3], Zoology Accession Number 1915-77). P. A. Taverner collected this individual on October 2, 1915 from Point Pelee, Ontario. (Logier 1925, M. Steigerwald pers. comm. 2005, F. R. Cook pers. comm. 2008). Identification is based on morphology, but cannot be confirmed via genetic testing due to the preservation of the specimen in formaldehyde for a period of time. Unfortunately, this record lacks further information regarding the exact location of the collection and the habitat in which the Tiger Salamander was found. Point Pelee National Park was 15.6 km^2 in size in 1931. However, a map, created by Taverner in 1908 (Taverner and Swales 1907-1908), shows that the area that was considered "Point Pelee", at that time, was likely larger than that, probably by one concession along the eastern half of its present-day northern boundary.

Questions remain regarding the origin of the specimen from Point Pelee. This is despite Taverner's knowledge of the Point Pelee area, extending back to at least 1905, his membership in the Great Lakes Ornithological Club that conducted extensive fieldwork at Point Pelee, and his position as Ornithologist at the Geological Survey of Canada, Victoria Memorial Museum Branch/National Museum of Natural Sciences, Ottawa from 1911 to 1942 (now the Canadian National Museum) (Cranmer-Byng 1996).

Since 1915, and despite extensive herpetofaunal research and surveys in what would become Point Pelee National Park (Taverner 1914[4]; Patch 1919[3]; Logier 1925; Cook 1967; Cook 1971; Ross 1971; Rivard 1973*a*, *b*; Damas and Smith Ltd. 1981; Wigle undated; Mason and Mason 1986; Kraus 1991; Hecnar and M'Closkey 1994, 1995; Oldham and Weller 2000), and herpetological notes recorded by staff (Bouckhout 1967, Roy 1967, Wyett 1967, Dutcher 1968, Mundy 1968, Wyett 1968, Neill 1968-1969, Burhoe 1969, Gemmell 1969, Bevan 1972), no other individuals of Eastern Tiger Salamander, or any other salamander species, have been found. Logier (1925), when describing a six week Royal Ontario Museum of Zoology expedition to Point Pelee National Park, in the summer of 1920, just five years after Taverner's discovery, noted "I was struck by the apparent absence of both newts and salamanders".

While unpublished Great Lakes Ornithological Club records (1915) and Taverner's personal communications (1915*a*, 1915*b*) document that Taverner was present at Point Pelee at a holiday reunion of the club on October 2, 1915, when the Tiger Salamander was reported to be collected, the collection is neither noted in the club records, which did document the collection of birds on that trip, nor in Taverner's Geological Survey of Canada field notes. However, the Great Lakes Ornithological Club records do document reptiles and amphibians collected on other trips. It is

[3] Canadian Museum of Nature Amphibian and Reptile Collection catalogue number.
[4] These two reports were based on the same 1913 biological field expedition of the Victoria Memorial Museum (Geological survey of Canada) (F. R. Cook pers. comm. 2008).

perplexing that Taverner could not recall the circumstances of the salamander's capture (Logier 1925), despite its significance (i.e. first record and first collection of Tiger Salamander in Ontario) and his occupation at the time. However, as his primary interest was birds, it is possible that he didn't realize the significance of the record. This is reinforced by the fact that the accession record for the specimens collected on that day simply notes "1 - salamander", with "*Ambystoma tigrinum* Green" noted above it in a different style of writing and ink. This suggests that identification took place at a later date. Similarly, the 1913 amphibians collected during the Victoria Memorial Museum expedition were simply identified as frogs when they were first catalogued, despite the presence of the now Threatened Fowler's Toad (*Bufo fowleri*) and the now Endangered Northern Cricket Frog (*Acris crepitans*) in the collection. Furthermore, neither Taverner (1914) nor Patch (1919) reported on the amphibians that they collected during their 1913 expedition, in their report on the reptiles found (F. R. Cook pers. comm. 2008). These facts suggest that neither of the men were familiar with amphibians (F. R. Cook pers. comm. 2008). It has also been noted that Taverner's specimen is quite emaciated, suggesting that it may have been held for some time prior to preservation and tagging (F. R. Cook pers. comm. 2008). A note to Taverner, from a colleague at the Royal Ontario Museum, less than two months after the Tiger Salamander was collected, suggesting that he should keep notes of his work beyond his field journal as "There are so many things that you do in the course of your work that you forget." (Fleming to Taverner, 22 November 1915, ROM as cited in Cranmer-Byng 1996) raises further questions regarding the adequacy of details recorded. These pieces of information have led experts to hypothesize that Taverner's specimen may have originated from the United States mainland, or have been collected on one of the western Lake Erie islands (J. P. Bogart pers. comm. 2008, F. R. Cook pers. comm. 2008). That this might have occurred is supported by the fact that this is not the only specimen for which Taverner's collection locality has been questioned. Two Dorcas Copper (*Lycaena dorcas*) butterfly specimens in the University of Michigan Museum of Zoology Collection labelled "Point Pelee, July 25, P. A. Taverner" are absent from Taverner's journals, despite the fact that he regularly listed butterflies he encountered at Point Pelee. No other records of the species exist for this locality. As such, it is suspected that the Dorcas Coppers may have originated from Michigan, where Taverner lived and regularly collected (Wormington 1982).

It is also possible that Taverner's specimen may represent a waif, from populations that include pure and hybrid individuals, existing on the nearby Kelleys or the Bass Islands in Ohio, rather than a representative of an Ontarian population (F. R. Cook pers. comm. 2008). King *et al.* (1997) stated "amphibians and reptiles represented by a single observation or specimen from a given island may represent waif or transient individuals, rather than representatives of resident breeding populations." This possibility is given further support by a single, live Timber Rattlesnake (*Crotalus horridus*), recorded at Point Pelee in 1918, where no apparent overwintering habitat is present (Cook 1974). The closest population of this species occurred on South Bass Island (F. R. Cook pers. comm. 2008). Similarly, two Northern Cricket frogs, known from Pelee Island and the Ohio Islands, are the sole representatives of their species from the Point Pelee area (Cook 1974, F. R. Cook pers. comm. to M. J. Oldham 2000). More recently, on September 17, 2007, a live, PIT-tagged[5] Lake Erie Watersnake (*Nerodia sipedon insularum*), that had originally been captured and marked on May 30th of that year on East Point of Middle Bass Island, was captured within Point Pelee National Park (Point Pelee National Park

[5] Passive integrated transponders are used to uniquely identify individuals.

unpublished data 2007). These individuals may all represent waifs that have drifted over to Point Pelee from the western Lake Erie islands (F. R. Cook pers. comm. 2008).

Two specimens, an adult and a transforming juvenile, originally reported to be Spotted Salamanders (*A. maculatum*), were collected on the 6th of June and the 19th of July, 1950 from Pelee Island by A. Reid (ROM 8096[6]) and V. Kohler (ROM 8083), respectively (Froom 1972, M. J. Oldham pers. comm. 2005, R. MacCulloch pers. comm. 2008). These were re-determined, to be Tiger Salamanders by C. A. Campbell, E. J. Crossman[7], and later J. P. Bogart. C. A. Campbell and R. Mitton collected two larvae in 1972 from an ephemeral, flooded (in some years), Red Ash (*Fraxinus pennsylvanica*) woods/Sartwell's Sedge (*Carex sartwellii*) lowland, along Stone Road on Pelee Island (Oldham 1983, M. J. Oldham pers. comms. 2005 and 2008, C. A. Campbell pers. comm. 2008). Gehlbach, a United States authority on Tiger Salamanders, identified these specimens as Tiger Salamanders (M. J. Oldham pers. comms. 2005 and 2008, C. A. Campbell pers. comm. 2008). However, all of the specimens from Pelee Island were identified based on visual characteristics (morphology, colouration, patterning), prior to recognition of the confusing array of hybrid Blue-spotted (*A. laterale*) and Small-mouthed (*A. texanum*) Salamanders present on the island, and the difficulties that such hybridization presents to accurate identification (Bogart *et al.* 1985, M. J. Oldham pers. comm. 2005, F. R. Cook pers. comm. 2008). Both ROM specimens have since been relabeled as *Ambystoma* species due to the uncertainty surrounding their identification (R. MacCulloch, pers. comm. 2005). Individual salamanders collected from the Campbell/Mitton Stone Road collection site on multiple occasions between the early 1980s and early 1990s were genetically determined by J. P. Bogart to be Blue-spotted/Small-mouthed Salamander hybrids (Oldham pers. comm. 2005).

Other Ontario records include a specimen of Gray Tiger Salamander (*A. t. diaboli)*, in the United States National Museum (USNM 13394[8]), noted as "taken at Ottawa 1883 [April 21] by Dr. Robert Bell" (Nash 1908, USNM). However, Dr. Bell, a Geologist for the Geological Survey of Canada in Ottawa, was likely involved in the Geological Surveys' western Canadian fieldwork taking place at the time. It is highly probable that he shipped the specimen from Ottawa, at the end of one of these expeditions, and that the USNM assigned a collection location based on where the specimen had been shipped from, as they occasionally did (F. R. Cook pers. comm. 2008). This theory is supported by the fact that the specimen is identified as a Gray Tiger Salamander, a more western subspecies than the Eastern Tiger Salamander. Similarly, a specimen, labelled *A. conspersum* (a Latin name used in the past for Tiger Salamander), recorded, at one time, in the ROM Collection catalogue and annotated by Dr. J. H. Garnier 1889, was reportedly from Kintail, Ashfield Township, Huron County (C. A. Campbell pers. comm. 2008). However, Garnier (ca. 18--) refers to a specimen of *Siredon canadense* (an unpublished synonym for Gray Tiger Salamander) "Perfected in Bruce, Ontario". F. R. Cook (pers. comm. 2008) suggests that this may refer to a Tiger Salamander kept in captivity at Garnier's residence at Lucknow on Lake Huron, Bruce County until it transformed (and thus "perfected"). As Kintail and Lucknow are very close to each other geographically, it is possible that this specimen was also labelled based on where it had been held in captivity, rather than where it was collected. Unfortunately, this specimen cannot be located within the ROM collection today.

[6] Royal Ontario Museum Collection catalogue number.
[7] Former Curator of Ichthyology and Herpetology, Royal Ontario Museum.
[8] United States National Museum Collection catalogue number.

An unsubstantiated report of Eastern Tiger Salamanders was made on an anonymous note found at Rondeau Provincial Park, indicating that these salamanders were once plentiful there (Campbell 1971, Froom 1972). Based on the commonness of the species suggested in this report, the extent to which Rondeau has been studied (Campbell 1971; Ontario Ministry of Natural Resources 1978; Weller and Oldham 1988; Hecnar and M'Closkey 1996, 1998; Gillingwater 2001; Timmermans *et al.* 2005)**,** and the fact that no other observations of this species exist for Rondeau**,** this report can likely be discounted as a case of misidentification, possibly of the Blue-spotted Salamander which does occur in the park (Timmermans *et al.* 2005, F. R. Cook pers. comm. 2008).

Today, visual identification to the level of a pure species and subspecies is considered inconclusive. Genetic testing is needed to confirm identification and genetic purity (J. P. Bogart pers. comm. to F. R. Cook 2008). As such, none of the above specimens, or any other reports of Tiger Salamander from southwestern Ontario, including Point Pelee and Pelee Island, can be considered confirmed. While Campbell and Mitton's specimens from Pelee Island cannot be considered confirmed at this time (M. J. Oldham pers. comm. 2005), at least one specimen, preserved in alcohol in C. A. Campbell's private collection, still exists which may lend itself to genetic testing in the future (C. A. Campbell pers. comm. 2008).

At the present time, Taverner's specimen is the only record of the Great Lakes population of the Tiger Salamander accepted by COSEWIC (Schock 2001), although it too has not been, and cannot be, genetically tested. This single specimen, and sole, confirmed Canadian observation, does not provide convincing evidence of the presence of a population in the Great Lakes region of Canada.

More significantly, given the intensive studies and electrophoretic work that has been completed, the absence of a Tiger Salamander genetic complement in hybrid mole salamanders on either the Ontario mainland or the Canadian islands of western Lake Erie, and Pelee Island in particular, suggests that Tiger Salamanders are neither present, nor were they likely present in the past (J. P. Bogart pers. comm. 2008).

In extreme southeastern Manitoba, adults and larvae that, in colouration and patterning, appear to be Eastern Tiger Salamanders (i.e. the same subspecies as the Great Lakes population), were collected from the Roseau River, in 1970 (CMNAR 12182, 12198, and 30016, F. R. Cook pers. comm. 2008). Additionally, egg masses collected near Tolstoy, Roseau River, and Stuartburn, in 1985, were raised through metamorphosis, and subsequently identified as Eastern Tiger Salamanders (CMNAR 14: 30975, 29: 30977, and 7: 30981, F. R. Cook pers. comm. 2008, L. A. Lowcock pers. comm. 2008). Several range maps (Conant and Collins 1998, Petranka 1998), likely based on these records, include extreme southeastern Manitoba within the distribution of the Eastern Tiger Salamander. While all Manitoba Tiger Salamanders are currently geographically ascribed, by COSEWIC, to the Prairie/Boreal population (COSEWIC in press), the isozyme[9] and mitochondrial DNA of these salamanders does not appear to be significantly different from the Eastern Tiger Salamanders of Kelleys Island, mainland Ohio, or Indiana (J. P. Bogart pers. comm. 2008). However, their DNA also showed little, to no, differentiation from the DNA of Gray Tiger Salamanders found elsewhere in Manitoba. The Red

[9] Any of the chemically distinct forms of an enzyme that perform the same function.

River, which separates the range of Manitoba's Eastern and Gray Tiger Salamander subspecies, is suspected to form only a partial barrier to gene flow, and intergrade specimens appear to have been found (ROM 18729, F. R. Cook pers. comm. 2008, L. A. Lowcock pers. comm. 2008). Based on the above, the relationship of Manitoba's Eastern Tiger Salamanders to a possible former Great Lakes population, and Gray Tiger Salamanders to the west, remains unclear.

1.4 Needs of the Tiger Salamander (Great Lakes Population)

The Canadian Great Lakes population of the Eastern Tiger Salamander is recognized from a single, ambiguous record that is now more than 90 years old. While the population is now considered extirpated, it is not clear whether a population of Eastern Tiger Salamanders ever actually existed in southwestern Ontario. The specific locality of the collection is not known, and the habitat is not described. Thus, all information on the habitat and biological requirements that follow are hypothesized based on United States populations of the Eastern Tiger Salamander.

1.4.1 Habitat and biological needs

Tiger Salamanders require broad areas of woodland or forest to support terrestrial adults, which spend the majority of their time below the ground. They burrow deeply in loose soil or leaf mould, or live in abandoned mammal runways, often over wintering in these sites. Eastern Tiger Salamanders have also been found under rocks, limestone flakes, piles of debris or manure, in sewers and drains, in cellars, and even in window wells (Pope 1964, Vogt 1981, Bogart *et al.* 1987).

Forested areas must include, or be located adjacent to, fish-free, vegetated ponds or marshes for breeding, with minimal barriers or threats to salamander passage in between (Duellman 1954, Conant and Collins 1991). The breeding ponds are typically deeper than those employed by other mole salamanders, though shallower ponds may be used (Downs 1989). While these ponds do not need to be permanent, they must hold water long enough (at least three to seven months) to allow for mating, egg laying, hatching, and for the larvae to develop and metamorphose.

In early spring (usually between February and April), on rainy nights, as the ground thaws, and nighttime temperatures near 0°C, adult Eastern Tiger Salamanders migrate from over wintering sites to breeding ponds (Sever and Dineen 1978, Vogt 1981, Semlitsch and Pechmann 1985). After mating, a cluster of pigmented eggs is attached to twigs or stems of emergent plants, 30 cm or more below the surface of the water.

At the end of the breeding season, which may vary from year to year, the adults return to the terrestrial portions of the forest (Hassinger *et al.* 1970, Sever and Dineen 1978, Vogt 1981, Semlitsch and Pechmann 1985, Petranka 1998). Once the eggs have hatched, and the larvae have metamorphosed, the juveniles also leave the ponds and migrate to their terrestrial habitat in the forest, though they may still be found at the margins of the pond for some time (Kraus 1985, Bogart *et al.* 1987, Petranka 1998).

Due to their secretive, and largely underground nature, the area required to support a stable population of Eastern Tiger Salamanders is not currently known. In addition, migration distances for the subspecies have not been documented. However, radio telemetry studies of other species of mole salamanders have shown considerable variation in migration distances, from an average of only 35.9 m for the California Tiger Salamander (*A. californiense*) (Loredo *et al.* 1996) to a maximum distance of 213 m for the Spotted Salamander.

Larval and neotenic adult Tiger Salamanders feed on herbivorous zooplankton, amphipods, molluscs, and insect larvae, as well as small frogs and other salamanders (Moore and Strickland 1955, Pope 1964, Dodson and Dodson 1971). Terrestrial juveniles and adults feed on a variety of earthworms, molluscs, insects, including crickets, grasshoppers, moths, flies, beetles, and cicadas, as well as spiders, small field mice, frogs, and other salamanders (Bishop 1941, Pope 1964, Petranka 1998).

1.4.2 Ecological role

Because representatives of the Great Lakes population of the Tiger Salamander have not been seen in Ontario since 1915, and the population is only accepted based on a single, ambiguous record, it may not have been a significant part of the Canadian faunal community for a prolonged period of time, if ever. Given the time since Taverner's collection, and the likelihood, as noted by experts, that a self-sustaining population may never have existed in Canada, the niche of this population may be occupied by other organisms.

Where common, Eastern Tiger Salamanders may be important predators of aquatic and forest floor invertebrates, as well as an opportunistic predator of small vertebrates (see Section 1.4.1). Despite popular belief, they do not seem to be a serious predator of fish fry and fingerlings (Schock 2001). Aquatic forms may be important predators of herbivorous zooplankton, consuming them in such quantities that phytoplankton biomass increases, resulting in a decline in orthophosphate levels in the water (Holomuzki *et al.* 1994). Tiger Salamanders may, themselves, serve as prey for larger predators in the area, such as aquatic vertebrates (especially predaceous fishes) and invertebrates, gartersnakes, and crows (Webb and Roueche 1971, Sprules 1972, Collins and Wilbur 1979, Vogt 1981, Petranka 1998, Larsen 1999).

1.4.3 Limiting factors

Eastern Tiger Salamanders appear to exhibit high site fidelity with respect to the breeding ponds from which they emerge (i.e. they return to same pond year after year). Translocated specimens in Long Island, New York bred in the ponds where they were placed, but seldom returned to them in subsequent years. However, individuals that were not translocated used the same pond across breeding seasons (Madison and Farrand 1998). As such, the species may be limited by the loss of its breeding locations.

1.5 Threats

Threats to the Eastern Tiger Salamander in the Great Lakes region of Canada are not known. As the Great Lakes population is only recognized from the single, ambiguous record of 1915, and confirmed reports have not been documented since, it is impossible to determine the threats that may have faced a population, had one been established in Canada. If a population did exist, the factors that ultimately led to its extirpation can only be surmised. Data from populations of Eastern Tiger Salamander south of the Great Lakes, discussed in Sections 1.5.1 through 1.5.5 below, however, may provide insight into potential threats to this population, past and present, if a population did indeed exist.

1.5.1 Road mortality

In general, road mortality is a significant threat to Tiger Salamanders. Because Tiger Salamanders migrate to and from breeding ponds (Section 1.4.1), they are susceptible where roads separate overwintering sites from breeding ponds (Duellman 1954, Conant and Collins 1991). In Point Pelee National Park, a road stretches approximately 80% of the park's length, separating a portion of the forest from potential breeding areas. This and a few other minor roads were already in place by 1908, when Taverner penned a map of the area (Taverner and Swales 1907 – 1908, Battin and Nelson 1978). At that time, traffic would likely have been considerably less than the volumes experienced today. More recently, researchers and staff at Point Pelee National Park have noted amphibian road mortality events, when weather conditions are optimal for anuran[10] migration (Hecnar and M'Closkey 1995). Elsewhere, amphibian populations have been shown to decrease in size with increasing traffic volume (Fahrig *et al.* 1995). Duellman (1954), while surveying a 3.54 km stretch of highway in Michigan, found 274 Eastern Tiger Salamanders in 30 hours. Of these, only 46 were alive, the remainder having been run over by automobiles.

1.5.2 Agricultural and septic run-off

Run-off of agricultural pesticides and fertilizers, and septic system seepage, also pose threats that have been demonstrated to impact Tiger Salamanders (Power *et al.* 1989). Nitrates, from agricultural fertilizers, cause reduced activity and feeding, as well as increased deformities in frog tadpoles (Hecnar 1995), and are likely to have similar effects on larval Eastern Tiger Salamanders. Rouse *et al.* (1999) evaluated environmental concentrations of nitrates in North American waters. The levels of nitrates were compared to controlled laboratory experiments on amphibian larvae and other species that play an important role in amphibian ecology. The watersheds of Lake Erie and Lake St. Clair, in Canada and the United States, had nitrate levels high enough to cause physical and behavioral abnormalities in some amphibian species, in 19.8% of 8,000 water samples. Disturbingly, 3.1% of the samples had nitrate levels high enough to kill tadpoles of some native species of frogs.

[10] Frogs and toads.

Over 20% of Point Pelee National Park's terrestrial environment was farmed at one time, with DDT, other pesticides, and fertilizers applied to agricultural crops, particularly the orchards. In addition, DDT "Toss-it Bombs" were deposited directly into the marsh, and terrestrial areas of the park were fogged for mosquito control (D. Reive pers. comm. 2008). Because Eastern Tiger Salamanders prey on vertebrates and invertebrates, they are subject to bioamplification of toxins such as DDT, and its breakdown products DDD and DDE. These toxins were found in Spring Peepers (*Pseudacris crucifer*) in Point Pelee National Park in 1993, at levels exceeding the limit for fish, despite discontinuation of DDT use in 1967 (Russell *et al.* 1995). Given the toxicity effects, the extent of agricultural development in the area, and the fact that pesticides can also indirectly impact habitat and food quantity and quality, the risks posed by runoff cannot be dismissed (Bishop 1992).

While septic systems were not of concern in 1915, when the Taverner Tiger Salamander was recorded at Point Pelee, by the late 1950s and early 1960s, the Park had over 350 buildings within its boundaries, many of those being houses and private cottages with septic tanks and weeping beds. While many septic tanks have been pumped out, and either removed or broken down and filled in with sand, and park infrastructure has been replaced, the old weeping beds remain in place, and may still be leaching small amounts of effluent (D. Reive pers. comm. 2008). In the late 1990s, a large plume of effluent in the groundwater around the Marsh Boardwalk/Blue Heron Day Use Area was identified. As a result, the Blue Heron septic system was replaced. However, this plume could continue to have an impact on marsh water quality near the Marsh Boardwalk area for an unknown period of time (D. Reive pers. comm. 2008).

1.5.3 Development and habitat loss

Human disturbances, in the form of development, traffic, wetland conversion to other uses, and land clearing, would likely have impacted any population that existed historically, while traffic would present a threat today (Section 1.5.1). The extensive development of the area north of Point Pelee National Park, with its associated wetland drainage and road construction, has already reduced, if not eliminated, available habitat north of the national park. Only 6% of Essex County, excluding Pelee Island and the city of Windsor, remains in tree cover (Ontario Ministry of Natural Resources 2006). However, Vogt (1981) indicates that urbanization and agricultural activity do not always result in the extirpation of Eastern Tiger Salamanders from an area. Extensive shoreline hardening, along with installation and expansions to the Wheatley Harbour, has resulted in increased erosion along Point Pelee National Park's eastern shore (W. F. Baird & Associates *et al.* 2007). This erosion has narrowed the east barrier beach, to the extent that breaches can occur during periods of high water. The potential for predatory fishes to enter the swamps' vernal pools, should marsh levels peak, render them unsuitable for Eastern Tiger Salamander breeding, at least in some years.

1.5.4 Infectious disease

Infectious disease is also a potential threat to Eastern Tiger Salamanders (Davidson *et al.* 2000, Seburn and Seburn 2000). The iridovirus *Ambystoma tigrinum* Virus (ATV) has been isolated from populations of the Sonoran Tiger Salamander (*A. t. stebbinsi*) in Arizona, and periodically causes mass mortality in populations of this subspecies (Jancovich *et al.* 1997). Chytrid fungus

(*Batrachochytrium sp.*) and another iridovirus, *Ranavirus*, have been implicated in declines or die-offs of Canadian populations of Tiger Salamander (Schock *et al.* 1998, Bollinger *et al.* 1999, Schock 2001). Transfer of iridovirus between salamanders and other organisms may also be possible. In California, sympatric Red-legged Frogs (*Rana aurora*) and Three-spined Sticklebacks *(Gasterosteus aculeatus)* were found to be carrying the same strain of iridovirus, suggesting that fish introduction, and subsequent host switching of the disease from fishes, may also be a threat (Mao *et al.* 1999).

1.5.5 Predation

In addition to being potential disease vectors, various fishes, including native predaceous fishes, are well known predators of Tiger Salamander eggs and larvae (Blair 1951, Carpenter 1953, Collins and Wilbur 1979, Collins 1981, Orchard 1992, Degenhardt *et al.* 1996, Corn *et al.* 1997, Hammerson 1999). Therefore, the presence of predaceous fish in the Tiger Salamander's breeding ponds is considered detrimental to their populations (Blair 1951, Carpenter 1953, Collins and Wilbur 1979, Collins 1981, Orchard 1991, Sarell 1996, Corn *et al.* 1997). The permanent ponds in the Point Pelee National Park marsh are, and probably always have been, occupied by a broad array of fish species (47 species recorded to date), including many that are predatory (Surette and M^{c}Kay 2007). In addition, exotics like the Goldfish (*Carassius auratus*) have become established, likely through introductions by the public. Many, if not all, of the ponds are interconnected, with three prone to breaching, connecting them to Lake Erie during periods of high water. Man-made irrigation canals in the park are also occupied by fishes, as they are connected with the marsh, at least when water levels are high (T. Dobbie pers. comm. 2008). This predator presence in the marsh and man-made canals would likely restrict any Tiger Salamander breeding activity to temporary pools, or sloughs, within Point Pelee National Park's deciduous, swamp forest. However, when Lake Erie water levels were high in the mid-1970s, the barrier beach separating the marsh from Lake Erie breached, and water levels became so high in the marsh that water overtopped the former East Beach Road into the swamp forest, bringing fishes, particularly Bowfin (*Amia calva*), into the sloughs (D. Reive pers. comm. 2008). While this has only been noted on one occasion, in the last 30 or so years, the duration of this flooding lasted a year or two, suggesting that even the sloughs of the swamp forest may not be suitable, in all years, for the breeding activities of Eastern Tiger Salamander.

2. RECOVERY FEASIBILITY

The singularity of the specimen upon which the Great Lakes population is based is of note for several reasons. Dunn (1940) states that, "Unless one has a series of adults from a locality it is difficult to be certain what form is present there. Single specimens may be very misleading." The Point Pelee specimen was identified based on patterning and morphology. The fact that it was preserved in formaldehyde for a period of time precludes genetic confirmation today. Further complicating identification is the propensity of Tiger Salamander to hybridize with other mole salamander species (J. P. Bogart pers. comm. to F. R. Cook 2008). Genetic testing of one of the nearest populations to Point Pelee, located on Kelleys Island approximately 50 km away in the western Lake Erie islands of Ohio, shows hybridization with the Small-mouthed Salamander, with some of the resulting hybrids containing genetic material from the Blue-spotted Salamander

(Bogart *et al.* 1987). Given the potential for Taverner's specimen to be a waif from Kelleys or the one of the Bass Islands, and the fact that difficulties exist in identifying not only the hybrids, but also the pure subspecies, on morphology alone, it can be questioned whether Taverner's specimen was a genetically pure individual (F. R. Cook pers. comm. 2008).

The uncertainty surrounding the existence of an historic, native Great Lakes population of the Tiger Salamander in Canada renders the appropriateness of recovery questionable. Nevertheless, an examination of the feasibility constraints is presented in Sections 2.1 to 2.5 below.

2.1 Availability of Individuals

No self-sustaining population of the Eastern Tiger Salamander, or individuals capable of reproduction, has been confirmed to exist in the presumed historic range (extreme southwestern Ontario) of the Canadian Great Lakes population. Consequently, recovery would necessitate the establishment of a new population in this area. The only genetically confirmed Canadian population of the Eastern Tiger Salamander is found in extreme southeastern Manitoba (L. A. Lowcock pers. comm. 2008). Isozyme and mitochondrial DNA analyses of Eastern Tiger Salamanders from this area did not appear to be significantly different from the Eastern Tiger Salamanders of Kelleys Island, mainland Ohio, or Indiana. However, they also did not appear to differ from another subspecies, the Gray Tiger Salamander, found on the opposite side of the Red River in Manitoba (J. P. Bogart pers. comm. 2008). Bogart speculates that the different colour patterns seem to be adaptive, having recently evolved. As such, the geographic isolation of individuals in southeastern Manitoba, from the reported Great Lakes' specimen, may have resulted in the development of their own environmental adaptations that cannot be easily observed, or tested (J. P. Bogart pers. comm. 2008). COSEWIC currently considers Manitoba's Eastern Tiger Salamanders to be part of a separate designatable unit, the Prairie/Boreal population, based on ecozones rather than subspecies (M. J. Oldham pers. comm. 2008). As such, the southeastern Manitoba Eastern Tiger Salamanders are not currently considered appropriate for recovery of a Great Lakes population (J. P. Bogart pers. comm. 2008, F. R. Cook pers. comm. 2008, L. A. Lowcock pers. comm. 2008).

Recovery, therefore, would require the introduction of individuals from one or more self-sufficient, source populations located outside of Canada. However, the subspecies is considered at risk in much of its range in the United States (Appendix 1). It is unclear if populations on the nearby South and Middle Bass Islands are extant (Downs 1989, King *et al.* 1997, J. P. Bogart pers. comm. 2008). Consequently, populations on these islands could not be considered as appropriate sources. The most appropriate source population would be from Kelleys Island, Ohio due to its proximity, within 50 km, of Point Pelee National Park. However, the Kelleys Island population of pure Eastern Tiger Salamanders may not be large enough to both serve as a source for animals and/or egg masses to be translocated and remain self-sustaining. This is further complicated by the existence of a complex hybridization system on Kelleys Island involving Eastern Tiger, Small-mouthed, and Blue-spotted Salamanders (Kraus 1985, Bogart *et al.* 1987). While populations of pure Eastern Tiger Salamanders are known from nearby mainland Ohio and Michigan, at least some of these are hybrids involving other species of mole salamanders (J. P. Bogart pers. comm. 2008, L. A. Lowcock pers. comm. 2008). This complicates selection of potential source animals due to the need to find pure individuals as hybrids, if introduced,

may "steal" spermatophores[11] from pure Eastern Tiger Salamanders. In addition, these mainland United States populations are still substantially separated from the presumed range of the Canadian Great Lakes population by the lakes themselves. It is not certain that individuals from United States populations would have the same genetic make-up as individuals from Canada might have had, particularly as isolation from United States populations may have resulted in local environmental adaptations, with a suite of unique genetic and ecological characteristics. Such characteristics may not be reflected in introduced animals from the United States. These differences would only be greater the farther away source populations are from southwestern Ontario. Consequently, selection of a source population is problematic.

2.2 Habitat Availability

As previously discussed, neither the collection location of the Point Pelee voucher specimen nor its habitat was recorded. Consequently, and because there are no clearly documented Canadian Eastern Tiger Salamander populations nearby, the habitat requirements in Canada, including the area needed to support a self-sustaining population, are not known. Habitat and ecological requirements may differ from more southerly populations of Eastern Tiger Salamander, and from Canadian populations of the other subspecies of Tiger Salamanders: the Gray Tiger Salamander and Blotched Tiger Salamander (*A. t. melanostictum*). However, as there was no other more fitting alternative, the potential habitat needs of the Great Lakes population of the Tiger Salamander were hypothesized in Section 1.4, based on populations of the Eastern Tiger Salamander in the United States. Based on these assumptions, a discussion of the availability of potentially suitable habitat in the presumed range of the historic population follows.

Selection of recovery sites must be done with careful consideration of both the subspecies' needs and potential threats to survival. For the Eastern Tiger Salamander, the following requirements need to be satisfied: the presence of contiguous forest and relatively unpolluted breeding ponds, that are free of predatory fishes, and that are distant from potential pesticide and fertilizer runoff and roads.

Point Pelee National Park has approximately 325 ha of thicketed, woodland, or forested friable, sandy soil appropriate for Eastern Tiger Salamander burrowing, sheltering, and overwintering. Eastern Moles (*Scalopus aquaticus*) that occur along the southern shoreline of Essex County (Waldron *et al.* 2000), and other small rodents, would provide the necessary tunnels. However, the forested habitat within Point Pelee National Park is split by the main road and several smaller driveways totaling 13.84 km (J. Keitel pers. comm. 2007). Parking lots also occur. As discussed in Section 1.5.1, the network of roadways would pose a mortality risk to salamander migration.

While permanent ponds occur in Point Pelee National Park, these are not fish-free. Permanent water in the man-made irrigation canals also has fishes. The presence of several species of predaceous fishes makes these locations unsuitable for Eastern Tiger Salamander breeding. The lingering pesticide and septic contamination in the marsh compound the problem, as discussed in Section 1.5.2. Together, these factors would be expected to restrict reproductive activity to the

[11] Sperm packets transferred from males to females.

flooded depressions in the park's 13 ha deciduous swamp or slough forest (Dougan & Associates 2007). This forest has a ridge and trough formation, that temporarily holds water in the depressions, or sloughs, between the ridges in the spring. These sloughs remain fishless during most years. However, the barrier beach between Point Pelee National Park's marsh and Lake Erie has been known to breach when water levels are high and/or storms are severe. Such breaches may not have occurred or may have occurred less frequently in the early 1900s, when the beach was much wider along this shoreline. However, the increasing susceptibility of the barrier beach to breaching events, as it narrows due to on-going erosion, combined with cyclical high water levels in Lake Erie, may make the entry of fishes into the sloughs a more regular event. This would suggest that these sloughs may no longer provide long-term breeding habitat suitable for Eastern Tiger Salamanders. In addition, these vernal pools may be too ephemeral to allow larval Tiger Salamanders to develop and metamorphose. With time required for salamanders to pair and mate, a month or more required for egg incubation, followed by another two to five months before metamorphosed salamanders can emerge from the water, the earliest emergence could be expected would be late June. However, Cook (pers. comm. 2008) suggests that transformation in Point Pelee, near the northern edge of the Eastern Tiger Salamander's range, would not likely occur until late July or August. Logier (1925) noted that the many temporary pools should serve, at least in rainy summers, to tide Wood Frogs (*Rana sylvatica*) (also absent from the park), over the larval stage, which usually finished in July. It is unknown if this referred to the sloughs of the swamp forest, or to temporary pools of water elsewhere in the park. Either way, this would suggest that the temporary pools he referred to might not remain wet for a sufficient period of time for Eastern Tiger Salamanders to emerge in some or all years. In the 1990s, the swamp forest sloughs typically dried by late July or early August, although they usually refilled in the fall (T. Dobbie pers. comm. 2008). However, given the droughts of the last half decade or more, even the deepest of the sloughs have dried, or are no more than muddy, by late May or early June (V. M^{c}Kay pers. obs.). Habitat, that would provide sufficient time for Tiger Salamander larvae to fully mature and transform to terrestrial form, is, therefore, currently unavailable, should recovery be proposed.

The area immediately north of the Point Pelee National Park, along with the majority of Essex County, is largely agricultural, and heavily drained. Minimal, patchy, forest cover or appropriate breeding areas exist, with most water found in roadside ditches. Road mortality risks, and associated pollution threats, also render adjacent areas unsuitable for Tiger Salamanders.

These considerations render Point Pelee National Park, and the areas north of it, which encompass the surmised original range of the Canadian Great Lakes population of the Eastern Tiger Salamander, less than suitable in terms of habitat availability.

2.3 Potential to Mitigate Threats to Individuals and Habitat

The potential for significant threats to the Eastern Tiger Salamander or its habitat to be mitigated, or avoided, must also be considered in assessing recovery feasibility. Some threat mitigation may be possible with regards to both road mortality and habitat loss, in terms of the availability of suitable breeding sites. However, these are unlikely to be sufficient to support effective Eastern Tiger Salamander recovery.

Under-road culverts are widely used to reduce road-related mortality for wildlife, including other mole salamanders (Jackson and Tyning 1989, Jackson 1996). Anecdotal evidence exists of at least some use of these structures, but no solid data yet substantiate their effectiveness (J. P. Bogart pers. comm. 2008).

Dredging could potentially improve breeding habitat by deepening the swamp forest sloughs enough to hold water throughout the season. However, this approach may not be viable for long-term management if lake water levels and precipitation continue to decline with regional warming trends. Reinforcement of the east barrier beach might prevent fishes accessing the ponds during periods of high water. While such actions might benefit other amphibian species in the park, modification of natural habitats to benefit one, or a select group of, species would have to be carefully considered, with potential negative impacts to other species and the ecosystem, and corresponding mitigation, addressed in greater detail in a project level environmental assessment under the *Canadian Environmental Assessment Act* (1992, c. 37).

Restoration of habitat bordering the park is also not feasible, without extensive land retirement and long-term habitat restoration estimated in the millions of dollars (W. F. Baird & Associates *et al.* 2007). Such work, if extensive enough, could potentially mitigate the threats presented by development, habitat loss and road mortality. However, past, intensive agricultural use of the land, involving pesticide, herbicide, and fertilizer application, might render restored wetland areas unsuitable for Eastern Tiger Salamander recovery. In addition, it would be highly unlikely that fishes could be excluded from such a restoration site over the long-term. Thus, even large scale, costly restoration activities might not prove effective.

Unfortunately, pesticide and septic contamination are also a legacy of Point Pelee National Park. To date, no feasible methods have been found to effectively remediate these threats. Ongoing shoreline erosion, that threatens the suitability of the swamp forest sloughs as Eastern Tiger Salamander breeding habitat, is also very much the result of past actions. Remediation alternatives have been investigated, and are estimated to cost millions of dollars (W. F. Baird & Associates *et al.* 2007). In addition, while steps can be taken to reduce the chance of introducing infectious disease through translocations, natural occurrences of disease may be unavoidable.

2.4 Existence of Effective Recovery Techniques

Repatriation of the Eastern Tiger Salamander has been executed in Long Island, New York, although with limited success (Lindberg 1988, 1991). Due to breeding site fidelity of Tiger Salamanders, translocation of egg masses, allowing the larvae to catch and develop in the target pond, is preferable to the movement of adult specimens (Enge and Stine 1987). However, egg mortality, under natural conditions, is high. In a study of the natural survival rate of Eastern Tiger Salamander eggs in New Jersey, Anderson *et al.* (1971) found that 96% of the eggs at their three study ponds died, with 100% dying in one pond.

Captive propagation in the lab, with translocation of egg masses, might be an option. However, there are no substantiated records of non-hormonally induced, captive reproduction of terrestrial forms of Eastern Tiger Salamander. Further, this effort would only minimally reduce the number

of animals that would have to be removed from a source population, since the same number of egg masses must still be translocated from the lab to the target site.

Should translocation occur under either scenario, the high rate of egg mortality would remain a major concern. In addition to this, the potential for predation on larvae, and the two to five years required for an Eastern Tiger Salamander to reach sexual maturity would pose significant hurdles to recovery. Consequently, any translocation effort would require a carefully monitored, multi-year plan, and a large source population. Any attempt to establish a viable population would be a costly and difficult task, even if all threats could be sufficiently mitigated.

2.5 Recovery Feasibility Conclusion

Recovery of the Great Lakes population of the Tiger Salamander, if a population ever existed, is considered neither biologically nor technically feasible at present. No self-sustaining population of the Eastern Tiger Salamander has been confirmed to exist in the presumed historic range of the Canadian Great Lakes population, and no adjacent populations are considered appropriate or secure enough to serve as a source of natural immigrants, or translocated individuals. The rarity of the Eastern Tiger Salamander throughout much of its range may render it impossible to recruit sufficient numbers of suitable animals for recovery, without negatively impacting the source population(s). Even then, the disjunct nature of the presumed former range implies genetic differentiation from United States populations. This raises concerns about how well translocated individuals would adapt to a new habitat. In addition, suitable breeding habitat does not appear available, or easily established, and existing terrestrial habitat presents threats of pesticide contamination. Repatriation attempts elsewhere have had limited success, largely due to the breeding site fidelity exhibited by Eastern Tiger Salamanders, and their high rate of egg mortality. Furthermore, given that Tiger Salamanders have been absent from the region for over 90 years, if a population ever existed, other organisms may now fill the ecological niche that they would occupy. Most importantly, however, is that recovery of the Great Lakes population is considered inappropriate at the current time, in light of the uncertainty surrounding the record(s) of the species, putting the very existence of an historic, native Great Lakes population of Tiger Salamanders in Canada in question.

3. CRITICAL HABITAT

3.1 Identification of the Species' Critical Habitat

Critical habitat for the Great Lakes population of the Tiger Salamander in Canada cannot be defined at this time, due to the uncertainty surrounding the existence of this population in Canada, and the lack of habitat and location specificity associated with the only accepted record. This latter fact makes it difficult, if not impossible, to assess the subspecies' and populations' habitat needs in Canada, should individuals, or a population, ever have been present here. In addition, the habitat needs of Eastern Tiger Salamanders in the United States (see Section 1.4.1) may, or may not, apply in Canada.

4. POTENTIAL EFFECTS ON OTHER SPECIES

Another consideration, beyond the biological and technical feasibility of recovery, is that, as a top predator, recovery of the Eastern Tiger Salamander may have significant impacts on another species at risk — the Endangered Small-mouthed Salamander (COSEWIC 2004). In Canada, the Small-mouthed Salamander is currently present, but restricted to Pelee Island. This much smaller salamander would be potential prey for the Eastern Tiger Salamander, were Pelee Island to be selected as a potential recovery site. Notwithstanding, these two species do co-exist on Kelleys Island, Ohio in western Lake Erie (F. R. Cook pers. comm. 2008).

5. CONSERVATION APPROACH

Recovery of the Great Lakes population of the Tiger Salamander in Canada is considered "not feasible", or recommended, at this time, and will not be pursued. Only one individual has ever been accepted as found in Canada, and the origin and purity of that specimen remains in question. As such, convincing evidence that there was ever a population, or individuals capable of reproduction, in this country is lacking. In the event that new information is brought to light that would alter this conclusion, this conservation approach will be reassessed.

It is, however, considered appropriate to attempt to confirm any newly reported observation of a Tiger Salamander in southwestern Ontario. In addition, surveyors conducting field investigations for other species in the presumed historic range should be made aware of the status of the Great Lakes population of the Tiger Salamander. They should be requested to record and report the details of any incidental observation appearing to be this species in a timely fashion as well as to obtain a tail clip for DNA analysis, if possible. Lastly, to rule out the possibility that the 1972 Pelee Island specimen from Stone Road in C. A. Campbell's private collection is different from the Blue-spotted/Small-mouthed Salamander hybrids analyzed from the same collection site since that time, it is recommended that C. A. Campbell's specimen be genetically tested, if permission can be obtained, to confirm its genetic identity.

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APPENDIX 1: SUBNATIONAL RANKS OF THE TIGER SALAMANDER (*A. T. TIGRINUM)*, INCLUDING THE GREAT LAKES POPULATION (NatureServe 2007)

S-Rank*	State/Province
S1	Delaware, Louisiana, Mississippi, Virginia
S1S2	New York
S2	Maryland, New Jersey, North Carolina
S2S3	South Carolina
S3	Alabama, Arkansas, Florida, Ohio
S3S4	Georgia, Michigan
S4	Indiana, Kentucky, Wisconsin
S5	Illinois, Iowa, Tennessee
SH	
SNR	Minnesota, Missouri, Texas
SX	Ontario
SU	

* Each state or province's Conservation Data Centre assigns subnational ranks. They are not legal designations, but reflect the relative rarity of the species within that jurisdiction.

S1 Extremely rare; usually 5 or fewer occurrences in the state/province or very few remaining individuals; often especially vulnerable to extirpation.

S2 Very rare; usually between 5 and 20 occurrences in the state/province or with many individuals in fewer occurrences; often susceptible to extirpation.

S3 Rare; usually between 20 and 100 occurrences in the province; may have fewer occurrences, but large number of individuals in some populations; may be susceptible to large-scale disturbances.

S4 Uncommon; but not rare; some cause for long-term concern due to declines or other factors.

S5 Common; widespread and abundant..

SH Historically known from the state/province, but not verified recently (typically not recorded in the state/province in the last 20 years).

SX Apparently extirpated, with little likelihood of rediscovery. Typically not seen in the state/province for many decades, despite searches at known historic sites.

SU Unrankable. Currently unrankable due to lack of information or due to substantially conflicting information about status or trends

SNR Not ranked.