Species at Risk Act
Recovery Strategy Series
Adopted under Section 44 of SARA

Amended Recovery Strategy for the Small-mouthed Salamander (*Ambystoma texanum*) and the Unisexual Ambystoma, Small-mouthed Salamander dependent population (*Ambystoma laterale - texanum*) in Canada

Small-mouthed Salamander and Unisexual Ambystoma, Small-mouthed Salamander dependent population

2024

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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].

Cover illustration: Small-mouthed Salamander photo from Pelee Island (top) and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) photo from Pelee Island (bottom) by T.J. Hossie.

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[1] www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html

Preamble

Amended Recovery Strategy for the Small-mouthed Salamander (*Ambystoma texanum*) and the Unisexual Ambystoma, Small-mouthed Salamander dependent population *(Ambystoma laterale - texanum*) in Canada

The Recovery Strategy for the Small-mouthed Salamander (*Ambystoma texanum*) in Canada (Environment and Climate Change Canada 2020) was posted as final on the Species at Risk Public Registry in March 2020. Under sections 45, 52 and 70 of the *Species at Risk Act*, the competent minister may at any time amend a recovery strategy, action plan and management plan, respectively. An amendment is necessary now to:

- include one newly listed species, the Unisexual Ambystoma, Small-mouthed Salamander dependent population *(Ambystoma laterale - texanum*); and
- revise critical habitat based on the new listing and new information.

Additional changes were made to align the recovery strategy with current guidelines and templates for recovery documents.

Once this amended document is posted on the Species at Risk Public Registry as final, it will replace the Recovery Strategy for Small-mouthed Salamander (*Ambystoma texanum*) in Canada (2020).

AMENDED RECOVERY STRATEGY FOR THE SMALL-MOUTHED SALAMANDER (*Ambystoma texanum*) AND THE UNISEXUAL AMBYSTOMA, SMALL-MOUTHED SALAMANDER DEPENDENT POPULATION (*Ambystoma laterale-texanum*) IN CANADA

2024

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.

In the spirit of cooperation of the Accord, the Government of Ontario has given permission to the Government of Canada to adopt the *Recovery Strategy for Small-mouthed Salamander (*Ambystoma texanum*) and Unisexual Ambystoma Small-mouthed Salamander dependent population (*Ambystoma laterale - texanum*) in Ontario* (Part 2), and the *Blue Racer, Lake Erie Watersnake and Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population) – Ontario Government Response Statement* (Part 3) under Section 44 of the *Species at Risk Act* (SARA). Environment and Climate Change Canada has included a federal addition (Part 1) which completes the SARA requirements for this federal recovery strategy.

The amended federal recovery strategy for the Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population in Canada consists of three parts:

Part 1 – Federal Addition to the *Recovery Strategy for Small-mouthed Salamander (*Ambystoma texanum*) and Unisexual Ambystoma Small-mouthed Salamander dependent population (*Ambystoma laterale - texanum*) in Ontario*, prepared by Environment and Climate Change Canada.

Part 2 – *Recovery Strategy for Small-mouthed Salamander (*Ambystoma texanum*) and Unisexual Ambystoma Small-mouthed Salamander dependent population (*Ambystoma laterale - texanum*) in Ontario*, prepared by Thomas J. Hossie for the Ontario Ministry of Natural Resources and Forestry, 2018.

Part 3 – *Blue Racer, Lake Erie Watersnake and Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population) – Ontario Government Response Statement,* prepared by the Ontario Ministry of the Environment, Conservation and Parks, 2019.

Table of Contents

Part 1 – Federal Addition to the *Recovery Strategy for Small-mouthed Salamander (*Ambystoma texanum*) and Unisexual Ambystoma Small-mouthed Salamander dependent population (*Ambystoma laterale - texanum*) in Ontario*, prepared by Environment and Climate Change Canada

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 Species at Risk Public Registry.

The Minister of Environment and Climate Change is the competent minister under SARA for the Small-mouthed Salamander and for the Unisexual Ambystoma, Small-mouthed Salamander dependent population and has prepared the federal component of this recovery strategy (Part 1), as per section 37 of SARA. To the extent possible, the federal component has been prepared in cooperation with the Province of Ontario, as per section 39(1) of SARA. SARA section 44 allows the Minister to adopt all or part of an existing plan for a species if it meets the requirements under SARA for content (sub-sections 41(1) or (2)). This federal recovery strategy adopts the *Recovery Strategy for the Small-mouthed Salamander (*Ambystoma texanum*) and the Unisexual Ambystoma Small-mouthed Salamander dependent population (*Ambystoma laterale-texanum*) in Ontario,* prepared by Thomas J. Hossie for the Ontario Ministry of Natural Resources and Forestry in 2018, in cooperation with Environment and Climate Change Canada (Part 2). This federal recovery strategy also adopts applicable portions of the multi-species Ontario Government Response Statement (GRS) for Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander and the Unisexual Ambystoma (Small-mouthed Salamander dependent population) prepared by the Ministry of the Environment, Conservation and Parks in 2019 (Part 3). The GRS is the Ontario Government's policy response to the provincial recovery strategy that outlines the provincial government's goal for the recovery of the species and summarizes the prioritized actions that it intends to take and support.

Given that the province does not publish French versions of provincial recovery strategies, translation of these provincial documents is attributed to Environment and Climate Change Canada.

This document constitutes the federal recovery strategy required under SARA for two species, the Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population[3].

[2] www.canada.ca/en/environment-climate-change/services/species-risk-act-accord-funding.html#2
[3] COSEWIC uses the term 'population' to refer to the total number of mature individuals of a taxon found in Canada (COSEWIC 2021b).

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 and Climate Change Canada, or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of the Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population, 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 and Climate Change Canada and other jurisdictions and/or organizations involved in the 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 these species, including identification of critical habitat to the extent possible. It provides all Canadians with information to help take action on species conservation. When critical habitat is identified, either in a recovery strategy or an action plan, SARA requires that critical habitat then be protected.

In the case of critical habitat identified for terrestrial species including migratory birds SARA requires that critical habitat identified in a federally protected area[4] be described in the *Canada Gazette* within 90 days after the recovery strategy or action plan that identified the critical habitat is included in the public registry. A prohibition against destruction of critical habitat under ss. 58(1) will apply 90 days after the description of the critical habitat is published in the *Canada Gazette*.

For critical habitat located on other federal lands, the competent minister must either make a statement on existing legal protection or make an order so that the prohibition against destruction of critical habitat applies.

If the critical habitat for a migratory bird is not within a federally protected area and is not on federal land, within the exclusive economic zone or on the continental shelf of Canada, the prohibition against destruction can only apply to those portions of the critical habitat that are habitat to which the *Migratory Birds Convention Act, 1994* applies as per SARA ss. 58(5.1) and ss. 58(5.2).

For any part of critical habitat located on non-federal lands, if the competent minister forms the opinion that any portion of critical habitat is not protected by provisions in or measures under SARA or other Acts of Parliament, or the laws of the province or

[4] These federally protected areas are: a national park of Canada named and described in Schedule 1 to the *Canada National Parks Act*, The Rouge National Park established by the *Rouge National Urban Park Act*, a marine protected area under the *Oceans Act*, a migratory bird sanctuary under the *Migratory Birds Convention Act, 1994* or a national wildlife area under the *Canada Wildlife Act,* see ss. 58(2) of SARA.

territory, SARA requires that the Minister recommend that the Governor in Council make an order to prohibit destruction of critical habitat. The discretion to protect critical habitat on non-federal lands that is not otherwise protected rests with the Governor in Council.

Acknowledgments

This recovery strategy was prepared by Karolyne Pickett (Environment and Climate Change Canada, Canadian Wildlife Service (ECCC-CWS)–Ontario Region), with the assistance of Jennifer Thompson and Marie-Claude Archambault (ECCC-CWS–Ontario Region). This recovery strategy benefited from information provided in the Recovery Strategy for Small-mouthed Salamander (2020) prepared by John Brett (ECCC-CWS–Ontario Region), and from input, review, and suggestions from the following individuals and organizations: Krista Holmes (ECCC-CWS–Ontario Region), Praveen Jayarajan, April Patmanathan and Lee Voisin (ECCC-CWS–National Capital Region), the Ontario Ministry of the Environment, Conservation and Parks, the Natural Heritage Information Centre (Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry), and Dr. Thomas J. Hossie (Trent University).

Acknowledgement and thanks is given to all other parties that provided comments and input to help inform the development of this recovery strategy.

Additions and Modifications to the Adopted Document

The following sections have been included to address specific requirements of the federal *Species at Risk Act* (SARA) that are not addressed in the *Recovery Strategy for the Small-mouthed Salamander (*Ambystoma texanum*) and the Unisexual Ambystoma Small-mouthed Salamander dependent population (*Ambystoma laterale - texanum*) in Ontario* (Part 2 of this document, referred to henceforth as “the provincial recovery strategy”) and to provide updated or additional information.

Environment and Climate Change Canada (ECCC) is adopting the provincial recovery strategy, with the exception of section 2.0, Recovery. In place of section 2.0, ECCC has established population and distribution objectives and performance indicators, and is adopting the province of Ontario’s government-led and government-supported actions listed in the *Blue Racer, Lake Erie Watersnake and Small-mouthed Salamander and the Unisexual Ambystoma (Small-mouthed Salamander dependent population) – Ontario Government Response Statement* (GRS) (Part 3) as the broad strategies and general approaches to meet the population and distribution objectives. Only those portions of the GRS pertaining to the Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population, are adopted in this recovery strategy.

Under SARA, there are specific requirements and processes set out regarding the protection of critical habitat. Therefore, statements in the provincial recovery strategy and Government Response Statement referring to protection of the species’ habitat may not directly correspond to federal requirements. Recovery measures dealing with the protection of habitat are adopted; however, whether these measures will result in protection of critical habitat under SARA will be assessed following publication of the final federal recovery strategy.

Recovery Feasibility Summary

Based on the following three criteria[5] that Environment and Climate Change Canada uses to establish recovery feasibility, recovery of the Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population is considered technically and biologically feasible.

(1) Survival characteristics: Can survival characteristics[6] be addressed to the extent that the species' risk of extinction or extirpation as a result of human activity is reduced?

Yes. There are two survival characteristics of the Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population that need to be addressed in order to reduce their risk of extirpation as a result of human activity: redundancy[7] and connectivity[8]. As applicable to the species, redundancy refers to the number of available breeding sites (defined under section 3.1 of this federal addition). The recent finding that both species have successfully reproduced in constructed breeding sites on Pelee Island (Ward and Hossie 2020) confirms that redundancy can be addressed (the number of available breeding sites can be effectively increased). As applicable to the species, connectivity refers to the ability of individual salamanders to reach a breeding site other than the one in which they were born. These so-called dispersal events are infrequent but necessary to allow long-term persistence of both species at a given breeding site (see explanation under section 5 of this federal addition). It is believed that connectivity can be addressed because the measures required to facilitate dispersal involve known techniques such as habitat rehabilitation (e.g., planting of native vegetation) and establishment of corridors (e.g. road exclusion fencing in combination with construction of road under-passes) in areas located between breeding sites such that salamander ambulation (travel) is physically possible.

(2) Independence: Is the species currently able to persist in Canada independent of deliberate human interventions, and/or will it eventually be able to achieve and maintain independence in the state where condition (1) is met (i.e., after key survival characteristics are addressed), such that it is not reliant on significant, direct, ongoing human intervention?

[5] Recovery is considered technically and biologically feasible if the species can meet the criteria for survival, improvement, and non-reliance on human intervention (Government of Canada 2020).
[6]Survival characteristics consist of stability, resilience, redundancy, connectivity, and non-vulnerability to human-caused threats (Government of Canada 2020).
[7] Redundancy refers to the the degree to which the species is widespread.
[8] Connectivity refers to continuity in species distribution, or its facility to recolonize an area from which it was extirpated. It may refer to the continuity in distribution between subpopulations or locations, as relevant to the species' circumstance in Canada (ECCC 2022). This federal addition considers the continuity between breeding sites (rather than subpopulations) as the most relevant metric for addressing connectivity for both species.

Yes, both species currently persist in Canada independent of direct human interventions[9], and will be able to maintain independence as long as key survival characteristics are addressed. The species' naturally limited distribution in Canada and consequent low abundance, in combination with the magnitude of wetland and forest loss that occurred historically on Pelee Island, have resulted in suitable habitat patches that are small and isolated from one another (Smith 2022). In the short-term (over the next ten years), indirect human intervention in the form of habitat management activities will need to continue in order to address the key survival characteristics discussed above. Examples of human interventions that will be required to address the historical loss of habitat include the creation of wetlands (in order to increase the amount of breeding sites), restoration of terrestrial habitat (to improve the extent and quality of habitat used for foraging, hibernation, and migration; restoration of dispersal habitat to connect extant breeding sites; and, reduction of larval, juvenile and adult mortality (by mitigating threats) (see section 6 of this federal addition). Successful implementation of these interventions will require continued co-operation amongst all levels of government, nature conservation organizations and residents of Pelee Island.

(3) Improvement: Can the species' condition be improved over when it was assessed at risk?

Yes. The condition of a species refers to the combination of factors that contribute to a species' risk of extinction or extirpation (Government of Canada 2020). Given that the Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population are not known to have ever occurred elsewhere in Canada other than on Pelee Island, Ontario, which has a small surface area (43 km^2), the natural condition of both species in Canada can be characterized as one with limited distribution and low abundance. Although the historical range and extent of occupied habitat for both species are naturally well below the threshold for Endangered status (extent of occurrence (EOO) <5,000 km^2 and index of area of occupancy (IAO) <500 km^2, COSEWIC 2021a), their current condition nevertheless represents a deterioration of their natural condition. However, the condition of both species can be improved by implementing the human interventions (recovery actions) described under section 6 and protecting the critical habitat described under section 7 of this federal addition. Though both species may retain a high natural risk of extirpation, even after the significant impacts of human activities have been successfully addressed, it is expected that redundancy and connectivity for both species can be improved through collaboration between the Township of Pelee, private landowners and nature conservation organizations to continue to work together to implement recovery actions and habitat conservation measures that improve the condition of both species.

[9] Significant, direct, and ongoing human interventions include those that are implemented to directly moderate the natural regeneration or mortality of individuals, for example supplementary feeding, vaccinating, captive breeding, augmentation, predator control, population guarding, and/or the need to deliberately create or maintain specific anthropogenic structures (ECCC 2022).

1. COSEWIC* Species Assessment Information

Assessment Summary - May 2014

Common Name:
Small-mouthed Salamander

Scientific Name:
Ambystoma texanum

COSEWIC Status:
Endangered

Reason for Designation:
The Canadian distribution of this salamander is restricted solely to Pelee Island. The entire Canadian range is only about 40 km^2, and only three breeding sites are known. Although this species was first assessed as Endangered 10 years ago, there is little new information and new threats exist for this salamander. The continued existence of the population is precarious because of habitat degradation of wetland breeding sites. Predation and habitat destruction by recently introduced Wild Turkeys is a new threat to the existence of salamanders on Pelee Island.

Canadian Occurrence:
Ontario

COSEWIC Status History:

Designated Special Concern in April 1991. Status re-examined and designated Endangered in May 2004 and May 2014.

* COSEWIC: Committee on the Status of Endangered Wildlife in Canada

Assessment Summary - May 2016

Common Name:
Unisexual *Ambystoma* - Small-mouthed Salamander dependent population

Scientific Name:
Ambystoma laterale

COSEWIC Status:
Endangered

Reason for Designation:
These unusual unisexual salamanders exist only on one isolated island in Canada (Pelee Island in Lake Erie) and depend on an endangered sperm donor species, Small-mouthed Salamander (*Ambystoma texanum*), for recruitment. The salamander faces numerous threats that make its continued existence precarious. These include predation and habitat modification by introduced wild turkeys, drainage activities that can cause premature drying of breeding ponds, road mortality during seasonal migrations, urban development, and recreational activities.

Canadian Occurrence:
Ontario

COSEWIC Status History:

Designated Endangered in April 2016.

2. Species Status Information

The Small-mouthed Salamander occurs in Canada and the U.S. The Canadian population likely represents less than 1% of the species' global range (COSEWIC 2004). Its global status was last reviewed in 2015 and was ranked Secure (G5) (NatureServe 2021). At the national scale, it is ranked as Critically Imperiled (N1) in Canada and Secure (N5) in the United States. At the sub-national level, it is ranked as Critically Imperiled (S1) in Ontario, and Critically Imperiled to Secure across its range in the United States (Appendix A).

The Unisexual Ambystoma, Small-mouthed Salamander dependent population, referred to henceforth as the "dependent Unisexual", also occurs in both countries. The size of the global population is not known (Hossie 2018[10]). However it was assigned a global status of 'Not applicable' because NatureServe[11] does not identify the dependent

[10] Hossie 2018 is the citation for the adopted document (the "provincial recovery strategy").
[11] https://www.natureserve.org/our-work

Unisexual as a separate species or population on U.S. territory (NatureServe 2021). In Canada, it is ranked as Critically Imperiled at both the national (N1) and provincial level (S1 in Ontario).

The Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population were listed as Endangered[12] on Schedule 1 of SARA in July 2005 and August 2021, respectively. Both species are also listed as Endangered[13] under the Ontario *Endangered Species Act, 2007* (ESA).

3. Species Information

3.1 Species Population and Distribution

Number of breeding sites

Small-mouthed Salamanders and dependent Unisexuals emerge from hibernation in early spring and migrate to wetlands[14] where they breed over the span of a few days (see the provincial recovery strategy for more detail). Following this brief reproductive season, adults emerge from the wetlands and remain in the surrounding forests to forage before returning to their hibernation sites in autumn. Given their life cycle, it is useful for conservation planning purposes to enumerate the number of wetlands known to be used for breeding by these species; these are henceforth defined as “breeding sites”[15] in this federal addition. Known breeding sites on Pelee Island consist of discrete, permanent ponds that hold water year-round, except for two breeding sites which consist of swamps. In the case of the latter, the location of the specific depressions that hold water sufficiently long to allow successful larval development may vary from year to year, according to climatic conditions.

The number of reported breeding sites for these species in Canada has varied over the years as genetic studies began to shed light on the genotype of salamander samples collected, and as more surveys were undertaken. Interpreting various enumerations of breeding sites in past reports (Bogart and Licht 1991, 2004; Hamill 2015; COSEWIC 2016; Hossie 2018) is complicated by the past use of various terms when referring to wetlands used for breeding by the salamanders (e.g., “pond”, “site”, “area”, “locality” and “location”). The term ‘area’ has been used in these reports to describe a variety of geographical and ecological entities, however consistent with the provincial recovery

[12] A species facing imminent extinction or extirpation.
[13] A species that is native to the wild in Ontario but is facing imminent extinction or extirpation.
[14] These wetlands include swamps (areas dominated by tree or tall shrub cover where the water table is at or below the substrate surface) and shallow open water wetlands, also called ponds or sloughs (NWWG 1997).
[15] This federal addition enumerates ‘breeding sites’ as a substitute for ‘subpopulations’ due to remaining knowledge gaps regarding the dispersal rate and dispersal distance of Small-mouthed Salamander and dependent Unisexual. In other words, there are uncertainties as to whether single breeding sites, or groupings of breeding sites, constitute subpopulations as defined by COSEWIC.

strategy, an ‘area’ in this federal addition refers to a grouping of breeding sites that are separated by less than 1 km. When breeding sites are lumped together in this manner, it creates a total of six geographical areas that are used by salamanders for reproduction: three within the eastern half of the Island and three within the western half.

This federal addition provides an up-to-date enumeration of breeding sites for each species, by reconciling previously reported species observations and by including breeding sites that have been documented since the publication of the provincial recovery strategy in 2018.

In the spring of 2019, Small-mouthed Salamanders and/or dependent Unisexuals were detected in 15 breeding sites on Pelee Island; seven of these sites were natural, and eight of these sites were ponds constructed for the purposes of nature conservation (Ward and Hossie 2020). Additional breeding sites were found during the 2021 field season, bringing the total minimum number of breeding sites used by Small-mouthed Salamanders on Pelee Island to 17 (Hossie, unpub. data). Dependent Unisexuals only were detected in an additional five breeding sites, bringing the minimum[16] number of breeding sites used by dependent Unisexuals to 22 (Hossie, unpub. data).

Population size

In their respective status reports, the population size (N) of the Small-mouthed Salamander, and that of the dependent Unisexuals, was deemed unknown but likely to each consist of less than 1,000 mature individuals (COSEWIC 2004, 2016). New empirical evidence gathered on Pelee Island from 2015 to 2022 has begun to address this knowledge gap.

- Proportion of Small-mouthed Salamander to dependent Unisexual

Over an 8-year period, Bare et al. (2023) collected tissue samples from juvenile and adult salamanders from a total of 10 breeding sites on Pelee Island. Of the 2,646 unique samples collected, 151 (5.7%) were identified as Small-mouthed Salamander and 2,493 (94.2%) were dependent Unisexuals. This ratio is consistent with results reported by Hossie and Murray (2017), who estimated that 95% of salamander individuals on Pelee Island are dependent Unisexuals.

[16] These totals do not include one breeding site that has not been surveyed since 1991.

- Subpopulation size

In 2018 and 2019, Hossie and Murray (2020) sampled a subset of breeding sites on Pelee Island to determine the abundance of adult salamanders at the site level. Capture rates were sufficient to generate adult salamander abundance estimates (both species combined) for the year 2019 for three of the twelve breeding sites sampled. Using these data, the authors also derived adult Small-mouthed Salamanders abundance estimates for each of the three sites, based on the proportion of Small-mouthed Salamander to dependent Unisexuals found at each. The average total salamander abundance, and Small-mouthed Salamander abundance averaged: for the first site, 933 and 27; for the second site,1076 and 115; and for the third site, 1440 and 5-10[17], respectively.

- Calculated estimates of population size

It is possible to estimate the abundance of each species by extrapolating the above subpopulation size estimates to the population as a whole, based on the known number of salamander breeding sites on Pelee Island and assuming that 95% of salamanders are dependent Unisexuals (but see caveats below).

Given that all breeding sites on the Island, except for one, are smaller than the 'second site' referred to above (Hossie and Murray 2020), the salamander abundance estimate for the 'second site' is not likely representative of the vast majority of salamander breeding sites. This assumption is supported by the fact that abundance estimates could only be calculated for three breeding sites due to low to nil capture rates in other sampled sites (Hossie and Murray 2020). Given the uncertainties associated with the Small-mouthed Salamander abundance estimate for the 'third site' (see footnote 16), it is reasonable to use the estimates from the 'first site' to extrapolate to other breeding sites. When applying the abundance estimates from the 'first site' to all but the two largest breeding sites, (14 sites for Small-mouthed Salamander and 19 sites for dependent Unisexuals), population size totals 618 Small-mouthed Salamander adults[18], and 20,576 dependent Unisexual adults[19]. The latter estimate is one order of magnitude greater than any figure hypothesized thus far and therefore likely inaccurate.

Alternatively, population size estimates for both species can be derived from data collected on other *Ambystoma* species in the U.S. For example, the estimated number of breeders per generation (N_e)[20] reported in the scientific literature ranges from 30 to

[17] This estimate range is highly uncertain given the very low prevalence (approx. 0.3%) of Small-mouthed Salamander at this site (Hossie and Murray 2020). The authors calculated an abundance of 30 adults, but suggest that abundance is likely 5-10 adults Small-mouthed Salamanders at this site.
[18] ((27 adults x 14 sites) + (115 adults x 2 sites) + 10 individuals for the 'third site') = 618 Small-mouthed Salamander adults.
[19] ((906 adults x 19 sites) + (961 adults x 2 sites) + 1440 individuals for the 'third site' +) = 20,576 dependent Unisexual adults.
[20] N_e: Effective population size. N_e represents the number of individuals that breed in the span of one generation. It is a parameter used by ecologists to estimate pond-breeding salamander population size within the specified timeframe.

123 individuals, depending on the salamander species (Funk et al. 1999; Savage et al. 2010; Wang et al. 2011). When applying an N_e/N ratio correction factor[21] to the above range of N_e values, and assuming an abundance ratio of 5 Small-mouthed Salamander: 95 dependent Unisexual (see above), the resulting estimate for the number of adults per breeding site ranges from 1 to 20 for Small-mouthed Salamander and 17 to 390 for dependent Unisexuals[22]. Based on this range of subpopulation size, total abundance of mature individuals in Ontario would range from 17 to 340 for Small-mouthed Salamanders and from 374 to 8,580 for dependent Unisexuals.

A significant limitation to both methodologies above is that the likely positive correlation between the size of a breeding site and salamanders' effective population size is not taken into account (Wang et al. 2011). This highlights the importance of measuring breeding site area (size) if abundance data collected from a subset of breeding sites is to be used to generate total population size estimates.

Clearly, a robust estimate of population size based on additional empirical evidence remains a knowledge gap. However, the estimates derived under both above methodologies suggest that Small-mouthed Salamander abundance is likely less than 250 mature individuals in any breeding site, and the total population likely comprises less than 1,000 mature individuals. With respect to the total population of dependent Unisexuals, the estimates derived under both methodologies as well as results from Bare et al. (2023) and Hossie and Murray (2020) indicate that it likely comprises more than 2,500 mature individuals.

3.2 Habitat

New information on the habitat needs of Small-mouthed Salamander and dependent Unisexuals has become available since the publication of the provincial recovery strategy. The new information does not warrant additional recovery measures to those being adopted under section 6 of this federal addition, but rather provides robust justification for the continuation of activities aimed at increasing the amount of breeding habitat on Pelee Island.

As a result of extensive habitat restoration and wetland creation activities undertaken by the Nature Conservancy of Canada on former agricultural land (NCC 2020), there is now empirical evidence confirming that Small-mouthed Salamander and dependent Unisexuals are breeding in constructed ponds on Pelee Island (Ward and Hossie 2020). The authors captured *Ambystoma* larvae in 15 of 32 ponds sampled; eight of those ponds have been constructed for the purposes of habitat stewardship/species at risk recovery. The other seven ponds, categorized as "natural" ponds, include two abandoned livestock ponds that have been left to naturalize for more than 50 years. The

[21] A correction factor must be applied to estimates of N_e in order to derive estimates of N (actual number of sexually mature individuals in a wild population), because N_e is usually different (typically smaller) than N. According to Waples et al. (2013), N_e/N ranged from 0.3 to 1.7 across seven amphibian species.
[22] Lowest values obtained if N_e=30 and N_e/N=1.7; Highest value obtained if N_e=123 and N_e/N=0.3

results are consistent with findings of successful colonization of restored wetlands by Small-mouthed Salamanders in a reclaimed open-pit coal mine in Indiana (Stiles et al. 2017), and in a floodplain previously under agricultural use in Illinois (Bookout and Bruland 2019).

The above studies also yield useful information on the characteristics of constructed ponds that have provided successful breeding habitat for Small-mouthed Salamanders. On Pelee Island, constructed ponds with *Ambystoma* larvae have a surface area of at least 1,875 m^2, a maximum depth of 2 m, leaf litter on the bottom, and are located within about 100 m of a forest edge (Ward and Hossie 2020). In a study of temporary ponds in Illinois, the pond from which the most number of Small-mouthed Salamander juveniles emerged also had the highest amount of litter input per pond area and highest canopy cover (Fritz and Whiles 2021). The restored ponds in the Indiana study had varying hydroperiods and were located within 3 km of source populations; furthermore, adjacent upland areas were seeded with herbaceous cover (Stiles et al. 2017). Similarly, successful restored wetlands in the Illinois floodplain study were constructed to different depths thus providing a variety of hydroperiods; they were planted with emergent and woody seedlings and were also located near already occupied breeding ponds (Bookout and Bruland 2019).

The age of the constructed ponds on Pelee Island is correlated with salamander habitat quality, and may thus be a more important factor than their origin in terms of whether or not they become successful salamander breeding sites (Hossie unpub. data). The age of constructed ponds in other studies however varies widely: restored wetlands studied by Stiles et al. (2017) were between 11 and 27 years old, constructed ponds in Drayer et al. (2020) were between 1 and 15 years old, and Bookout and Bruland (2019) detected salamanders within 3 years of the start of wetland restoration activities.

4. Threats

4.1 Description of Threats

This federal addition provides updated information on the threats to Small-mouthed Salamander and dependent Unisexuals that are described in section 1.6 of the provincial recovery strategy (Part 2), as well as new information on emerging threats for which the current impact is unknown. The new information does not warrant adjusting the impact ranking of threats provided in COSEWIC (2016), however it reveals new knowledge gaps that can be addressed under the recovery measures being adopted under section 6 of this federal addition.

The provincial recovery strategy identifies the following as threats to the species: habitat alteration, loss and fragmentation; road mortality; Wild Turkey predation and habitat modification; emerging pathogens; fish introduction; invasive species; pollution; and climate change. The corresponding threat categories as identified under the

International Union for Conservation of Nature (IUCN) and the Conservation Measures Partnership unified threats classification system (Version 2.0) have been added in parentheses after each threat sub-heading.

Habitat alteration, loss and fragmentation
(IUCN Threat 1.1 Housing & urban areas; Threat 2.1 Annual & perennial non-timber crops; Threat 7.2 Dams & water management/use)

In the provincial recovery strategy, habitat alteration, loss and fragmentation encompasses activities that convert land to residential and agricultural uses, in addition to drainage activities.

Historically, an extremely large proportion of wetland cover on Pelee Island was converted to agricultural land. However, further habitat loss and fragmentation from expansion of agricultural fields, or residential development, is not a significant threat at this time (COSEWIC 2016). Known breeding sites are located either within nature reserves or on private land where they are maintained in cooperation with the landowners for the purposes of nature conservation (Hossie pers. comm. 2021). Furthermore, the Township of Pelee does not permit development or site alteration in the habitat of endangered and threatened species, and development in adjacent lands must demonstrate no negative impacts to the habitat or its ecological functions (Township of Pelee 2011).

Habitat alteration and loss due to drainage activities however continue to pose a significant threat to the species. The Township of Pelee’s asset management plan indicates that, based on age, the island’s drainage system will need replacement starting in the late 2040s and peak in the early 2060s (PSD Inc. 2019). Although these infrastructure works are not anticipated to result in additional land being incorporated into the drainage system (Rood Engineering Inc. 2018), there is potential for the undertaking to indirectly alter the water regime of the species’ habitat. More specifically, improved drainage of agricultural fields on the Island may lower water levels within the breeding sites and decrease soil moisture in adjacent terrestrial habitat, in turn altering the surrounding forest community.

Wild Turkey predation and habitat modification
(IUCN Threat 8.1 Invasive non-native/alien species)

Predation and modification of micro-habitat by Wild Turkeys (*Meleagris gallopavo*) were included in the provincial recovery strategy as potential but poorly understood threats. At the time of its publication, it was unknown whether the turkeys on Pelee Island consumed salamanders. A recent study has since found evidence that salamanders on Pelee Island are exposed to the risk of predation from Wild Turkeys (Myette et al. 2019). Of 1600 model salamanders deployed on Pelee Island as part of the study, 18% were attacked by Wild Turkey, a higher predation rate than that of mammalian or passerine predators. Leaf litter depth was found to reduce the risk of turkey attack on the models, suggesting that processes that reduce leaf litter depth (such as reduced canopy cover) could increase predation risk. Warming temperatures due to climate change may also reduce survival from predation attempts, as defensive posturing in salamanders lessens at higher temperatures (Myette et al. 2019).

Emerging pathogens
(IUCN Threat 8.4 Pathogens & microbes)

Ranaviruses and chytrid fungi are pathogens that have caused mortalities in various amphibian species across North America (Green et al. 2002; Duffus et al. 2015). A recent Illinois study has confirmed that Small-mouthed Salamander and Unisexual Ambystoma are susceptible to local ranavirus (Low et al. 2019); it is therefore likely that the Pelee Island population would be similarly susceptible. Ranavirus has not been detected on Pelee Island, but has been detected elsewhere in Ontario both as environmental DNA (eDNA; Torres Vilaca et al. 2019) and in confirmed disease cases (Brunner et al. 2021). Confirmed cases have additionally been documented in the states of Ohio and Pennsylvania, which also border the shores of Lake Erie.

Batrachochytrium salamandrivorans (Bsal), a salamander-specific chytrid fungus native to Asia, has become widespread in the European salamander trade (Fitzpatrick et al. 2018; Sabino-Pinto et al. 2018). While some ambystomatid salamanders[23] exhibit resistance to chytrid fungi (Pereira and Woodley 2021), Bsal infection can still elicit stress response and hinder growth (Barnhart et al. 2020). Though it has yet to be detected in North America (both in the wild and in the pet trade; Klocke et al. 2017), southern Ontario is at moderate to high risk of Bsal introduction based on temperature suitability modelling (Carter et al. 2021; Crawshaw et al. 2022).

Finally, a single-cell parasite of the genus *Dermotheca* that causes skin lesions in Small-Mouth Salamanders has been reported by Adamovicz et al. (2020) in Illinois. This parasite is only known to occur in Illinois at this time.

Pathogen introduction on Pelee Island remains a possibility via visitor contamination or the global amphibian pet trade. In response to this threat, the federal government

[23] Salamanders belonging to the genus *Ambystoma*.

amended the Wild Animal and Plant Trade Regulations in May 2018 to prohibit the import of all species of the order Caudata[24] unless authorized by a permit issued by Environment and Climate Change Canada.

Invasive species
(IUCN Threat 8.1 Invasive non-native/alien species)

The provincial recovery strategy discusses two invasive species introduced to Pelee Island that have the potential to negatively affect Small-mouthed Salamander and dependent Unisexuals: the European Reed (*Phragmites australis* ssp. *australis*) and the Emerald Ash Borer (*Agrilus planipennis*). The following provides an update on the status of these species on Pelee Island, and also discusses the potential threat from Amur Honeysuckle (*Lonicera maackii*) and White River Crayfish (*Procambarus acutus*).

European Reed
European Reed is a very tall non-native grass that grows in dense stands on the edges of wetlands and other shallow aquatic habitat. The provincial recovery strategy reported that European Reed was not present at any of the breeding sites at the time of publication. However recent mapping of European Reed occurrences on Pelee Island indicates that it is present within or in close proximity to all of the breeding sites except for those in the south-east corner of the Island (NCC 2020). As such, the potential for European Reed to colonize salamander breeding sites on Pelee Island has likely increased. Although the effects of European Reed on salamanders are not well understood, it is assumed to be a threat due to its ability to displace native vegetation growing along wetland edges (Nichols 2020). Whether European Reed is having an actual impact on Pelee Island salamanders is unknown at this time.

Emerald Ash Borer
The Emerald Ash Borer (EAB) is a non-native beetle that feeds on the leaves of Ash trees (*Fraxinus* sp.) to such an extent that it leads to the death of the trees. As reported in the provincial recovery strategy, EAB is present on Pelee Island and is predicted to negatively affect salamanders by reducing canopy cover (a closed tree canopy appears to improve the quality of salamander breeding habitat (see section 3.2 above), and by decreasing leaf litter depth, which appears to increase predation risk (Myette et al. 2019). Youngquist et al. (2017) discuss the possible consequences of Black Ash tree defoliation and death on wetland amphibian communities, highlighting possible impacts to wetland hydroperiod, canopy cover and litter input. The impact on Small-mouthed Salamanders and dependent Unisexuals of ash tree defoliation by EAB are likely to be scenario-dependent and determined by site-specific conditions.

[24] Taxonomic order of amphibians that includes salamanders, newts and mudpuppies.

Amur Honeysuckle

Amur Honeysuckle is a non-native, shade tolerant shrub that can grow up to 6 m tall. It has been reported in the south-east corner of Pelee Island (EDDMapS 2021, NCC 2020). Because the plant can grow in a variety of habitats including disturbed forests, thickets and grasslands (Tassie and Sherman 2014), it could become established in the terrestrial portion of salamander habitat, especially where breeding sites are located within open canopy cover habitat. Despite evidence of negative impacts on wetland food webs and frog larval development (Robison et al. 2021), effects of Amur Honeysuckle on salamanders themselves remain unclear. For example, in a U.S. study, exposure to Amur Honeysuckle did not reduce larval survival of Spotted Salamander larvae (Watling et a. 2011a), but plots with a high density of the shrub had lower amphibian species richness and evenness, and an absence of Small-mouthed Salamanders (Watling et al. 2011b). Whether the plant is having an impact on Pelee Island salamanders is unknown at this time.

White River Crayfish

The White River Crayfish is a freshwater crustacean native to the eastern U.S. (NatureServe 2023) that predates eggs and larvae of various amphibian species (e.g., Figiel and Semlitsch 1991; Wilson et al. 2014). It was first discovered in Canada in 2015, on Pelee Island (Hossie and Hamr 2022).

The introduction of non-native crayfish species into the environment can have negative impacts on amphibians (see overview in DiStefano et al. (2009)). For example, Cruz et al. (2006) reported lower amphibian species richness in ephemeral (briefly existing) ponds where the Red Swamp Crayfish (*P. clarkii*) had been introduced, however the study was conducted in an area where no native crayfish occur. The situation is therefore not similar to Pelee Island, where two native crayfish species are present (Hossie and Hamr 2022). Whether the White River Crayfish will have a negative impact on Pelee Island salamanders is unknown at this time.

Pollution

(IUCN Threat 9.)

The provincial recovery strategy identifies road salt and agricultural run-off as threats to Small-mouthed Salamanders and dependent Unisexuals. The following provides an update on these threats on Pelee Island, and also discusses the potential threat from perfluoroalkyls and polyfluoroalkyl substances, as well as microplastics.

Road salt

Although the provincial recovery strategy identified de-icing road salt as a threat to the species, it is unlikely to be the case given that the Township of Pelee does not use road de-icing salt on public roads as part of winter maintenance (Township of Pelee pers. comm. 2021).

Perfluoroalkyls and polyfluoroalkyl substances

Per- and polyfluoroalkyl substances (PFAS) are not discussed as threats in the provincial recovery strategy. They are widespread, persistent environmental pollutants that negatively affect wildlife and human health and may enter an ecosystem via agriculture and packaging (Government of Canada 2021; Tornabene et al. 2021). Perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) are PFAS that are toxic to Small-mouthed Salamander and other amphibians (Tornabene et al. 2021); these substances are prohibited by regulations in Canada, and the federal government is undertaking further action to address PFAS as a class (Government of Canada 2021).

Copper and nitrites

Results reported in recent publications are consistent with previous findings that certain agriculture-derived pollutants are toxic to ambystomatid salamanders, including copper (Weir et al. 2019) and nitrites (Kroupova et al. 2018). The impact of these pollutants on salamanders on Pelee Island are currently unknown.

Microplastics

The prevalence of environmental contamination from microplastics has garnered an increasing amount of attention from the scientific community over the last ten years (see review in Prokić et al. 2021). Microplastics, commonly referring to plastic debris less than 5mm in size, have been detected in air, water, and soil (especially agricultural fields) throughout the world (Prokić et al. 2021). There are several pathways by which microplastics may enter small inland waterbodies, including agricultural runoff, atmospheric deposition, sewage/effluent, and plastics breakdown (Hu et al. 2020). In southern Ontario wetlands, agriculture is a prominent source of microplastics due to the use of polymer beads for controlled release of pesticides and fertilizers (Balsdon 2018). Given that microplastics are present in lake surface waters off Pelee Island (Eriksen et al. 2013), they are likely to be present within salamander habitat as well.

Prokić et al. (2019) identify amphibians as highly sensitive organisms owing to their biphasic and multi-stage life history. Microplastic intake has been found to have a variety of adverse effects on amphibians (Boyero et al. 2020; da Costa Araújo et al. 2020a, b; da Costa Araújo and Malafaia 2020; Malafaia et al. 2021) The impact of microplastics on Pelee Island salamanders is unknown.

Climate change
(IUCN Threat 11. Climate change & severe weather)

The impact that climate change may have on the Small-mouthed Salamander and dependent Unisexual remains uncertain. The vulnerability to climate change of the Spotted Salamander (*Ambystoma maculatum*), another pond-breeding ambystomid that occurs in the Great Lakes Basin, was assessed as moderate[25] by Brinker et al. (2018) due to four factors that also apply to Small-mouthed Salamander and dependent Unisexuals: prevalence of anthropogenic barriers to movement within the species range (defined as large areas of intensive urban development and agricultural lands), limited dispersal capability, and predicted sensitivity to increases in temperature and overall climate moisture deficit. Such changes to the climate could decrease the availability, or shorten the hydroperiod[26], of freshwater wetlands on which the species are dependent for breeding. On the other hand, a more recent analysis projects that precipitation in southern Ontario will increase from March through May, and decrease only mildly in August (Shresta et al. 2022); in that case, wetter conditions during the salamander mating and egg development period may be sufficient to maintain the required hydroperiod for salamander larvae metamorphosis despite drier conditions in late summer.

Warmer air temperatures due to climate change may also compound the threat of some pathogens to amphibians. The average annual temperature in the Great Lakes basin is projected to increase by at least 2.4 ^{o}C over the next 40 years (Shresta et al. 2022), which may decrease immune function and thus worsen the severity of chytrid infections (Rollins-Smith 2020), Kohli et al. (2019) additionally link drought conditions to reduced immune function and poorer disease outcomes in amphibians.

5. Population and Distribution Objectives

Under SARA, a population and distribution objective for the species must be established. Consistent with the goal for the recovery of the species provided in the provincial recovery strategy (Part 2) and that of the provincial government stated in the Government Response Statement (Part 3), Environment and Climate Change Canada's population and distribution objective for the Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population in Canada is to lower the risk of extirpation of both species by:

a) Maintaining the current Extent of Occurrence (EOO);
b) Maintaining, and where technically and biologically feasible, increasing the number of extant breeding sites (as defined in this federal addition);

[25] 'Moderately Vulnerable' means that the abundance and/or range extent of the species within the geographical area assessed is likely to decrease by 2050 (Brinker et al. 2018).
[26] The number of days per year that an area of land is wet or the length of time that there is standing water at a location

c) Maintaining, and where technically and biologically feasible, increasing the current Index of Area of Occupancy (IAO);
d) Arresting the inferred decline in the number of mature individuals.

COSEWIC evaluated the status of both salamanders as Endangered because the EOO and IAO of each species are less than 5,000 km² and 500 km², respectively; each species is considered to exist at less than five locations[27], and; there is a continuing decline, in the case of the Small-mouthed Salamander, in the quality of habitat and the number of mature individuals, and a continuing decline, in the case of the dependent Unisexual, in the EOO, IAO, quality of habitat and number of locations. Given that the EOO and IAO for either species cannot be increased above the Endangered status threshold while respecting the natural distribution and area of occupancy of both species in Canada (Pelee Island is 43 km²), the recovery objectives target connectivity[28] and redundancy[29] by aiming to first arrest the decline in the EOO, IAO, quality of habitat, number of locations and number of mature individuals.

Maintaining all extant breeding sites is the most efficient way to arrest the inferred declines in three of the five parameters listed above (i.e., declines in EOO, IAO, and number of locations). Restoring habitat at existing breeding sites is required to arrest the declines in the quality of habitat and the number of mature individuals.

By striving for an increase in the IAO and the number of breeding sites, the consequent improvement in redundancy and connectivity will significantly contribute to lowering the risk of extirpation of both species. Improvements to both parameters can be achieved, where technically and biologically feasible, by: improving the habitat quality of existing breeding sites and that of as of yet uncolonized wetlands; constructing new ponds for the purposes of creating additional breeding sites; improving the terrestrial habitat surrounding breeding sites and wetlands that could be used for breeding (see section 3.2), and restoring terrestrial habitat in order to create natural dispersal corridors linking breeding sites to uncolonized wetlands and constructed ponds.

[27] COSEWIC defines the term ‘location’ as “a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations” (COSEWIC 2021b). A location according to COSEWIC may therefore consist of more than one breeding site.
[28] Connectivity is a key survival characteristic that is relevant to a species’ condition if COSEWIC applied criteria B1a and/or B2a to the species (ECCC 2022) (see COSEWIC 2021a for criteria definitions). COSEWIC applied criteria B1a and B2a to both the Small-mouthed Salamander (COSEWIC 2014) and to the Unisexual Ambystoma, Small-mouthed Salamander dependent population (COSEWIC 2016). As explained in footnote 8, this federal addition considers the continuity between breeding sites (rather than subpopulations) as the most relevant metric for addressing connectivity for both species.
[29] Redundancy is a key survival characteristic that is relevant to a species’ condition if COSEWIC applied criteria B1b, B1c, B2b, B2c, and/or D2 to the species (ECCC 2022) (see COSEWIC 2021a for criteria definitions). COSEWIC applied criteria B1b and B2b to both the Small-mouthed Salamander (COSEWIC 2014), and the Unisexual Ambystoma, Small-mouthed Salamander dependent population (COSEWIC 2016).

Both species of salamanders share the same population and distribution objectives given that, as the name suggests, dependent Unisexuals are dependent on Small-mouth Salamander males to successfully reproduce, because eggs laid by the all-female dependent Unisexuals will only develop if exposed to sperm from Small-mouthed Salamanders (see full description of reproductive biology in Bogart 2019). By not having to expend energy producing males, it is hypothesized that over time, dependent Unisexuals will outcompete Small-mouthed Salamanders to the point of the latter's extirpation, which would invariably lead to the subsequent extirpation of the dependent Unisexuals themselves. Therefore, constant immigration of Small-mouthed Salamanders to non-natal breeding sites (all of which are used by dependent Unisexuals on Pelee Island) is necessary to allow long-term persistence of both species at those breeding sites (Bogart 2019).

The distance separating breeding sites is therefore highly relevant to the salamanders' persistence on Pelee Island: the requisite on-going immigration of Small-mouthed Salamanders from their natal breeding site to other breeding sites used by dependent Unisexuals can occur only if the breeding sites are located within the Small-mouthed Salamander's dispersal capability (which is a function of distance and presence of habitat suitable for dispersal[30]).

6. Broad Strategies and General Approaches to Meet Objectives

The government-led and government-supported actions from the *Blue Racer, Lake Erie Watersnake and Small-mouthed Salamander and the Unisexual Ambystoma (Small-mouthed Salamander dependent population) – Ontario Government Response Statement* (Part 3) applicable to Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population are adopted as the broad strategies and general approaches to address the threats and meet the population and distribution objectives for the species. Environment and Climate Change Canada is not adopting the approaches identified in section 2.0 of the *Recovery Strategy for Small-mouthed Salamander (*Ambystoma texanum*) and Unisexual Ambystoma Small-mouthed Salamander dependent population (*Ambystoma laterale - texanum*) in Ontario* (Part 2).

Approaches to recovery for both species involve working in collaboration with the municipality, provincial government, local community and conservation organizations to implement threat mitigation measures tailored to each existing breeding site, improve the quality of habitat currently used by the species, increase the amount of available wetlands suitable for breeding, establish dispersal corridors between breeding sites

[30] Dispersal refers to the occasional long-distance emigration of juveniles from their natal breeding site, as opposed to the much shorter distances traveled during the yearly seasonal migration of individuals between hibernation sites and breeding sites.

(see potential routes in Smith 2022), and assess the risk to the species from potential/emerging threats. Given new information confirming that Small-mouthed Salamander is susceptible to Ranaviruses and chytrid fungi, it will be important to highlight the threat posed by reptiles and amphibians obtained through the pet trade in public awareness initiatives. Engaging private landowners in habitat stewardship activities remains a key pillar to the conservation and recovery of the Small-mouthed Salamander and dependent Unisexuals.

7. Critical Habitat

7.1 Identification of the Species' 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. Under Section 2(1) of SARA, critical habitat is "the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species".

Identification of critical habitat is not a component of provincial recovery strategies under the Province of Ontario's ESA. Under the ESA, when a species becomes listed as endangered or threatened on the Species at Risk in Ontario List (Ontario Regulation 230/08), it automatically receives general habitat protection unless protections are temporarily suspended through a Minister's order. The Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population currently receive general habitat protection under the ESA; however, a description of the general habitat has not yet been developed. In some cases, a habitat regulation for a species on the Species at Risk in Ontario List may be developed that replaces the general habitat protection. The habitat regulation is a legal instrument that prescribes an area that will be protected[31] as the habitat of the species by the Province of Ontario. A habitat regulation has not been developed for Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population under the ESA; however, the provincial recovery strategy (Part 2) contains a recommendation on the area for consideration in developing a habitat regulation. This federal recovery strategy identifies critical habitat for the Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population in Canada to the extent possible based on this recommendation and on the best available information.

Critical habitat for the Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population in Canada is identified as the extent

[31] Under the federal *Species at Risk Act* (SARA), there are specific requirements and processes set out regarding the protection of critical habitat. Protection of critical habitat under SARA will be assessed following publication of the final federal recovery strategy.

of biophysical attributes (see Section 7.1.2) wherever they occur within the areas described in Section 7.1.1 (Figure 1).

The critical habitat identified in this federal recovery will assist in meeting the species' population and distribution objectives for the Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population formulated under section 5. A schedule of studies is included in this recovery strategy because the available information is considered inadequate to identify critical habitat for one historical subpopulation, hence further investigation is warranted. If new or additional information becomes available, refinements to current critical habitat, or additional critical habitat may be identified in an amendment to this recovery strategy. For more information on critical habitat identification, contact Environment and Climate Change Canada – Canadian Wildlife Service at RecoveryPlanning-Planificationduretablissement@ec.gc.ca.

7.1.1 Areas Containing Critical Habitat

Recovery of the Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population in Canada depends on the persistence of the species in an area greater than that which is currently occupied by individuals of the species (see population and distribution objectives under section 5). Critical habitat identified in this recovery strategy therefore includes areas that are currently occupied by the species, and additionally, areas that could become occupied by the species based on the salamanders' dispersal capability. The size-related attributes of the critical habitat components described below were informed by published estimates of post-breeding migration distances for the closely-related salamanders of the genus *Ambystoma* (namely, *A. jeffersonianum* and *A. laterale – (2) jeffersonianum*) (Semlitsch 1998; Faccio 2003; Bériault 2005; Hoffmann et al. 2018; Van Drunen et al. 2020).

The area containing critical habitat for Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population consists of:

1. A wetland, including a pond or vernal or other temporary pool on Pelee Island where the presence of one or more Small-mouthed Salamander or Unisexual Ambystoma, Small-mouthed Salamander dependent population individual has been recorded[32];
2. An area that provides suitable foraging, dispersal, migration or hibernation habitat for Small-mouthed Salamander or Unisexual Ambystoma, Small-mouthed Salamander dependent population individuals and that is within 300 m of habitat described in subparagraph 1;.

[32] Located within 300 m of observations of Small-mouthed Salamander or Unisexual Ambystoma, Small-mouthed Salamander dependent population as currently sourced from the Natural Heritage Information Centre (NHIC) (current to March 2021), Ward and Hossie 2020, and Hossie unpublished data).

3. A wetland, including a pond or vernal or other temporary pool on Pelee Island that provides habitat suitable for breeding by Small-mouthed Salamander or Unisexual Ambystoma, Small-mouthed Salamander dependent population individuals and that is within 1 km of an area described in subparagraph 1., and;
4. Areas that provide suitable dispersal habitat for Small-mouthed Salamander or Unisexual Ambystoma, Small-mouthed Salamander dependent population between an area described in subparagraph 1. and an area described in subparagraph 3.

7.1.2 Biophysical Attributes of Critical Habitat

Within the areas described under 7.1.1., critical habitat is identified where the following biophysical attributes occur:

Table 1. Detailed biophysical attributes of critical habitat for specific life cycle activities of the Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population in Canada.

Life Stage and/or Need	Biophysical Attributes
Breeding (mating, egg-laying, and larval development)	Includes wetlands (bodies of slow-moving water) such as ponds, vernal pools, swamps, and marshes. The wetlands have variable depths but at minimum retain water throughout the egg and larval development stages[33] in at least some years[34], and often include woody debris, leaf litter, and emergent and/or submerged vegetation. As per information in the provincial recovery strategy, water conditions are typically as follows: o dissolved oxygen: 0.3 to 15.0 mg/L o pH: between 6.9 and 9.2 o total dissolved solids: 145 to 510 mg/L o salinity: 97 to 348 mg/L
Foraging, hibernation, migration and dispersal	Includes swamps, marshes, and terrestrial habitats such as woodlands, forests, meadows, prairies and old fields. Habitat typically contains ground cover objects such as logs, rocks, and leaf litter, and contains suitable terrestrial prey items such as insects, earthworms, or other invertebrates. Hibernation habitat also contains features that extend below the frost line, such as deep rock fissures and rodent burrows. Migration and dispersal habitat also includes agricultural fields.

[33] Typically from March to late June.
[34] Given that precipitation, temperature, and Lake Erie water levels vary year-to-year, breeding sites that are temporary in nature may only contain standing water for a sufficient duration in some years.

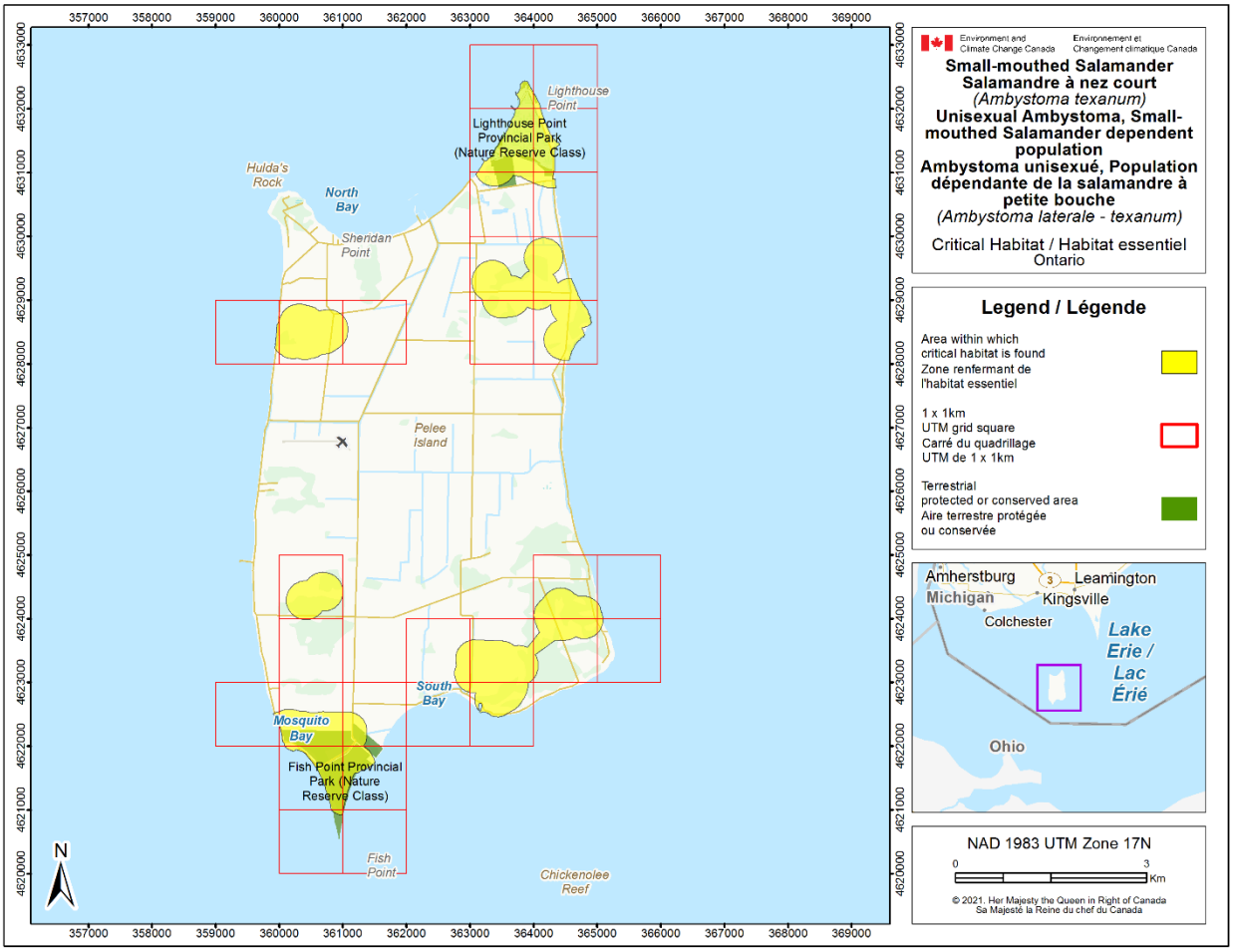

Figure 1: Critical Habitat for Small-mouthed Salamander and Unisexual Ambystoma, Small-mouthed Salamander dependent population. The area within which critical habitat is found for the Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population in Canada, as described in section 7.1, is represented by the yellow shaded unit. Within this area, critical habitat only occurs where the biophysical attributes described in section 7.1.2 are found. The 1 km × 1 km UTM grid overlay (red outline) shown on this figure is a standardized national grid system used to indicate the general geographic area within which critical habitat is found.

7.2 Schedule of Studies to Identify Critical Habitat

Table 2. Schedule of Studies to Identify Critical Habitat

Description of Activity	Rationale	Timeline
Survey the historical breeding site to determine whether the subpopulation(s) is/are extant.	The subpopulation is considered 'Historical' given that no known surveys to confirm species occurrence have been conducted in more than 20 years[35]. As such it is not identified as critical habitat at this time. According to best available information, suitable habitat is likely still present at this breeding site. Verifying the status of the subpopulation(s) will assist in meeting the population and distribution objectives.	2024-2029

7.3 Activities Likely to Result in 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 was degraded, either permanently or temporarily, such that it would not serve its function when needed by the species. Destruction may result from a single activity or multiple activities at one point in time or from the cumulative effects of one or more activities over time, and can occur at a variety of scales and in both aquatic and terrestrial habitats. It may occur from an activity taking place either within or outside of the critical habitat boundary and it may occur in any season of the year. The distance away from the critical habitat boundary where the activity is taking place is site-dependent and will vary according to the hydrological regime and vegetation cover at the landscape scale. Within the critical habitat boundary, activities may affect breeding sites and the areas within 300 m of breeding sites that provide suitable conditions for foraging, dispersal, migration or hibernation (i.e., the areas described in Table 1). All breeding sites constitute critical habitat regardless of their hydroperiod in a given year, which can vary based on climatic conditions. Activities may also affect dispersal areas (see subsection 7.1.1, Table 1). Because the biophysical attributes of dispersal habitat are not always identical to those of critical habitat used by the species for other life stages (Table 2), certain activities likely to result in the destruction of breeding sites may not result in the destruction of dispersal habitat. It should be noted that not all activities that occur in or near critical habitat are likely to cause its destruction.

Activities likely to result in the destruction of the species' critical habitat include, but are not necessarily limited to, those listed in Table 3.

[35] In accordance with NatureServe guidelines regarding 'Element Occurrence' status categories (NatureServe 2002), the NHIC has assigned a status of 'Historical' to one Unisexual Ambystoma, Small-mouthed Salamander dependent population subpopulation on Pelee Island.

Table 3. Activities Likely to Result in the Destruction of Critical Habitat.

Description of activity	Description of effect in relation to function loss	Details of effect
Site clearing and grading, filling and drainage of wetlands	Activities that remove wetlands, tree and/or shrub cover, understory vegetation, and biotic and abiotic ground cover components (e.g., rocks, logs or vegetation debris) eliminate habitat used for breeding, foraging, and hibernation. Filling or completely draining wetlands at any time of year will permanently eliminate the aquatic habitat that is used for breeding and larvae development into terrestrial juvenile salamanders. Partial wetland draining at any time of the year will also eliminate breeding habitat if it shortens the wetland's hydroperiod[36] to the extent that it is rendered insufficient to allow larval development (i.e., the wetland dries up before larvae have fully developed into terrestrial juvenile salamanders). Grading and paving may alter the topography and the hydrology (e.g., surface and subsurface drainage patterns) of the area, which may in turn degrade breeding habitat by altering the wetland's hydroperiod and aquatic vegetation composition.	The activity is likely to destroy critical habitat if it occurs in any of the areas described under 7.1.1., at any time of the year. If the activity occurs outside of critical habitat, it may damage or destroy breeding areas or potential breeding areas in cases where the site of the activity has a hydrological connection with a breeding area or a potential breeding area.

[36] The duration of time in which water is present in a wetland.

Description of activity	Description of effect in relation to function loss	Details of effect
Water management activities that result in the removal, redirection or reduction of groundwater and surface water (e.g., water extraction for irrigation and/or household use, stormwater management).	Alteration to the hydrology of the habitat at any time of the year will eliminate or impair the function of breeding habitat if it shortens the wetland's hydroperiod to the extent that it is rendered insufficient to allow larval development (i.e., the wetland dries up before larvae have fully developed into terrestrial juvenile salamanders).	The activity is likely to destroy critical habitat if it occurs within a breeding area or a potential breeding area. The activity may damage or destroy critical habitat if it occurs outside the critical habitat boundary in cases where the area has a hydrological connection (surface or subsurface) to breeding areas or potential breeding areas.
Introduction of invasive plant species	Invasive plant species colonize new areas usually through direct planting or indirectly from moving fill (i.e., depositing soil that contains invasive plant seeds). Invasive plant species may negatively impact breeding habitat (e.g. by reducing a wetland's hydroperiod) and terrestrial habitat used for foraging, migration and dispersal (e.g. by displacing native vegetation such that the amount and quality of canopy cover and/or leaf litter input is decreased).	The activity is likely to damage or destroy critical habitat if it occurs within any of the areas described under 7.1.1., at any time of year. The activity may damage or destroy critical habitat if it occurs outside of critical habitat, in cases where the site of the introduction is located within the plant's dispersal distance to the critical habitat boundary.
Construction of structures that create barriers to movement	The activity damages or destroys habitat used for migration and dispersal if it includes the construction of temporary or permanent physical structures that prevent or hinder salamander ambulation (travel) through the habitat during the active season (e.g., concrete lane dividers).	The activity is likely to damage or destroy critical habitat if it occurs within any of the areas described under 7.1.1., at any time of year. The likelihood of damage or destruction is greater if the activity occurs during the active season and if the constructed structures are permanent.

Description of activity	Description of effect in relation to function loss	Details of effect
Building new roads or widening/ upgrading of existing roads	Construction or widening of a road removes all wetlands, tree cover, understory vegetation and biotic and abiotic ground cover components located within the construction project's direct footprint, thereby eliminating habitat functions such as breeding, foraging, hibernation, migration and dispersal.	The activity will damage or destroy critical habitat if it occurs within any of the areas described under 7.1.1., at any time of year; however, if the activity is confined to an existing road footprint, does not occur during the active season (March to October), and does not result in permanent impacts (e.g., no increase of road footprint, creation of new physical barriers or increase in pollution), it is unlikely to damage or destroy critical habitat. The activity may damage any of the areas described under 7.1.1 if it occurs outside of the critical habitat boundary, in cases where the activity results in increased wetland pollutant concentrations or altered hydroperiod.
Release of pollutants into surface or groundwater	Runoff of industrial chemicals, pesticides, fertilizers and road-use related pollutants (e.g., salt, metals, and products of combustion) into aquatic habitat can degrade water quality such that the habitat can no longer function as breeding habitat. Reduction and removal of natural vegetation on the perimeter of breeding habitat will increase the amount and concentration of pollutants entering the water which may also degrade water quality such that it is no longer suitable to function as breeding habitat.	The activity may damage or destroy critical habitat if it occurs in any of the areas described under 7.1.1. The likelihood of damage or destruction is greater if the activity occurs during the active season. The activity may damage or destroy critical habitat it if occurs in areas that are outside critical habitat but that are hydrologically connected to a breeding area or a potential breeding area.
Introduction of carnivorous fish	Introducing fish (whether native species or exotics/pets) to wetlands will eliminate their function as breeding habitat because fish prey upon all life stages of salamanders, particularly larvae, to an extent that precludes long-term co-existence in a given body of water.	The activity is likely to destroy critical habitat if it occurs in a breeding area or a potential breeding area, at any time of year. The activity may destroy critical habitat if it occurs in a water body located outside the critical habitat boundary, if there is a hydrological surface connection that allows fish to disperse from the water body to a breeding area or a potential breeding area.

8. Measuring Progress

The performance indicators presented below provide a way to measure progress toward achieving the population and distribution objectives. Every ten years, success of recovery strategy implementation will be measured against the following performance indicators:

- The extent of occurrence for each species is 43 km^2.
- The number of extant breeding sites totals at least 17 for Small-mouthed Salamander and 22 for the dependent Unisexuals.
- The index of area of occupancy is at least 20 km^2 for both species.
- The number of mature individuals[37] of each species in Canada is 250 or more.

9. Statement on Action Plans

One or more action plans will be completed for Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population by December 31, 2029.

10. 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*[38]. 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[39] (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.

[37] Number of individuals known, estimated or inferred to be capable of reproduction (COSEWIC 2021b)
[38] www.canada.ca/en/environmental-assessment-agency/programs/strategic-environmental-assessment/cabinet-directive-environmental-assessment-policy-plan-program-proposals.html
[39] https://www.canada.ca/en/environment-climate-change/services/climate-change/federal-sustainable-development-strategy.html

Recovery efforts that are focused on the Small-mouthed Salamander and the Unisexual Ambystoma, Small-mouthed Salamander dependent population will likely benefit species inhabiting extant breeding sites and the surrounding habitat, including many Carolinian plant species, Blue-spotted Salamander (*Ambystoma laterale*), Eastern Foxsnake (*Pantherophis gloydi*) and Blue Racer (*Coluber constrictor foxii*). No species of conservation concern are expected to be detrimentally affected.

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Appendix A: NatureServe Subnational Conservation Ranks (S-Ranks) of Small-mouthed Salamander (*Ambystoma texanum*) in Canada and the United States

S-rank	State/Province
S1 (Critically Imperiled)	Ontario, Michigan, Nebraska, West Virginia
S3 (Vulnerable)	Alabama, Iowa, Mississippi
S4 (Apparently Secure)	Indiana
S5 (Secure)	Arkansas, Illinois, Kansas, Kentucky, Louisiana, Missouri, Tennessee, Texas
SNR (Unranked)	Ohio, Oklahoma

Source: NatureServe (2021).

Rank Definitions

S1: Critically Imperiled - At very high risk of extirpation in the jurisdiction (i.e., N - nation, or S - state/province) due to very restricted range, very few populations or occurrences, very steep declines, severe threats, or other factors.

S3: Vulnerable - At moderate risk of extirpation in the jurisdiction due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats or other factors.

S4: Apparently Secure – At a fairly low risk of extirpation in the jurisdiction due to an extensive range and/or many populations or occurrences but with possible cause for some concern as a result of local recent declines, threats or other factors.

S5: Secure - At very low risk of extinction or elimination due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats.

SNR/NNR: Unranked – National or subnational conservation status not yet assessed.

Part 2 – ***Recovery Strategy for Small-mouthed Salamander (*****Ambystoma texanum*****) and Unisexual Ambystoma Small-mouthed Salamander dependent population (*****Ambystoma laterale - texanum*****) in Ontario*****,***
prepared by Thomas J. Hossie for the Ontario Ministry of Natural Resources and Forestry, 2018

Photo: T.J. Hossie

Small-mouthed Salamander *(Ambystoma texanum)* and Unisexual Ambystoma Small-mouthed Salamander dependent population *(Ambystoma laterale - texanum)* in Ontario

Ontario Recovery Strategy Series

2018

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Ontario

About the Ontario Recovery Strategy Series

This series presents the collection of recovery strategies that are prepared or adopted as advice to the Province of Ontario on the recommended approach to recover species at risk. The Province ensures the preparation of recovery strategies to meet its commitments to recover species at risk under the *Endangered Species Act 2007* (ESA) and the Accord for the Protection of Species at Risk in Canada.

What is recovery?

Recovery of species at risk 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 a species' persistence in the wild.

What is a recovery strategy?

Under the ESA a recovery strategy provides the best available scientific knowledge on what is required to achieve recovery of a species. A recovery strategy outlines the habitat needs and the threats to the survival and recovery of the species. It also makes recommendations on the objectives for protection and recovery, the approaches to achieve those objectives, and the area that should be considered in the development of a habitat regulation. Sections 11 to 15 of the ESA outline the required content and timelines for developing recovery strategies published in this series.

Recovery strategies are required to be prepared for endangered and threatened species within one or two years respectively of the species being added to the Species at Risk in Ontario list. Recovery strategies are required to be prepared for extirpated species only if reintroduction is considered feasible.

What's next?

Nine months after the completion of a recovery strategy a government response statement will be published which summarizes the actions that the Government of Ontario intends to take in response to the strategy. The implementation of recovery strategies depends on the continued cooperation and actions of government agencies, individuals, communities, land users, and conservationists.

For more information

To learn more about species at risk recovery in Ontario, please visit the Ministry of Natural Resources and Forestry Species at Risk webpage at: **www.ontario.ca/speciesatrisk**

Recommended citation

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Cover illustration: Small-mouthed Salamander photo from Pelee Island (top) and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) photo from Pelee Island (bottom) by T.J. Hossie.

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Cette publication hautement spécialisée « Recovery strategies prepared under the Endangered Species Act, 2007 », n'est disponible qu'en anglais en vertu du Règlement 411/97 qui en exempte l'application de la Loi sur les services en français. Pour obtenir de l'aide en français, veuillez communiquer avec recovery.planning@ontario.ca.

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This Recovery Strategy updates and expands the 2015 Recovery Strategy for the Small-mouthed Salamander (Ambystoma texanum) in Ontario which was written by Stewart E. Hamill – Wildlife Biologist, Merrickville.

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Declaration

The recovery strategy for the Small-mouthed Salamander and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) was developed in accordance with the requirements of the *Endangered Species Act, 2007* (ESA). This recovery strategy has been prepared as advice to the Government of Ontario, other responsible jurisdictions and the many different constituencies that may be involved in recovering the species.

The recovery strategy does not necessarily represent the views of all of the individuals who provided advice or contributed to its preparation, or the official positions of the organizations with which the individuals are associated.

The goals, objectives and recovery approaches identified in the strategy are based on the best available knowledge and are subject to revision as new information becomes available. Implementation of this strategy is subject to appropriations, priorities and budgetary constraints of the participating jurisdictions and organizations.

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.

Responsible jurisdictions

Ontario Ministry of Natural Resources and Forestry
Environment and Climate Change Canada – Canadian Wildlife Service, Ontario

Executive summary

The Small-mouthed Salamander (*Ambystoma texanum*) is a medium to large salamander with a robust body and a broad head. They are black or dark grey and the flanks and tail are covered with light grey or grey-blue flecking. Compared to other salamanders in this group, Small-mouthed Salamanders have a small head and the snout is short and blunt. This species occurs widely in the USA, but within Canada it is restricted to Pelee Island, a 42 km² island in Lake Erie, where the species reaches the northern edge of its range. Small-mouthed Salamanders co-occur on Pelee Island with an essentially all-female lineage of *Ambystoma* salamanders that are reproductively dependent on Small-mouthed and Blue-spotted Salamanders (*Ambystoma laterale*). These animals are called Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) and are sometimes referred to as 'unisexual polyploids' because an individual may possess anywhere from two to five sets of chromosomes. All Unisexual *Ambystoma* in this population share nuclear DNA with both Small-mouthed and Blue-spotted salamanders. Yet, Unisexual *Ambystoma* have mitochondrial DNA (DNA located in mitochondria and inherited only from the mother) that is distinct from any contemporary species indicating that they are not recent hybrids, but instead stem from a distinct ancient lineage. Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) are intermediate in appearance to Small-mouthed and Blue-spotted salamanders and cannot be readily distinguished from these species without genetic testing. This fact, combined with the logistical challenges associated with accessing Pelee Island in March, has made it difficult to obtain population estimates for these species. However, the permanent loss of historical breeding sites and the severity of ongoing threats has meant that both Small-mouthed Salamanders and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) are now listed as Endangered in Ontario. Rejuvenated survey efforts have resulted in the discovery of previously unknown breeding ponds, yet these salamanders remain restricted to six areas across the island.

The major threats facing these species include:

- habitat alteration, loss and fragmentation through drainage, land clearing or development;
- road mortality of migrating adults and dispersing juveniles;
- predation or habitat modification by a large and possibly increasing population of Wild Turkeys;
- emerging pathogens, including salamander chytrid fungus and Ranavirus;
- introduction of fish into breeding ponds;
- invasive species, including *Phragmites australis* subsp. *australis*;
- pollution of breeding ponds through agricultural runoff or de-icing salt; and
- climate change which is expected to make drought conditions more frequent and could cause breeding sites to dry up prematurely.

The recommended recovery goal is to ensure the long-term persistence of the Small-mouthed Salamander and Unisexual *Ambystoma* (Small-mouthed Salamander

dependent population) on Pelee Island. The strategy describes protection and recovery objectives for this species in Ontario, including to:

- Protect and maintain or enhance the quality and quantity of habitat on Pelee Island where *Ambystoma* salamanders occur, and support habitat creation or restoration activities that increase connectivity among populations.
- Implement a monitoring program for salamander populations on Pelee Island that includes assessment of abundance, size or age structure, genetic composition, habitat and screening for emerging pathogens.
- Promote and carry out research to better understand Small-mouthed Salamander and Unisexual *Ambystoma* habitat needs, genetics, population dynamics and threats.
- Investigate existing, former and potential *Ambystoma* salamander habitats on Pelee Island to determine if restoration, re-introduction or population interventions would be appropriate.
- Promote stewardship, education and outreach programs for private landowners, residents and visitors on Pelee Island.

The main approaches to recovery should include: (i) implementation of a monitoring program, (ii) studying patterns of habitat use and movement in adults and juveniles, (iii) supporting research on genetics, demographics, and threats and (iv) implementing education and outreach programs to minimize the introduction or spread of invasive species and emerging pathogens. Recent surveys have failed to detect Blue-spotted Salamanders on Pelee Island indicating a possible decline in abundance. Given their importance as sperm donors for Unisexual *Ambystoma*, additional surveys should seek to determine if and where Blue-spotted Salamanders are still present on Pelee Island.

It is recommended that a habitat regulation for Small-mouthed Salamanders and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) include:

- Any wetland, pond or vernal or other temporary pool that is being used by Small-mouthed Salamander or Unisexual *Ambystoma*, or was used by a Small-mouthed Salamander or Unisexual *Ambystoma* at any time in the previous ten years.
- An area that is within 300 m of a wetland, pond or vernal or other temporary pool described above that provides suitable foraging, dispersal, migration or hibernation conditions for Small-mouthed Salamander or Unisexual *Ambystoma*.
- Areas that provide suitable conditions for Small-mouthed Salamander or Unisexual *Ambystoma* to disperse and are within one kilometer of known Small-mouthed Salamander or Unisexual *Ambystoma* breeding sites.
- A wetland, pond, vernal or temporary pool that would provide suitable breeding conditions for Small-mouthed Salamander or Unisexual *Ambystoma* that is within one kilometer of a known *Ambystoma* salamander breeding site.

While not explicitly included in the recommendation for a habitat regulation, habitat that could facilitate dispersal among known breeding sites that are within three kilometers of one another should be protected and enhanced through stewardship and best management practices, where possible.

Table of contents

List of figures

List of tables

1.0 Background information

1.1 Species assessment and classification

Table 1. Species assessment and classification of the Small-mouthed Salamander (*Ambystoma texanum*).

Assessment	Status
SARO List Classification	Endangered
SARO List History	Endangered (2008), Endangered – Not Regulated (2005), Threatened (2004)
COSEWIC Assessment History	Endangered (2014), Endangered (2004), Special Concern (1991)
SARA Schedule 1	Endangered (2005)
Conservation Status Rankings	GRANK: G5, NRANK: N1, SRANK: S1

*The glossary provides definitions for the abbreviations within and for other technical terms in this document.

Table 2. Species assessment and classification of Unisexual *Ambystoma* Small-mouthed Salamander dependent population (*Ambystoma laterale - texanum*).

Assessment	Status
SARO List Classification	Endangered
SARO List History	Endangered (2017)
COSEWIC Assessment History	Endangered (2016)
SARA Schedule 1	No schedule, no status
Conservation Status Rankings	GRANK: Not assessed, NRANK: Not assessed, SRANK: Not assessed.

*The glossary provides definitions for the abbreviations within and for other technical terms in this document.

1.2 Species description and biology

Species description

The Small-mouthed Salamander (*Ambystoma texanum*) is a typical member of the Mole Salamander family (Ambystomatidae), being a medium to large salamander (maximum length 18 cm) with 13-16 prominent costal grooves, robust limbs and body and a broad head (Harding 1997, Owen and Jutterbock 2013). The head in this species, however, is noticeably smaller than that of other mole salamanders and the snout is short and blunt (MacCulloch 2002). The back is black or dark grey and the belly is dark with a few light spots. The flanks and tail are covered with light grey or grey-blue flecking (Petranka 1998). Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) are intermediate in appearance between Small-mouthed Salamanders and Blue-spotted Salamanders and cannot be readily distinguished from these species without genetic testing. Colouration of Unisexuals is variable, but most individuals are black or grey with light grey, blue-grey, or blue flecking along the flanks and tail. Unisexual *Ambystoma* in this population can have anywhere from 12 to16 costal grooves (Hossie, unpubl.). Unisexual adults have proportionally smaller heads than Blue-spotted Salamanders of similar size (Kraus et al. 1991) and the distance between the nares (nostrils) tends to be larger in the unisexuals than that of similarly sized Small-mouthed Salamanders (Downs 1989, Hossie, unpubl.).

Larvae have external gills and measure 7 to 14 mm in total length at time of hatching, but may grow to over 75 mm in total length prior to metamorphosis. They possess a broad head and the upper tail fin extends along the dorsum to just behind the head (Petranka 1998, Mills 2016). Colouration is variable and depends on both the amount of ultraviolet (UV) light exposure and water temperature (Garcia et al. 2003, Garcia et al. 2004). Larvae may be a light yellowy-olive colour with dark blotches or almost black (Harding 1997). A pale yellowish lateral stripe is present along the side, but this becomes less distinct with age. The tail fin is heavily blotched and mottled with black, particularly towards the tip (Owen and Jutterbock 2013, Mills 2016). It is not possible to visually distinguish unisexual larvae from the larvae of coexisting Small-mouthed and Blue-spotted Salamanders.

Species biology

In Canada, the Small-mouthed Salamander is only found on Pelee Island, Ontario where the species reaches the northern limits of its range (Bogart et al. 1985, NatureServe 2017). These salamanders live alongside Blue-spotted Salamanders and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population). Unisexual *Ambystoma* vastly outnumber both Small-mouthed and Blue-spotted Salamanders, making up over 80 percent of all the *Ambystoma* salamanders on the island (Hossie and Murray 2017, see also COSEWIC 2004). These three species were isolated together on Pelee Island roughly 4000 years ago with Small-mouthed Salamanders and Unisexual *Ambystoma* likely having originated from populations to the south, but Blue-

spotted Salamanders originating from the Ontario mainland (Lowcock 1989). Together these species now form a unique salamander 'complex' on Pelee Island which has persisted without immigration from outside populations despite intense and widespread changes to the island's landscape.

Unisexual *Ambystoma* (i.e., including all designatable units) are characterized by a unique genetic system and do not fit the conventional biological species concept. The term 'unisexual' refers to the fact that nearly all of the salamanders from this lineage are female (Bogart et al. 1985, Bogart and Licht 1986). All Unisexual *Ambystoma* share mitochondrial DNA that is distinct from any bisexual species (i.e., species with two sexes) indicating that they are not hybrids resulting from recent mating events among contemporary species (Hedges et al. 1992). Instead, all Unisexual *Ambystoma*, including those on Pelee Island, form a monophyletic lineage that arose 3 to 5 million years ago (Bi and Bogart 2010). All Unisexual *Ambystoma* do however share nuclear DNA with other co-occurring bisexual species from the genus *Ambystoma* and individual unisexual salamanders may possess anywhere from two to five chromosome complements (i.e., may be diploid, triploid, tetraploid or pentaploid). At least one chromosome complement in all Unisexual *Ambystoma* is invariably derived from the Blue-spotted Salamander genome (Bogart et al. 2009, Bi et al. 2008). A shorthand nomenclature is used to refer to various genomotypes of Unisexual *Ambystoma* depending on which chromosome complements they possess. Specifically, in this nomenclature the number of *A. laterale* and *A. texanum* chromosome sets that an individual salamander possesses corresponds to the number of uppercase 'L's and 'T's, respectively. For example, a diploid unisexual with one chromosome set from *A. laterale* (L) and one chromosome set from *A. texanum* (T) would be referred to as an 'LT' individual, whereas a triploid unisexual with one chromosome set from *A. laterale* (L) and two from *A. texanum* (T) would be an 'LTT' individual. In this nomenclature, pure (i.e., diploid, bisexual) Small-mouthed Salamanders are referred to as 'TT', and pure (i.e., diploid, bisexual) Blue-spotted Salamanders are 'LL".

No other Canadian population of Unisexual *Ambystoma* coexists with Small-mouthed Salamanders, and all unisexuals in this population possess one or more chromosome complements from the Small-mouthed Salamander genome (COSEWIC 2016). Unisexuals on Pelee Island lack any genetic contribution from Jefferson Salamanders and exhibit a relatively high proportion of diploid and symmetrical tetraploids relative to mainland populations (COSEWIC 2016). Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) therefore includes all unisexual salamanders on Pelee Island (COSEWIC 2016). The Unisexual *Ambystoma* (Small-mouthed dependent population) designatable unit includes diploids (LT), triploids (LLT, LTT), tetraploids (LLLT, LLTT, LTTT), and rare pentaploids (e.g., LLTTT, LTTTT) (COSEWIC 2004, COSEWIC 2016, Hossie and Murray 2017).

For all Unisexual *Ambystoma*, sperm is required to initiate egg development, but typically does not contribute nuclear DNA to the resulting embryo (Bogart and Licht 1987, Bogart et al. 2007). This form of reproduction is termed 'gynogenesis' and produces offspring that are genetically identical to the mother (Bogart et al. 2007). Rarely, nuclear DNA from the sperm is incorporated into the egg resulting in an embryo

that has an additional set of chromosomes relative to its mother (i.e., increased ploidy). This form of reproduction has been termed ‘kleptogenesis’ and is unique to Unisexual *Ambystoma* (Bogart et al. 2007). The frequency of sperm incorporation increases with water temperature during reproduction (Bogart et al. 1989). Five bisexual *Ambystoma* species are known to be viable sperm donors for Unisexual *Ambystoma* (*A. laterale*, *A. texanum*, *A. jeffersonianum*, *A. tigrinum*, and *A. barbouri*; Bogart et al. 2009), however only *A. texanum* and *A. laterale* are potential sperm donors for unisexuals in the Small-mouthed Salamander dependent population due to geographic isolation. The process of ploidy-reduction is less well understood, but must be possible for diploid unisexuals to exist. A leading hypothesis suggests that symmetrical tetraploids (e.g., animals that possess two sets of chromosomes from each of *A. laterale* and *A. texanum* genomes) are uniquely capable of producing reduced diploid embryos which receive one set of chromosomes from each of the two bisexual genomes (Bogart and Bi 2013). If true, symmetrical tetraploids would be critical to the generation of genetic diversity in unisexual populations. Symmetrical tetraploids can only be produced in systems where there are two sperm-donating species. This is an uncommon situation, but occurs on Pelee Island and appears to have shaped the genetic structure of the Unisexual *Ambystoma* that occur there (Bogart et al. 1985, COSEWIC 2016).

Adult salamanders from all three species (i.e., Small-mouthed Salamander, Blue-spotted Salamander and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population)) migrate to fishless vernal pools in early spring. Male Small-mouthed Salamanders may engage in courtship with females prior to depositing small packages of sperm called spermatophores along the bottom of the pond, or may deposit spermatophores randomly (Petranka 1998, Owen and Jutterbock 2013). Courtship of Unisexual *Ambystoma* by male Small-mouthed Salamanders has also been observed (Licht 1989; Licht and Bogart 1990). Female salamanders, including unisexuals, mount spermatophores and pick up seminal fluid with their cloaca. Females may collect sperm from multiple spermatophores (Garton 1972) and fertilization of eggs is internal. Unisexual *Ambystoma* on Pelee Island may collect sperm deposited by either Small-mouthed or Blue-spotted Salamanders (Bogart et al. 1985, Bi et al. 2008).

Small-mouthed Salamanders and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) deposit eggs either in loose clusters along submerged vegetation or singly along the bottom of the pond roughly 24 to 48 hours after sperm collection. Adults disperse back to the terrestrial habitat shortly after depositing eggs. Small-mouthed Salamanders produce more numerous egg clutches with eggs that are smaller in diameter compared to unisexuals on Pelee Island (Licht 1989). Clutch size for both Small-mouthed Salamander and unisexuals on Pelee Island averages roughly 200 eggs, but may be as numerous as 560 eggs (Licht 1989). The hatching success of eggs produced by Small-mouthed Salamanders and unisexuals on Pelee Island is low (range = 0-63%, mean ± SD = 22.9 ± 25.6, n = 7 egg masses; Bogart and Licht 1986, Licht 1989). Typical hatching success rate of Unisexual *Ambystoma* eggs in this population is reported to be only about 16 percent (Bogart and Licht 1986), but ranges from 0 to 74.5 percent (Licht 1989). The relatively low hatching success and viability of developing embryos may be attributed to low fertilization rates and developmental abnormalities in

unisexual embryos (Licht 1989). Developing egg masses and larvae can survive under ice (Cagle 1942), but development is inhibited below 5°C (Punzo 1983).

Surviving eggs hatch 2 to 8 weeks from deposition depending on water temperature (Downs 1989, Minton 2001) and develop into free swimming larvae with external gills. Larvae feed on various aquatic invertebrates, but may opportunistically consume amphibian larvae and are occasionally cannibalistic (Minton 2001). Breeding sites must hold water continuously from mid-March to late June for larvae to reach metamorphosis, however, larvae may not leave ponds until late August when conditions are favourable. Upon completing metamorphosis juveniles disperse from ponds into the terrestrial habitat on rainy or humid nights. Once on land salamanders spend most of their time under rocks or decaying logs, but may be found under bark, wood boards or sheets of tin. Small-mouthed Salamanders are also known to use burrows made by mammals and crayfish and are occasionally plowed up in agricultural fields (Owen and Juterbock 2013). Juveniles and adults feed primarily on earthworms and small invertebrates (Owen and Juterbock 2013). As summer progresses salamanders move deeper underground and are more difficult to find. In the fall, salamanders move below the frost line where they remain until the following spring.

Small-mouthed Salamanders reach sexual maturity in about two years (Petranka 1998), but Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) may require more time and probably reach sexual maturity after 2 to 3 years (Licht and Bogart 1989). Adult *Ambystoma* salamanders from many species do not attempt to breed every year and may forego migration to breeding sites for multiple successive years (Petranka 1998, Pfingsten et al. 2013). The main predators of juveniles and adult salamanders are raccoons, foxes, snakes, and birds, while larvae are fed on by crayfish, insects, birds and snakes (Petranka 1998, Pfingsten et al. 2013). If present, carnivorous fish will rapidly consume developing embryos and larvae (Kats et al. 1998).

1.3 Distribution, abundance and population trends

Global Range

Small-mouthed Salamander and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) occur in both Canada and the USA. Small-mouthed Salamanders have a global range extent of 200,000 to 2,500,000 square km (NatureServe 2017) and their range extends from southwestern Ontario and Ohio westward to eastern Kansas, and southward to eastern Texas, Louisiana, Mississippi, and Alabama (Petranka 1998). A complete list of states and provinces where the Small-mouthed Salamander occurs and the relevant Conservation Status Ranks can be found in Appendix Table A1. Small-mouthed Salamanders occur on Pelee Island, and have also been found on other islands in Lake Erie, including Kelly's Island and Middle Bass Island (King et al. 1997). The global population size of Small-mouthed Salamanders is unknown, but probably exceeds 100,000 (NatureServe 2017). Over its entire range

Small-mouthed Salamander abundance appears to be relatively stable, but may have experienced small declines (less than 30%) over the short-term (NatureServe 2017).

The Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) designatable unit is, by definition, restricted to Pelee Island (COSEWIC 2016). However, Unisexual *Ambystoma* that are dependent on Small-mouthed Salamanders can be found in Michigan, Indiana, and Ohio (COSEWIC 2016), and are known from several Lake Erie islands including, Kelly's Island (Ohio) and the Bass Islands (Ohio) (COSEWIC 2016). The full range may not be well defined because genetic testing is required to identify these animals and many populations have not yet been tested (COSEWIC 2016). The global population size for Unisexual *Ambsytoma* (Small-mouthed Salamander dependent population) is not known. Unless specified otherwise, any subsequent reference to Unisexual *Ambystoma* in this document refers specifically to Unisexual *Ambystoma* (Small-mouthed Salamander dependent population).

Canadian Range

In Canada, Small-mouthed Salamanders and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) are restricted to Pelee Island, a 42 km² island in the western basin of Lake Erie. In 1991, they were known to occupy at least five locations on the island, however two of these breeding ponds were eliminated by development and permanent loss of water by the year 2000 (COSEWIC 2004). Recent work beginning in 2015 has identified six areas on the island that are currently occupied by these species and separated by more than 1 km (COSSARO 2016, Hossie and Murray 2017). This increase reflects renewed survey efforts that included land subsequently acquired by the Nature Conservancy of Canada (NCC) as well as private property where landowners have recently authorized surveys.

In this document "breeding site" refers to a specific pond, wetland, vernal or other temporary pool where salamanders reproduce, and "breeding location" refers to larger areas typically separated by more than 1 kilometer that may include several breeding sites (e.g., several ponds within close proximity). Current breeding locations are composed of a mixture of semi-natural habitat, abandoned livestock ponds, and vernal ponds created through stewardship activities. Specifically:

- ponds isolated from the lake located in Lighthouse Point Nature Reserve;
- a spring-fed abandoned livestock pond located in a patch of secondary succession forest on private property and a flooded woodlot owned by NCC which are located within close proximity to each other;
- multiple small ponds created through stewardship activities on two adjacent parcels of private land;
- a flooded woodlot on a nature reserve jointly owned by Ontario Nature, Essex Region Conservation Authority (ERCA) and the NCC;
- a spring-fed abandoned livestock pond located in a patch of secondary succession forest owned by NCC; and
- a flooded woodlot within the provincial Fish Point Nature Reserve.

One additional breeding location identified in the 2004 COSEWIC *Assessment and Update Status Report on the Small-mouthed Salamander* is on private land and has not been surveyed in over 10 years because of land access restrictions. No Small-mouthed Salamanders were observed at this location when it was last surveyed, but it did have abundant Blue-spotted Salamanders and various genomotypes of Unisexual *Ambystoma* (COSEWIC 2004). The current status of this breeding location is not known.

In recent years the NCC has undertaken several wetland creation and restoration activities on Pelee Island (J. Crosthwaite, pers. comm. 2017). While eggs and larvae (including LT, LTT, and LTTT individuals) were observed in one of these new ponds, effective recruitment has not yet been demonstrated (T. Hossie, pers. obs. 2017).

The abundance of Small-mouthed Salamanders and Unisexual *Ambystoma* on Pelee Island is not currently known. Obtaining populations estimates has been complicated by the cryptic nature of salamanders outside of the breeding season combined with logistical challenges in accessing and working on the island during the breeding season in March. Additional difficulties arise from the fact that genetic methods are required to accurately distinguish among Small-mouthed Salamanders, Blue-spotted Salamanders and Unisexual *Ambystoma*. A mark-recapture estimate based on four consecutive nights of trapping in one breeding pond in March 2016 estimated the number of salamanders (i.e., both bisexuals and unisexuals) in that pond at the time of sampling to be 789 individuals (95% confidence interval: 430-2367) (Hossie and Murray 2017).

Using data obtained from more than 1200 larvae collected on Pelee Island from 1984 to 1991, unisexuals made up 78 percent of the *Ambystoma* salamander population (COSEWIC 2004). More recent survey efforts on Pelee Island examined more than 830 samples (adults and larvae) collected from 2015 to 2017 and found that unisexuals made up over 95 percent of the sample (Hossie and Murray 2017). This may indicate that the relative abundance of Small-mouthed Salamanders has declined since 1991. Note however that historic and contemporary samples used different sampling methods and were drawn from different localities on Pelee Island which could limit direct comparison. For example, contemporary samples do not include two historical sites that no longer exist or the historical breeding location where Blue-spotted Salamanders were abundant, whereas historic samples did not include samples from two recently discovered sites. A more direct comparison can be made for two breeding locations that were surveyed in both time periods (i.e., 1984-1991 and 2015-2017) and by restricting the comparison to larval samples. Such comparisons reveal a significant decline in relative abundance of Small-mouthed Salamanders at one site where *A. texanum* was historically abundant (proportion of *A. texanum* in historic sample: 28.1%, n = 274, contemporary sample: 3.3%, n = 61; $\chi^2 = 17.01$, DF = 1, $P < 0.001$), but not the other site where the relative abundance of *A. texanum* was already low (historic: 1.4%, n = 351, contemporary: 1.2%, n = 169; $\chi^2 = 0.05$, DF = 1, $P = 0.82$).

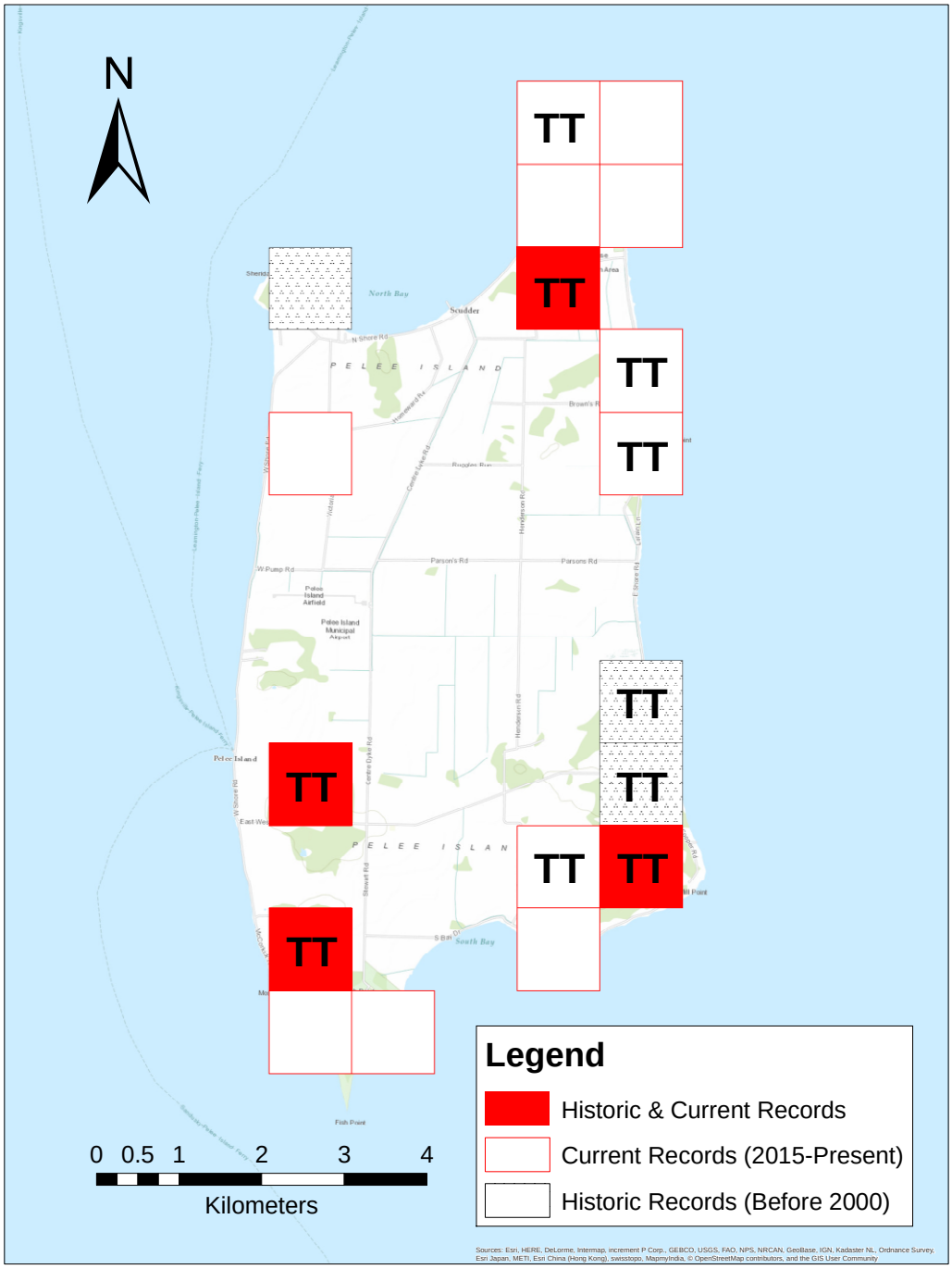

Figure 1. Historical and current distribution of the Small-mouthed Salamander and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) in Ontario. Areas where genetically-confirmed Small-mouthed Salamanders have been recorded are indicated with '**TT**'.

1.4 Habitat needs

Breeding Habitat

Adults require woodland ponds, wetlands or other fishless water bodies for breeding activities that occur in March. The combination of water connected to suitable terrestrial habitat is therefore essential. Breeding sites are generally ephemeral and may be filled by spring run-off, ground water or by springs. These vernal pools must hold water until at least late June for the aquatic larvae to reach metamorphosis (Ryan 2007, Hossie and Murray 2017). Breeding ponds require egg attachment sites (e.g., submerged sticks and branches or emergent vegetation), as well as a food source (i.e., aquatic invertebrates) for developing larvae. Small-mouthed Salamanders and Unisexual *Ambystoma* on Pelee Island appear to use water bodies with a wide range of abiotic conditions (Table 3). Studies of pond characteristics in other populations of Small-mouthed Salamander or Unisexual *Ambystoma* indicate that embryos and larvae tolerate a wide range of water depth, temperature and water chemistry conditions (Pierce and Wooten 1992, Punzo 1983, Bériault 2005). Large increases in embryonic mortality occur as pH drops below 6 and low pH could be problematic if it results in reduced availability of aquatic invertebrate prey (Sandinski and Dunson 1992).

Table 3. Range of water conditions in breeding sites on Pelee Island where viable eggs or larvae of *Ambystoma* sp. were observed in 2016 to 2017 (modified from Hossie and Murray 2017).

Month	Dissolved Oxygen (mg/L)	pH	Total dissolved solids	Salinity	Temperature (°C)
March	0.5-13.5	7.2-9.2	220-470	130-205	2.3-14.9
April	2.6-15.0	7.3-9.0	158-373	103-244	10.0-14.9
May	0.4-8.9	7.2-8.5	145-510	97-348	13.4-24.1
June	0.3-6.7	6.9-8.28	185-468	128-320	17.6-31.5

Terrestrial Habitat

Outside of the spring breeding season adult Small-mouthed Salamanders and Unisexual *Ambystoma* generally remain hidden underground in shaded areas with soft moist soil, such as poorly drained swamp woodlands and floodplains, but may also use rocky quarry sites and alvars. In Ontario, Small-mouthed Salamanders are found in several types of moist habitats, including tall-grass prairies, dense hardwood forests and agricultural lands if such areas contain, or are adjacent to, suitable breeding ponds. These habitats also possess soils soft enough to enable adults to find burrows, such as those created by crayfish (Williams 1973, Owen and Juterbock 2013). The habitat needs of Unisexual *Ambystoma* (Small-mouthed Salamander-dependent population) are assumed to be similar to those of Small-mouthed and Blue-spotted Salamanders

(COSEWIC 2016). Their reliance on sperm from male Small-mouthed or Blue-spotted Salamanders for reproduction means that unisexuals inhabit areas where at least one of these species occurs. Petranka (1998) reports that Unisexual *Ambystoma* with genomes from Small-mouthed Salamanders are restricted to habitats with clay-based soils. In contrast, Blue-spotted Salamanders are more strongly associated with drier, sandy soils (Minton 1954, Jutterbock and Owen 2013), which could mean such habitats are suitable for unisexuals on Pelee Island as well. Salamanders can be found within crayfish burrows, beneath or within rotting logs, and under rocks or leaf litter (Williams 1973, Downs 1989). Preliminary work on the Pelee Island salamander complex indicates that microhabitat selection is influenced by both soil moisture (preferred range = 10-30%) and canopy cover (preferred range = 50-100% cover) (Hossie and Murray 2017). The overwintering ecology of adult Small-mouthed Salamanders and Unisexual *Ambystoma* is poorly understood, however they presumably retreat below the frost line into deep rock fissures and rodent burrows during the winter.

Adult Small-mouthed Salamanders are thought to undergo less substantial migration compared to other *Ambystoma* species and remain close to their breeding ponds (i.e., within 50-60 m) (Williams 1973, Parmalee 1993). Treadmill endurance trials recently conducted on adult *Ambystoma* salamanders in Ohio indicate that Small-mouthed and Blue-spotted Salamanders can walk further than sympatric Unisexual *Ambystoma* prior to exhaustion (Denton et al. 2017). This work indicated that in a single movement session Small-mouthed and Blue-spotted Salamanders can travel over 150 m, whereas unisexuals can only travel less than 50 m in a single session (mean ± SD: *A. texanum*: 159.25 ± 86.4 m, *n* = 14; *A. laterale*: 161.20 ± 16.09 m, n = 2; unisexuals: 34.47 ± 28.2 m, n = 19). Hoffman (2017) radio-tracked unisexual salamanders (*Ambystoma laterale* (2) – *jeffersonianum*) from a population in Maine. Her work indicates that salamanders make large initial migrations away from the pond, then subsequently make few short movements in random directions (Hoffman 2017). Over 94 days these salamanders traveled an average straight line distance of 172 m from the wetland (range 6 - 403 m), and the average distance travelled in one night was 41 m (SD = 51, max = 194 m) (Hoffman 2017). She found that, with 95 percent confidence, a radius of 362 m from the pond would include the average maximum distance moved by unisexual salamanders in the populations she studied. This number should not be confused with the area that includes 95 percent of the salamanders which could be larger or smaller. Similar work conducted by Karine Bériault (2005) in Ontario examined migration distances for unisexuals (mostly *Ambystoma laterale* – (2) *jeffersonianum*) and found that the average net distance travelled from the breeding pond was 206.3 ± 134.8 m (range = 37.3-514.4, n = 12). These salamanders were tracked for an average of 53.25 ± 13.4 days (range 8-60) (Bériault 2005). Work by Bériault (2005) did not re-implant transmitters in salamanders after the 8 to 60 day period and may not capture the entirety of their movements away from breeding ponds (K. Bériault, pers. comm. 2017). It therefore remains possible that salamanders move further from breeding ponds in late summer or fall (e.g., towards more distant overwintering sites). Similar radio-tracking work has not been conducted on Small-mouthed Salamanders or Unisexual *Ambystoma* (Small-mouthed Salamander dependent population).

Small-mouthed Salamanders and Unisexual *Ambystoma*) also require terrestrial habitat suitable to disperse among breeding ponds. Work by Denton et al. (2017) estimated realized dispersal distance for Small-mouthed Salamanders and Unisexual *Ambystoma* in Ohio by combining genetic assignment tests with landscape analyses. They found that Small-mouthed Salamanders can disperse further than Unisexual *Ambystoma*, but both species can disperse more than 3 km from their natal ponds (mean Euclidean distance travelled: *A. texanum* = 6826 m, n = 13; unisexuals = 3300 m, n = 11) (Denton et al. 2017). These realized dispersal distances are much greater than the typical migration distances and instead probably reflect occasional long-distance dispersal events made by juveniles, possibly over multiple years. Adult Small-mouthed Salamanders do cross roads (COSEWIC 2004) indicating that roads are not an impermeable barrier, although this will depend on the type of road and heavy traffic could reduce survival during migration or dispersal. Greenwald et al. (2009) found that ponds surrounded by agricultural landscapes were associated with more genetically isolated populations, whereas greater amounts of deciduous forest were associated with decreased genetic isolation in three species of pond-breeding *Ambystoma*. This indicates that dispersal among sub-populations may be hindered when ponds are separated by agriculture opposed to forest. These authors also found that in relatively pristine habitats, genetic isolation increases with distance from neighboring breeding ponds (Greenwald et al. 2009), indicating that effective dispersal among populations decreases with distance. Small-mouthed Salamanders may however be more tolerant of human activities such as agriculture than other *Ambystoma* species (Owen and Juterbock 2013). This has been inferred based on repeated observations of Small-mouthed Salamanders being plowed up in farm fields (Minton 2001), and from studies which suggest that they can persist in agricultural areas with some degree of habitat fragmentation (Kolosvary and Swihart 1999, Owen and Juterbok 2013).

1.5 Limiting factors

A number of intrinsic or evolved factors probably limit the abundance of both Small-mouthed Salamanders and Unisexual *Ambystoma* (Small-mouthed salamander dependent population), these include:

- low hatching success of eggs and low viability of developing embryos,
- intermittent juvenile recruitment (i.e., occasional years where no, or very few, larvae survive to metamorphosis),
- delayed maturation,
- site fidelity to breeding habitat,
- limited dispersal ability, and
- high degree of specificity for limited habitats (i.e., areas where fishless temporary ponds are within or adjacent to forested areas).

In addition to these limiting factors, Unisexual *Ambystoma* are strongly limited by the abundance of co-occurring Small-mouthed Salamanders and Blue-spotted Salamanders (COSEWIC 2016). Unisexual *Ambystoma* require sperm from either of these species in order to reproduce (Bogart and Licht 1987, COSEWIC 2016). Both the

number of unisexuals that get an opportunity to reproduce and the hatching success of the resulting egg clutches is therefore directly linked to the number of available spermatophores produced by male Small-mouthed Salamanders and Blue-spotted Salamanders co-occurring in those breeding ponds.

1.6 Threats to survival and recovery

Many of the threats to Small-mouthed Salamander and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) are poorly or incompletely understood. Direct or indirect evidence is presented to support each identified threat, however additional work is needed to fully evaluate the relative severity of their impact on this salamander complex.

Habitat Alteration, Loss and Fragmentation

The loss or degradation of terrestrial and breeding habitat remains a significant threat to Small-mouthed Salamanders and Unisexual *Ambystoma*. The entire range for both of these species in Canada is restricted to Pelee Island. Much of the suitable habitat was lost through historical logging and wetland drainage in the late 1800s, followed by the conversion of this land to agriculture. Despite these dramatic changes the salamander complex persists in patches of habitat across the island. These patches of habitat appear to be at least partly isolated from one another by drainage canals, roads and unsuitable habitat, however the degree of such isolation remains poorly understood. Small-mouthed Salamander populations within agricultural landscapes in western Ohio have been shown to be inbred and have limited gene flow among forest patches (Rhoads et al. 2017). The apparent low abundance of Small-mouthed Salamanders in each sub-population on Pelee Island could make gene flow among breeding ponds particularly important for maintaining genetic diversity. Much of the existing habitat occurs within protected areas owned by Ontario Parks, NCC, Ontario Nature, or ERCA. Additional salamander habitat on the island is protected by easement agreements or voluntary land stewardship by private land owners.

Both terrestrial and breeding habitat would be impacted by expansion or intensification of drainage activities if they cause premature drying of breeding ponds or reduce soil moisture of terrestrial habitat. Intensification of drainage activities might also change the composition of forest communities over the long-term (R. Gould, pers. comm. 2017), however the impact of such effects on salamanders is unknown. There is ongoing pressure for development (e.g., new trail systems) on Pelee Island including within areas where salamanders occur (R. Gould, pers. comm. 2017). If trail development entails opening up the canopy it could reduce habitat quality. The impact of trail footprints on terrestrial habitat is exaggerated when visitors (incl. hikers, birders, nature photographers, cyclists) stray from well-defined trails (R. Gould, pers. comm. 2017). The effect of existing trails could be mitigated by adding an elevated boardwalk within an existing trail footprint which could reduce soil compaction and create more habitat for the species beneath the boardwalk, as well as reduce human trampling of the

surrounding areas (by restricting people to a boardwalk). More generally, the decline or destruction terrestrial habitat from the clearing of wooded areas has been identified as an important threat to this population (COSEWIC 2016).

Road Mortality

Salamanders on Pelee Island may need to cross roads during their spring migrations to or from breeding sites in March, during dispersal of newly metamorphosed juveniles in June to August, or when adults migrate to overwintering sites in the fall. Heavily used or wide roads may constitute a barrier to dispersal and road mortality of breeding adults would strongly impact populations. On Pelee Island, spring migrations to and from breeding ponds generally occur before ferry access to the mainland has begun. As a result, traffic on Pelee Island is generally low during spring migrations. Traffic does increase substantially once the ferry commences operation in April, peaking by mid-summer. Mazerolle (2004) studied amphibian road mortality in New Brunswick and found that *Ambytoma* salamanders occurred on the road most frequently in the spring (April-May) and late-summer though fall (August-September), but were rarely on the road in mid-summer (June-July). He also observed that road mortality of *Ambsytoma* salamanders did not vary with traffic intensity within the range he examined (i.e., 5 and 26 vehicles/h) with approximately 40% of salamanders encountered on the road consisting of dead individuals (Mazerolle 2004). Roads may therefore be a source of mortality for adults or juveniles that migrate or disperse late in the summer or fall. Little work has been done to assess this threat, however road mortality has been documented to occur on Pelee Island (R. Gould, pers. comm. 2017) and can strongly impact population viability in pond-breeding salamanders (Gibbs and Shriver 2005). The Township of Pelee has significantly reduced speed limits on most roads in response to the threat that road mortality poses to the many species of endangered wildlife on the island (MNRF 2017). It is not known whether reducing speed limits has an influence on rates of road mortality in salamanders. Construction of new roads, widening of roads or increases in traffic would likely increase mortality and create or amplify barriers to dispersal and remains an important threat.

Wild Turkey Predation and Habitat Modification

Wild Turkeys (*Meleagris gallopavo*) have been identified as a possible threat to salamanders on Pelee Island (COSEWIC 2014a, Hamill 2015, COSEWIC 2016). Wild Turkeys were introduced to the island in 2002 and this population is now actively hunted in the spring. Turkeys are opportunistic predators that scratch to find food and may consume salamanders. The Natural Resources Conservation Service (an agency of the United States Department of Agriculture) lists salamanders as an important food item in the diet of Eastern Wild Turkey (Natural Resources Conservation Service 1999). In addition salamanders are noted as a dietary item of Wild Turkey by McRoberts et al (2014). It remains unclear whether or not salamanders on Pelee Island are well adapted to defend themselves from such predation. Turkeys are highly diurnal and primarily forage during the day when salamanders are concealed under cover, which could

minimize predation risk to the salamanders (J. Bowman, pers. comm. 2017). The extent to which predation by Wild Turkeys represents an important threat to the long-term persistence of Small-mouthed Salamanders and Unisexual *Ambystoma* on Pelee Island depends on many factors including: (i) the extent to which turkeys inhabit areas occupied by salamanders, (ii) the extent to which salamanders are available or accessible to turkeys, (iii) the willingness of turkeys to feed on salamanders, (iv) the age classes and genotypes of salamanders that are consumed, and (v) the overall abundance of turkeys. A separate but related threat posed by Wild Turkeys is the potential for destruction of terrestrial hiding places for salamanders (e.g., decaying logs) when scratching to find food (J. Bogart, pers. comm. 2017).

The turkey population on Pelee Island has grown considerably following the release of 25 birds on the island in 2002. A single flock of over 200 birds was observed in the spring of 2016 (T. Hossie, pers. obs. 2016) and turkeys occur in all areas on the island where salamanders are found (Hossie and Murray 2017). Hunters can purchase up to two turkey tags in the spring and hunt anywhere in Ontario where there is an open season. This currently includes Pelee Island. Other than opening a fall hunting season currently there is no policy mechanism to further increase harvest pressure on Pelee Island. While Pelee Island meets the criteria for considering a fall turkey hunt based on the harvest density in spring, a fall hunt would conflict with the annual pheasant hunt on Pelee Island (J. Bowman, pers. comm. 2017).

Examination of turkey gizzard contents by the Ministry of Natural Resources and Forestry (MNRF), which included animals from Pelee Island, did not find evidence of salamander consumption (J. Bowman, pers. comm. 2017). Techniques such as examining gizzard or stomach contents of captured turkeys are not, on their own, sufficient to determine the level of threat posed by turkeys. Failure to find salamanders (or their DNA) in the gizzard or stomach of turkeys could result from many processes including: (i) sampling turkeys at a time when salamanders are not being consumed, (ii) sampling turkeys in locations where salamanders are scarce or absent, and (iii) salamanders representing a small proportion of the turkey's diet. Furthermore, even if salamanders represent a small proportion of the Wild Turkey diet on Pelee Island, turkeys could still impose demographically significant mortality in the salamander complex if the turkey population becomes large, turkeys consume large adult salamanders, a large proportion of dispersing juveniles are consumed, or turkeys consume males or females of the less abundant bisexual species (i.e., Small-mouthed or Blue-spotted Salamanders) on which Unisexual *Ambsytoma* rely. This threat remains poorly understood, but has the potential to severely impact salamander populations.

Research by Trent University has employed artificial (clay) salamanders and trail cameras to examine rates of predation by turkeys and other predators (e.g., raccoons). This work will also shed light on whether salamander behavioural responses to predators (i.e., tail raise) effectively deflect predator strikes (including those by turkeys) away from their head and body. Analysis of this data is ongoing.

Emerging Pathogens

There is increasing concern in Canada regarding the possible introduction of *Batrachochytrium salamandrivorans* (Bsal) which has caused mass die-offs in wild populations of European salamanders (Martel el al 2013, Martel et al. 2014). Bsal is a relative of *Batrachochytrium dendrobatidis* (Bd) that causes chytridiomycosis in salamanders leading to skin infections that cause lesions, lethargy, anorexia and death (Martel et al. 2013, Martel et al. 2014). Bsal has not yet been reported in Canada or the USA, but both countries are at risk of introduction primarily through the global pet trade (Stephen et al. 2015). Salamanders from the genus *Cynops* and *Paramesotriton* are proposed as potential reservoirs for Bsal (Martel et al. 2014). Once introduced to North America, Bsal could become established and impossible to eradicate (Stephen et al. 2015). In January of 2016, the US Fish and Wildlife service issued an interim ruling that lists 201 salamander species as injurious wildlife under the Lacey Act, effectively banning their importation into the USA without a permit. On May 26 2017 Canada followed with a legal import ban on all species of the order Caudata (i.e., all salamanders and newts), living or dead, including any egg, sperm, tissue culture or embryo of such a specimen without a permit for scientific and research purposes (http://www.cbsa-asfc.gc.ca/publications/cn-ad/cn17-17-eng.html). These regulations are implemented through amendments to section 5(a) of the Wild Animal and Plant Trade Regulations. Pelee Island is in an area of low-moderate vulnerability to Bsal based on recently produced risk maps (Yap et al. 2015, Richgels et al. 2016) and a Canadian threat assessment produced by Stephen et al. (2015). The susceptibility of Small-mouthed Salamanders and Unisexual *Ambystoma* to Bsal is unknown (Stephen et al. 2015). Proper decontamination procedures for Bsal and Bd are freely available online from Canadian Herpetofauna Health Working Group (2017) and should help to limit the potential introduction or spread of such pathogens. Unfortunately, such procedures are unlikely to be followed by most users of natural areas on Pelee Island. Specifically, birders, hunters, nature photographers and other tourists frequently travel among locations on the island, but are unlikely to have decontaminated footwear prior to travelling to the island or when moving among locations.

Ranaviruses from the family Iridoviridae have caused major die-offs in wild populations of amphibians in North America. These viruses can also be pathogenic to fish and reptiles (Daszak et al. 1999). Salamanders from the genus *Ambystoma* are susceptible to some of these viruses and salamander mortalities linked to Ranavirus infection have been documented in Canada (Bollinger et al. 1999, Seburn and Seburn 2000). Larvae are the most susceptible life stage with mortality rates reaching 100 percent and metamorphs can die without overt signs of infection (Seburn and Seburn 2000). Ranavirus may interact with other stressors, such as exposure to agricultural contaminants including Atrazine and nitrates, increasing the susceptibility of salamanders to infection (e.g., Forsan and Storfer 2006). Ranavirus may be able to persist in environments and reservoir species, but such dynamics remain poorly understood (Lesbarreres et al. 2012). Humans can incidentally introduce or spread Ranavirus through contact with infected animals (including salamanders, frogs, turtles, snakes and fish), water or soil. The limited geographic extent and number of sub-populations of Small-mouthed Salamanders and Unisexual *Ambystoma* on Pelee Island

means that the potential impact of Ranavirus is high. Similar concerns regarding lack of decontamination (detailed above) apply equally for Ranavirus and Bsal.

Small-mouthed and Jefferson Salamanders infected by the trematode parasite *Clinostomum marginatum* have been reported from east-central Illinois (McAllister et al. 2010). The COSEWIC Status Appraisal Summary on the Small-mouthed Salamander *Ambystoma texanum* in Canada identified the parasite as a possible threat with unknown impact on population viability (COSEWIC 2014a). This parasite is has a complex life cycle which begins with eggs in the water that hatch into miracidia that infect snails where they undergo asexual reproduction. The parasites then become cercaria that leave the snail host and burrow inside the flesh of fish (or amphibians) where they encyst as metacercaria and can remain for years. Finally, these infected hosts are consumed by an aquatic bird (e.g., herons or egrets) and the parasites encyst in their throat then proceed to mature and produce eggs. In 2016 and 2017 Unisexual *Ambystoma* salamanders with lumps that resemble the cysts from the *Clinostomum marginatum* were observed on Pelee Island (Hossie and Murray 2017). The identity of these parasites has not yet been confirmed. Further, it remains unclear whether such parasitism, if confirmed, is novel versus previously undetected due to low sampling effort. The apparent incidence on Pelee Island is currently low (i.e., 6 out of 333 salamanders) and the risk posed to the salamander population is unknown.

Fish Introduction

The introduction of carnivorous fish to breeding ponds would have rapid and serious effects on the viability of impacted sub-populations. Fish are predators on all life stages of salamanders and can effectively eliminate recruitment. Small-mouthed Salamanders are poorly adapted to avoid fish predation (Kats et al. 1988) and fish reduce the reproductive success of these salamanders (Walston and Mullin 2007). Fish may colonize breeding sites through deliberate or incidental human introduction. Ponds or wetland near the margins of the island could also be colonized if they become temporarily connected to the lake following severe weather or high water levels in Lake Erie. Such colonization events are probably infrequent, but have occurred in the past (R. Gould, pers. comm. 2017). Fish should not be able to persist in breeding ponds that are highly ephemeral, making these sites less susceptible to the long-term effects of fish introduction.

Invasive Species

The encroachment of European Common Reed (*Phragmites australis* ssp. *australis*) into wetlands and riparian areas on Pelee Island could degrade wetland habitat and reduce the availability of suitable egg placement sites. Although the specific impacts on salamanders are unknown, an analysis by Greenberg and Green (2013) has shown that population decline in Fowler's Toad (*Anaxyrus fowleri*) populations is associated with the spread of the European Common Reed. Uncontrolled growth of dense stands of Common Reed stems can effectively eliminate shallow, sparsely vegetated, aquatic

areas which are needed by both Fowler's Toad and Small-mouthed Salamander. European Common Reed forms dense stands around the 'Lake Henry' marsh at Lighthouse Point and around Fox Pond at Fish Point, however there is no evidence that either of these water bodies are currently being used for reproduction by Small-mouthed Salamanders or Unisexual *Ambystoma*. At the present time, European Common Reed is not present at any of the known breeding sites, perhaps because high canopy cover in these areas renders the habitat less suitable for this plant. If the canopy around currently used breeding habitat is opened up, European Common Reed may quickly become an important threat to the persistence and quality of this habitat.

The loss of shade due to the death of ash (*Fraxinus spp.*) trees caused by the Emerald Ash Borer (*Agrilus planipennis*), an invasive, non-native species, may change wetland or forest conditions, making them less suitable for salamanders. Surveys conducted in 2012 indicated that the Emerald Ash Borer is present at Stone Road Alvar, Lighthouse Point, Fish Point, Red Cedar Savannah, and Sheridan Point (COSEWIC 2014b). Emerald Ash Borer is considered the most significant threat to Blue Ash on Pelee Island, and in 2012 the percentage of infested Blue Ash trees ranged from 4.0-34.5% of trees (COSEWIC 2014b). Damage to ash trees has been heavy in some areas of Pelee Island, however loss of canopy cover is likely to be transient as other tree species appear to be swiftly responding to the gaps in the canopy (Ron Gould, pers. comm. 2017). The resulting change in forest community composition on salamanders in unknown.

Pollution

Salamanders are particularly sensitive to various pollutants which can kill outright or induce sublethal effects in embryos, larvae and adults. Agricultural pesticides are a particular threat as they can reduce survival and metamorphosis of *Ambystoma* larvae by killing zooplankton thereby reducing food resources (Metts et al. 2005). Nitrogen runoff from agricultural fields or other sources can accumulate in breeding ponds and has been shown to have lethal and sublethal impacts on *Ambystoma* salamanders (e.g. Marco et al. 1999, Forsan and Storfer 2006, Griffis-Kyle 2007). Many private land owners on Pelee Island practice low-impact farming to support biodiversity and natural heritage, which could limit such impacts. De-icing salt runoff from Pelee Island roads can accumulate in breeding sites and is another pollutant threat. Research has shown that acute exposure (nine days) to experimental concentrations of de-icing salt caused significant reductions in mass of *Ambystoma* eggs (Karraker and Gibbs 2011).

Climate Change

Globally warming temperatures are causing water availability in the Great Lakes area to decrease. Specifically, the Great Lakes area has experienced an increase in evapotranspiration of 0.69 mm/year over the period of 1960 to 2000 (Fernandes et al. 2007). While marginal increases in precipitation are predicted for the Great Lakes area, it may not be enough to offset increasing actual evapotranspiration rates in the region

resulting from rising temperatures (Fernandes et al. 2007). Water levels in the Great Lakes themselves, including Lake Erie, are also predicted to decrease over the long term (Moulton and Cuthbert 2000, Mortsch et al., 2006). The salamander communities on islands in Lake Erie, including Pelee Island, may become increasingly imperiled as drought conditions more frequently compromise effective reproduction. Small-mouthed Salamanders are relatively long-lived amphibians. This life history strategy permits multiple attempts at reproduction and buffers populations against occasional years with abnormally warm or dry conditions. Over the long-term, climate change may cause the reduction or loss of suitable breeding habitat for *Ambystoma* salamanders on Pelee Island. Blue-spotted Salamanders are a cold-adapted species. As conditions on Pelee Island warm the available habitat may become less suitable for both Blue-spotted Salamanders and Unisexual *Ambystoma* given their shared nuclear genome. Presuming that the genetic model proposed by Bogart and Bi (2013) is accurate (see **Species Biology** above), the loss of Blue-spotted Salamanders would prevent further generation of symmetrical tetraploids and ultimately prevent Unisexual *Ambystoma* salamanders on Pelee Island from generating new genetic diversity.

1.7 Knowledge gaps

Population Size

The population size of Small-mouthed Salamanders, Unisexual *Ambystoma*, or Blue-spotted Salamander on Pelee Island remains unknown (COSEWIC 2014a, COSEWIC 2016). Estimates of population size are necessary to determine whether populations are in decline and to assess the long-term viability of the population.

Demographic Processes

The demographic mechanisms that influence population size and composition within bisexual-Unisexual *Ambystoma* salamander complexes (e.g., density-dependence, recruitment, survival, age-to-maturity) are poorly understood, but are key to developing effective species management strategies. The mechanisms underlying low abundance of Small-mouthed Salamanders and Blue-spotted Salamanders relative to Unisexual *Ambystoma* on Pelee Island are poorly understood, but have important consequences related to the their long-term viability. Research is needed to understand whether and to what extent Small-mouthed Salamander population size is influenced by the abundance of Unisexual *Ambystoma* and vice versa. The salamander community on Pelee Island has coexisted since isolation from the mainland, however the mechanisms though which this is achieved are not known. Improving our understanding of such mechanisms would inform management of this system.

Genetic Composition and Processes

Apparent changes in the genetic composition of the salamander complex on Pelee Island over time have now been documented (Hossie and Murray 2017), however the cause of such changes is not known. Such changes could reflect the impact of one or more of the threats listed above. Effective management of Small-mouthed Salamanders and Unisexual *Ambystoma* will also benefit from both an improved understanding of ploidy reduction and rates of genome exchange. The mechanism for genome exchange proposed by Bogart and Bi (2013) requires empirical validation, but may inform how complex systems involving Unisexual *Ambystoma* should be managed. For example, if symmetrical tetraploids are key to generating new genetic diversity within Unisexual *Ambystoma,* and Blue-spotted Salamanders are required to produce symmetrical tetraploids, then protections may need to be extended to Blue-spotted Salamanders. Moreover, managers may need to consider creating corridors that facilitate dispersal of Blue-spotted Salamanders to adjoining sub-populations, given that Blue-spotted salamanders appear to be restricted to a single location on the island (or possibly extirpated).

Movement Ecology

Existing radio-telemetry work with salamanders in Ontario has focused on Jefferson Salamanders and Unisexual *Ambystoma* (Jefferson Salamander dependent population) (e.g. Bériault, 2005). While work from Ohio indicates that the movement ecology of Small-mouthed Salamanders differs from that Unisexual *Ambystoma* (Denton et al. 2017), to date little is known about the movement ecology of salamanders on Pelee Island. Such information is critical for identifying key habitat areas (such as over summer foraging areas and hibernation sites), determining the appropriate size of habitat buffers and designing habitat corridors to link populations across the island. Radio-telemetry work could also help determine the extent to which roads and drainage canals act as barriers to movement.

Threat Posed by Wild Turkeys

The degree to which Wild Turkeys pose a threat to Small-mouthed Salamanders or the Unisexual *Ambsytoma* on Pelee Island remains unknown. It is clear however that if turkeys do consume salamanders or influence salamander habitat, then such effects would be of greatest concern when the turkey population grows large. The turkey population size on Pelee Island is unknown. Efforts to assess turkey population size to date have been limited to assessment of harvest records and it is unknown whether these populations will continue to increase given that opportunities for harvest are restricted to the spring. Detailed knowledge of turkey population size, population growth rate, carrying capacity and habitat use would enable researchers or managers to better assess the threat posed by Wild Turkeys.

Value and Quality of Artificial Breeding Ponds

Salamanders on Pelee Island have been documented using artificial ponds including abandoned cattle ponds and ponds dug through stewardship activities. There is substantial variation in the use and apparent quality of these breeding ponds, however the source of this variation is not known. It would be valuable to know the biotic and abiotic factors that expedite the use of artificial ponds and facilitates normal hatching success, egg development and larval recruitment.

Blue-spotted Salamander Abundance and Distribution on Pelee Island

Blue-spotted Salamanders act as sperm donors for Unisexual *Ambystoma* on Pelee Island, but may also be critically important to the maintenance of genetic diversity within unisexual populations (see **Species Biology** above). From 2015 to 2017 efforts have been made to characterize the genetic composition of the Pelee Island salamander complex. This work has resulted in the collection and genotyping of 655 adult salamanders and 378 larval samples from across the island. Despite this sampling effort no pure Blue-spotted Salamanders have been identified to date, including in areas where they were observed historically. In addition, only about 2 percent of this sample are unisexuals with proportionally more Blue-spotted Salamander DNA (e.g., LLT, LLLT, Hossie and Murray 2017) which is substantially less than was observed historically (COSEWIC 2004). This indicates that Blue-spotted Salamanders may be absent or at least very rare in the areas surveyed. Recent surveys did not include one breeding location on private land that contained the primary breeding site for Blue-spotted Salamanders historically. This location has not been visited in over 10 years. The current viability and quality of terrestrial and breeding habitat at this location is unknown as is population size and genetic composition of the animals that may occur there. Given the importance of Blue-spotted Salamanders to Unisexual *Ambystoma* on Pelee Island, research is needed to understand why Blue-spotted Salamanders appear to have declined across much of the island.

Historic and Additional Populations

Several historical populations have not been visited in over 10 years leaving their current viability and genetic composition unknown. In addition, numerous areas around the island have not been surveyed adequately or at all. It is possible that additional sub-populations exist on the island including on both private and protected land.

1.8 Recovery actions completed or underway

Various organizations have undertaken the acquisition and protection of land on Pelee Island in order to maintain species and habitat; Ontario Parks, ERCA, Ontario Nature and the NCC are included. Each provides some level of visitation and surveillance of their properties. The NCC is actively working to restore large portions of habitat on the island, including the creation of a large wetland complex (J. Crosthwaite, pers. comm.

2017). If this wetland complex remains fish free, meets the criteria outlined above for suitable breeding sites and is located close enough to source populations it could provide new habitat. Note however that there is limited evidence to evaluate whether breeding sites created though stewardship activities provide suitable habitat. The NCC actively removes garlic mustard, honeysuckle and European Common Reed from their properties. Removal of European Common Reed likely benefits the salamanders that occur in those areas. Garlic mustard and honeysuckle removal could be beneficial if these species restrict salamander movement, however data is not available to assess whether this is the case. ERCA is not planning any specific management actions relating to Small-mouthed Salamander conservation at this time, but does actively manage their properties to increase and maintain native biodiversity (D. Lebedyk, pers. comm. 2017). Note however that management activities aimed at increasing or maintaining native biodiversity do not necessarily constitute recovery actions for *Ambystoma* salamanders. Ontario Nature and Ontario Parks have deployed artificial cover boards to help monitor salamanders on their property. Although positive identification based on morphology is not possible for *Ambystoma* on Pelee Island, the recently launched Ontario Reptile and Amphibian Atlas phone app may help with outreach and education efforts.

Several private land owners on Pelee Island have engaged in stewardship activities to protect or increase the quality of habitat for salamanders including in areas where the presence and reproductive activities of Small-mouthed Salamanders have been confirmed (Hossie and Murray 2017, MNRF 2017). The Township of Pelee has updated waste disposal methods on Pelee Island which has enabled previous retaining ponds to progress into functioning wetlands (MNRF 2017). In addition, the Township of Pelee has significantly reduced speed limits across much of the island to help address road morality concerns for species at risk including the Small-mouthed Salamander (MNRF 2017). It is not known whether reducing speed limits has an influence on rates of road mortality in salamanders.

Hossie and colleagues initiated a long-term individual-based mark-recapture program on Pelee Island in 2015 (Hossie and Murray 2017). To date, over 740 salamanders (including both Small-mouthed Salamanders and Unisexual *Ambystoma*) have been measured, individually marked and genotyped across various locations on the island. This team has also established standardized survey areas across the island and has begun monitoring spring breeding activities, larval recruitment and habitat. This work has largely been funded by the Species at Risk Stewardship Fund.

2.0 Recovery

2.1 Recommended recovery goal

The recommended recovery goal is to ensure the long-term persistence of the Small-mouthed Salamander and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) on Pelee Island.

2.2 Recommended protection and recovery objectives

Table 4. Recommended protection and recovery objectives.

Number	Protection or recovery objective
1	Protect and maintain or enhance the quality and quantity of habitat for Small-mouthed Salamanders and Unisexual *Ambystoma* on Pelee Island where *Ambystoma* salamanders occur, and support habitat creation or restoration activities that increase connectivity among populations.
2	Implement a monitoring program for salamander populations on Pelee Island that includes assessment of abundance, size or age structure, genetic composition, habitat and screening for emerging pathogens.
3	Promote and carry out research to better understand Small-mouthed Salamander and Unisexual *Ambystoma* habitat needs, genetics, population dynamics and threats.
4	Investigate existing, former and potential *Ambystoma* salamander habitats on Pelee Island to determine if restoration, re-introduction or population interventions would be appropriate.
5	Promote stewardship, education and outreach programs for private landowners, residents and visitors on Pelee Island

2.3 Recommended approaches to recovery

Table 5. Recommended approaches to recovery of the Small-mouthed Salamander and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) in Ontario.

Objective 1: Protect and maintain or enhance the quality and quantity of habitat for Small-mouthed Salamanders and Unisexual *Ambystoma* on Pelee Island where *Ambystoma* salamanders occur, and support habitat creation or restoration activities that increase connectivity among populations.

Relative priority	Relative timeframe	Recovery theme	Approach to recovery	Threats or knowledge gaps addressed
Critical	Short-term	Protection	**1.1** Develop a habitat regulation or habitat description to define the area protected as habitat for Small-mouthed Salamander and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) in Ontario.	• Habitat alteration, loss and fragmentation.
Beneficial	Ongoing	Inventory	**1.2** Survey suitable habitats to find unknown populations and locations which could be used in population intervention programs, which might include: • Surveying protected areas. • Engaging private land owners in efforts to find additional populations.	• Habitat alteration, loss and fragmentation. • Historic and additional populations. **o** Additional unknown populations. **o** Viability of historic populations.
Necessary	Ongoing	Protection, Management	**1.3** Engage landowners, residents Conservation Authorities and Non-Government Organizations (NGOs) to develop habitat management and protection programs, which might include: • habitat improvement, protection or restoration activities; and implementation of conservation tools (e.g., easements, donations, land gifts, tax subsidies)	• Habitat alteration, loss and fragmentation.

Relative priority	Relative timeframe	Recovery theme	Approach to recovery	Threats or knowledge gaps addressed
Beneficial	Ongoing	Stewardship	**1.4** Support and carry out activities that seek to create new terrestrial or breeding habitat adjacent to or between known *Ambystoma* populations on Pelee Island	• Habitat alteration, loss and fragmentation.
Necessary	Ongoing	Protection, Inventory, Monitoring and Assessment	**1.5** Conduct surveys of suitable habitat to identify areas with remaining populations of Blue-Spotted Salamanders on Pelee Island and protect through legislation	• Blue-Spotted Salamander abundance and distribution on Pelee Island.
Beneficial	Long-term	Management, Stewardship	**1.6** Control invasive *Phragmites* within areas of known salamander habitat.	• Invasive species. **o** Vulnerability of habitats to *Phragmites australis australis*).

Objective 2: Implement a monitoring program for salamander populations on Pelee Island that includes assessment of abundance, size or age structure, genetic composition, habitat and screening for emerging pathogens.

Relative priority	Relative timeframe	Recovery theme	Approach to recovery	Threats or knowledge gaps addressed
Critical	Ongoing	Inventory, Monitoring and Assessment	**2.1** Carry out regular inventory, monitoring, surveying and sampling activities to establish abundance, genetic composition, size or age structure, and recruitment.	• Population size. • Demographic processes. • Genetic composition and processes.
Necessary	Ongoing	Monitoring and Assessment	**2.2** Carry out regular monitoring of terrestrial and aquatic habitat. • Terrestrial habitat monitoring should include canopy cover, soil moisture and cover object availability. • Aquatic habitat monitoring should include water level, pH, pollutants and fish presence.	• Habitat alteration, loss and fragmentation. • Fish introduction. • Pollution. • Invasive species. • Value and quality of artificial breeding ponds.

Relative priority	Relative timeframe	Recovery theme	Approach to recovery	Threats or knowledge gaps addressed
Necessary	Ongoing	Monitoring and Assessment	**2.3** Establish a monitoring program for emerging pathogens (e.g., Bsal, Ranavirus) and assess the threat posed by emerging pathogens.	• Emerging pathogens.

Objective 3: Promote and carry out research to better understand Small-mouthed Salamander and Unisexual *Ambystoma* habitat needs, genetics, population dynamics and threats.

Relative priority	Relative timeframe	Recovery theme	Approach to recovery	Threats or knowledge gaps addressed
Necessary	Short-term	Protection, Management, Research	**3.1** Conduct research on movement patterns and habitat use of adults and juveniles to support the development of evidence-based habitat protections.	• Habitat alteration, loss and fragmentation. **o** Unknown migration distance from breeding ponds. **o** Dispersal capabilities and barriers unknown. **o** Location of overwintering sites unknown.
Beneficial	Short-term	Research	**3.2** Investigate the factors that influence quality of created breeding ponds and how readily they are used.	• Value and quality of artificial breeding ponds.

Relative priority	Relative timeframe	Recovery theme	Approach to recovery	Threats or knowledge gaps addressed
Beneficial	Short-term	Research	**3.3** Conduct research on genetic composition and genetic interactions within the Small-mouthed Salamander and Unisexual *Ambystoma* complex.	• Genetic composition and processes. **o** Incompletely understood genetic processes related to ploidy elevation and reduction. **o** Causes of change in genetic composition unknown. **o** Hypothesized role of Blue-spotted Salamander in maintaining genetic diversity in Unisexual *Ambystoma*
Beneficial	Long-term	Research	**3.4** Conduct research that investigates the limiting and regulating factors that influence salamander population dynamics on Pelee Island.	• Demographic processes.
Beneficial	Long-term	Protection, Management, Research	**3.5** Investigate the connectivity of existing salamander sub-populations on Pelee Island to identify possible dispersal corridors and barriers.	• Movement ecology. **o** Poorly understood dispersal patterns, corridors or barriers. **o** Unknown levels isolation among sub-populations.
Beneficial	Short-term	Monitoring and Assessment	**3.6** Identify where and when salamanders are likely to cross, or attempt to cross, roads and investigate the need for road mitigation solutions (e.g., culverts/ecopassages).	• Road mortality.

Relative priority	Relative timeframe	Recovery theme	Approach to recovery	Threats or knowledge gaps addressed
Beneficial	Short-term	Research	**3.7** Study the impact of Wild Turkey predation and habitat disturbance on *Ambystoma* salamanders. • Establish abundance and population growth rate of Wild Turkeys. • Study foraging behaviour, habitat use and movement ecology of Wild Turkeys on Pelee Island. • Document the potential predation and habitat impacts of Wild Turkeys.	• Wild Turkey predation and habitat modification. • Threat posed by Wild Turkeys.
Beneficial	Long-term	Research	**3.8** Investigate the impact of climate change on the *Ambystoma* complex on Pelee Island.	• Climate change **o** Extent of habitat loss or degradation unknown as are the long-term effects on population viability.

Objective 4: Investigate existing, former and potential *Ambystoma* salamander habitats on Pelee Island to determine if restoration, re-introduction or population interventions would be appropriate.

Relative priority	Relative timeframe	Recovery theme	Approach to recovery	Threats or knowledge gaps addressed
Beneficial	Long-term	Inventory, Management	**4.1** Carry out investigations on existing, former and potential Small-mouthed Salamander habitats on Pelee Island in order to gather information on current conditions, human activities and land uses which would be needed to develop and implement programs for restoration, translocation, or re-introduction, if appropriate.	• Habitat loss, alteration and fragmentation. • Blue-spotted Salamander abundance and distribution on Pelee Island.

Relative priority	Relative timeframe	Recovery theme	Approach to recovery	Threats or knowledge gaps addressed
Beneficial	Long-term	Management, Research	**4.2** Investigate the need for translocation among sites, assisted colonization of new sites, or population augmentation (e.g., via *ex situ* headstarting or conservation breeding colonies) for Small-mouthed and Blue-Spotted Salamanders on Pelee Island.	• Habitat loss, alteration and fragmentation.

Objective 5: Promote stewardship, education and outreach programs for private landowners, residents and visitors on Pelee Island.

Relative priority	Relative timeframe	Recovery theme	Approach to recovery	Threats or knowledge gaps addressed
Beneficial	Short-term	Stewardship, Education and Outreach, Communication	**5.1** Develop and implement programs that engage landowners in in the conservation of *Ambystoma* salamanders on their lands.	• Habitat loss, alteration and fragmentation.
Beneficial	Short-term	Stewardship, Education and Outreach, Communication	**5.2** Develop and implement education and outreach programs for visitors and residents that would help to mitigate the negative effects of road mortality and habitat disturbance/degradation.	• Road mortality. • Habitat loss, alteration and fragmentation.
Beneficial	Ongoing	Education and Outreach, Communication	**5.3** Develop and implement educational programs to help prevent the introduction or spread of invasive species and emerging amphibian pathogens (specifically Bsal and Ranavirus). • Such programs should target both residents and visitors, especially hikers, hunters, birders and nature photographers.	• Invasive species. o Vulnerability of *Phragmites australis australis*. • Emerging pathogens (e.g., Bsal, Ranavirus).

2.4 Performance measures

The following performance measures can be used to determine whether recovery actions outlined in this recovery strategy have had beneficial effects on Small-mouthed Salamanders, the Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) or their habitats. These measures should be used within an adaptive management framework to determine if and when recovery actions outlined in this document should be adjusted. They include:

- population trends (increase/decrease), confirmation of breeding activity and recruitment;
- quantification of new/extirpated populations;
- changes in genetic composition of the salamander complex (e.g., proportion of bisexuals, relative abundance of unisexual genomotypes);
- the number and participation of stakeholders involved in related stewardship and monitoring;
- the number of locations for which identified threats have been reduced, mitigated or eliminated;
- assessment, characterization and monitoring of breeding habitat hydrology;
- increased knowledge of aquatic and terrestrial habitat (e.g., radio-telemetry research); and
- recommendations used to inform the habitat regulation process under the ESA 2007;

2.5 Area for consideration in developing a habitat regulation

Under the ESA, a recovery strategy must include a recommendation to the Minister of Natural Resources and Forestry on the area that should be considered in developing a habitat regulation. A habitat regulation is a legal instrument that prescribes an area that will be protected as the habitat of the species. The recommendation provided below by the author will be one of many sources considered by the Minister when developing the habitat regulation for this species.

Habitat protection is perhaps the most important means through which conservation efforts can ensure the long-term persistence of Small-mouthed Salamanders and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population). Protection of both breeding and terrestrial habitat is required for the species to persist.

Breeding Habitat

Given the limited geographic extent of the population in Canada, it is recommended that regulated habitat include all confirmed breeding sites on Pelee Island where Small-mouthed Salamander and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) occur. Specifically, a habitat regulation should include any

wetland, pond or vernal or other temporary pool on Pelee Island that is being used by a Small-mouthed Salamander or Unisexual *Ambystoma* or was used by a Small-mouthed Salamander or Unisexual *Ambystoma* on Pelee Island at any time during the previous ten years. A ten year time period recognizes the cryptic nature of these salamanders, the limited availability of suitable habitat, and the difficulty in conducting surveys on Pelee Island when salamanders are most detectable (e.g., during the March breeding season). Similar rationale has been used to support comparable recommendations for a habitat regulation in other highly cryptic and endangered taxa (e.g., Common Five-lined Skink (Carolinian population), Seburn 2010; King Rail, Kraus 2016). More importantly, a 10 year timeframe would allow for variation in usage of breeding sites from year-to-year, and recolonization of the few remaining breeding sites on the island following local extinction. A ten year window would encompass the eight year generation time estimated for Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) (COSEWIC 2016), plus a two year time period for new adults to reach sexual maturity. Empirical estimates of local extinction and subsequent recolonization in amphibians range widely, but routinely occur within this timeframe for many species (e.g., see Hecnar 1997, Marsh and Trenham 2001 and references therein). A study of Small-mouthed Salamanders in Indiana found egg masses in two sites that were marked as non-breeding sites ten years earlier (Summitt 2009), suggesting recolonization can occur in ten years or less. That said, recolonization of breeding sites by *Ambystoma* Salamanders following local extinction may be slow when the nearest source population is further than one kilometer away or when the breeding sites are separated by agriculture. For example, a genetic assessment of Small-mouthed Salamander migration rates within an agricultural landscape in Ohio found low rates of migration among adjacent breeding pools (Rhoads et al. 2017). In a related species (*A. macrodactylum*), five of six Montana lakes that were inhospitable to salamanders in 1978 had been subsequently colonized prior to 1997/1998 (Funk and Dunlap 1999). A separate study estimated annual breeding site colonization rates of 0.20-0.42 for *A. macrodactylum* (Hossack and Corn 2007).

Small-mouthed Salamanders generally select breeding sites that are especially shallow and ephemeral by nature (i.e., for courtship, egg laving and larval habitat). As a consequence, important breeding sites may not fill up or hold water long enough to facilitate reproduction every year due to annual variation in precipitation and water level in Lake Erie. While this can result in variable breeding activity and recruitment success from one year to next, even breeding sites that occasionally dry up prematurely remain essential habitat because they provide key breeding habitat during particularly wet years. Moreover, adult *Ambystoma* may forego migration to breeding sites for multiple successive years (Petranka 1998, Pfingsten et al. 2013).

While salamanders may use created ponds for breeding activities, artificial ponds on their own may not be enough to sustain viable populations (J. Bogart, pers. comm. 2017). That said, created breeding sites do currently provide functional breeding habitat for salamanders on Pelee Island (see **Distribution, abundance and population trends**). It is unknown whether the creation of new ponds could fully compensate for the loss or degradation of existing breeding habitat. Thus long-term protection of known breeding sites is critical.

Known breeding sites which have not been surveyed for over 10 years should undergo no fewer than three consecutive years of surveys to determine the presence of Small-mouthed Salamander or Unisexual *Ambystoma* before determining that a given breeding site is not in use. A three year survey requirement to determine salamander presence at a breeding site is consistent with requirements outlined in the Jefferson Salamander Recovery Strategy (Jefferson Salamander Recovery Team 2010).

Suitable breeding sites that are within one kilometer of a known salamander breeding site should also be included in a habitat regulation as these areas may provide important habitat in some years and would allow for population expansion. Small-mouthed Salamanders and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) may use vernal pools, woodland pools, deciduous swamps, spring-fed pools, groundwater-supported wetlands, sloughs, old deepened or created ponds or ditches. These sites should have egg attachment sites and hold water from March until late June in some or all years. Small-mouthed and Unisexual Salamanders are vulnerable to predation by fish, and therefore ponds that contain fish that prey on salamander eggs, larvae or adults are not suitable habitat until fish can be removed and recolonization prevented.

Terrestrial Habitat

All suitable terrestrial habitat extending radially 300 meters from the edge of a known Small-mouthed or Unisexual *Ambystoma* breeding site should be included in a habitat regulation. Terrestrial habitat for adults and juveniles includes woodlands, swamps, successional areas, meadows, old fields, agricultural fields and other vegetated areas that provide conditions required for foraging, dispersal, migration, growth and hibernation. Suitable terrestrial habitat will always surround or be adjacent to suitable breeding habitat, and is essential for the survival of Small-mouthed Salamanders as well as Unisexual *Ambystoma* (Small-mouthed Salamander dependent population). *Ambystoma* salamanders may cross roads or other open areas such as meadows or agricultural fields when migrating or dispersing and this habitat should be protected or managed in such a way that maintains or augments the ability of *Ambystoma* salamanders to move though these areas. While the movement ecology of salamanders on Pelee Island remains unstudied, estimates from related systems indicate that salamanders move hundreds of meters from breeding ponds during spring migrations to and from breeding sites (e.g., Bériault 2005, Hoffman 2017, Denton et al. 2017). Telemetry work conducted on mainland *Ambystoma* salamanders in Ontario guided the Jefferson Salamander Recovery Team to recommend that regulated habitat for Jefferson Salamanders include all suitable terrestrial habitat extending radially 300 m from the edge of the breeding pond (Jefferson Salamander Recovery Team 2010). Hoffmann (2017) found that the 95 percent life zone (i.e., the area we can be 95% sure will include the mean of maximum distances moved by the salamanders, not the area that includes 95% of the salamanders) for *Ambystoma laterale* (2) – *jeffersonianum* unisexual salamanders was 362 m when including data from four breeding locations. Natural history literature is limited, but suggests that Small-mouthed Salamanders may

make less extensive migrations to and from breeding ponds compared to other *Ambystoma* species (Downs 1989).

A habitat regulation should also include areas that provide suitable conditions for Small-mouthed Salamander or Unisexual *Ambystoma* to disperse and are within one kilometer of known Small-mouthed Salamander or Unisexual *Ambystoma* breeding sites. Such a recommendation is consistent with the regulated habitat for the Jefferson Salamander (Jefferson Salamander Recovery Team 2010). Moreover, this would enable intermittent use of nearby suitable habitat and allow for population expansion.

Corridors (i.e., patches of habitat that provide suitable foraging, dispersal, migration or hibernation) which connect known breeding sites that are within three kilometers of one another will be important for the long-term persistence of Small-mouthed Salamanders and Unisexual *Ambsytoma* (Small-mouthed Salamander dependent population). Corridor habitat allows for recolonization of old sites following local extinctions and facilitates gene flow (and genetic rescue) among existing sub-populations. Increasing connectivity among sub-populations is particularly important for the Pelee Island salamander complex given that existing populations are already separated by some degree of habitat fragmentation and there is no chance for genetic rescue from populations external to the island. The realized dispersal distances reported by Denton et al. (2017) suggest that, given suitable connecting habitat, Small-mouthed Salamanders and Unisexual *Ambystoma* possess dispersal capabilities that enable colonization of breeding sites several kilometers (i.e., greater than 3 km) from their natal ponds. At the present time robust delineation of corridor habitat beyond one kilometer is difficult due to the poorly understood movement ecology of Small-mouthed Salamanders and Unisexual *Ambystoma* combined with unknowns regarding the necessary width of such features. Moreover, corridor habitat linking sub-populations separated by up to three kilometers is likely to include agricultural land and private property. Therefore, areas that provide suitable conditions for Small-mouthed Salamander or Unisexual *Ambystoma* to migrate or disperse, and would link breeding sites that are separated by up to three kilometers, but are beyond one kilometer from breeding sites should be protected and enhanced through stewardship and best management practices instead of explicit inclusion within a habitat regulation at this time. Wherever possible efforts should be made to increase the connectivity of various sub-populations on the island by protecting or augmenting forested habitat between breeding sites, even when breeding sites are further than one kilometer from one another or separated by roads or agricultural fields. Note that corridors need not be continuous patches of forest, however forested habitats offer the lowest resistance to dispersing and migrating *Ambystoma* salamanders (Rothermel and Semlitsch 2002, Compton et al. 2007). Efforts to identify and improve corridor habitat should be informed by techniques such as least-cost path analysis employing resistance values from related *Ambystoma* species, such as those reported by Compton *et al* (2007).

Until the movement ecology of *Ambystoma* salamanders on Pelee Island is better documented, it is recommended to enact protection of terrestrial habitat and breeding sites that is no less stringent than existing regulations for Jefferson Salamander habitat outlined in the *Endangered Species Act* (ESA 2007). However, habitat regulations

should also incorporate contemporary knowledge about the migration and dispersal capabilities of Small-mouthed Salamanders and Unisexual *Ambystoma* (e.g., Denton et al. 2017), and be revised when data specific to populations on Pelee Island becomes available. Namely, it is recommended that the habitat regulation for Small-mouthed Salamander and Unisexual *Ambystoma* (Small-mouthed Salamander dependent population) include:

- Any wetland, pond or vernal or other temporary pool that is being used by Small-mouthed Salamander or Unisexual *Ambystoma*, or was used by a Small-mouthed Salamander or Unisexual *Ambystoma* at any time during the previous ten years.
- An area that is within 300 meters of a wetland, pond or vernal or other temporary pool that is being used by Small-mouthed Salamander or Unisexual *Ambystoma*, or was used by a Small-mouthed Salamander or Unisexual *Ambystoma* at any time during the previous ten years, on Pelee Island that provides suitable foraging, dispersal, migration or hibernation conditions for Small-mouthed Salamander or Unisexual *Ambystoma*.
- Areas that provide suitable conditions for Small-mouthed Salamander or Unisexual *Ambystoma* to disperse and are within one kilometer of known Small-mouthed Salamander or Unisexual *Ambystoma* breeding habitat.
- A wetland, pond, vernal or temporary pool that would provide suitable breeding conditions for Small-mouthed Salamander or Unisexual *Ambystoma* that is within one kilometer of a wetland, pond or vernal or other temporary pool that is being used by Small-mouthed Salamander or Unisexual *Ambystoma*, or was used by a Small-mouthed Salamander or Unisexual *Ambystoma* at any time during the previous ten years.

Exclusions

Existing houses, buildings, and structures that are within 300 meters of a breeding pond should not be included within the habitat regulation. Open areas such as agricultural fields that are within 300 meters of a breeding pond, but do not serve as corridors to forested terrestrial habitats and/or other breeding areas should also be excluded. The ESA (2007) describes species exemptions for pits and quarries that include the Small-mouthed Salamander. Where possible opportunities for stewardship and collaboration with pit and quarry operators should be sought.

Newly Discovered Occurrences

There are numerous locations on Pelee Island that have not yet been adequately surveyed to determine whether Small-mouthed Salamanders or Unisexual *Ambsytoma* are present. Surveys of breeding sites may take up to three years to sufficiently document the presence or absence of these salamanders.

Glossary

Cercaria: A free-swimming larval stage of a parasitic flatworm (also known as trematodes or flukes) during which it passes from an intermediate host (e.g. a snail) to another intermediate host or to the final vertebrate host. In some species, the cercaria will encyst in the intermediate host and rest as a metacercaria.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC): The committee established under section 14 of the Species at Risk Act that is responsible for assessing and classifying species at risk in Canada.

Committee on the Status of Species at Risk in Ontario (COSSARO): The committee established under section 3 of the *Endangered Species Act, 2007* that is responsible for assessing and classifying species at risk in Ontario.

Conservation status rank: A rank assigned to a species or ecological community that primarily conveys the degree of rarity of the species or community at the global (G), national (N) or subnational (S) level. These ranks, termed G-rank, N-rank and S-rank, are not legal designations. Ranks are determined by NatureServe and, in the case of Ontario's S-rank, by Ontario's Natural Heritage Information Centre. The conservation status of a species or ecosystem is designated by a number from 1 to 5, preceded by the letter G, N or S reflecting the appropriate geographic scale of the assessment. The numbers mean the following:

1 = critically imperilled
2 = imperilled
3 = vulnerable
4 = apparently secure
5 = secure
NR = not yet ranked

Cloaca: A common outlet into which the intestinal, urinary, and genital tracts open. It is located at the base of the tail in salamanders and becomes swollen in male *Ambystoma* during the breeding season.

Costal grooves: Indentations in the skin corresponding to the location of ribs along the sides of salamanders.

Designatable unit: Following COSEWIC criteria, a designatable unit is any wildlife species, subspecies or variety that is eligible for status assessment (see full details in COSEWIC's *Guidelines for Recognizing Designatable Units, Appendix F5*). Briefly this includes species or groups that are genetically distinct, separated by a major range disjunction, or biogeographically distinct. Normally these species must also be considered a native wildlife species that regularly occurs in Canada.

Endangered Species Act, 2007 (ESA): The provincial legislation that provides protection to species at risk in Ontario.

Genetic rescue: The natural or facilitated transfer of genes to inbred populations which results in an overall increase in genetic diversity and biological fitness (e.g., fertility, survival, longevity) in that population. Inbred populations have low genetic diversity, typically resulting from reproduction among closely related individuals in small populations, and often experience a reduction to their biological fitness.

Genome: A set of chromosomes containing the genetic material of an organism.

Hybrid: An offspring of two individuals of different species.

Life zone: The area around a breeding pond that we can be 95% sure will include the mean of maximum distances moved by the salamanders migrating away from that pond. This is not equivalent to the area that includes 95% of the salamanders. See Hoffman (2017) for more details.

Metacercaria: See cercaria above.

Metamorphosis: Change of physical form, structure or substance, such as the change from larva to adult.

Monophyletic lineage: A group of organisms that consists of all the descendants from a common ancestor. For example, genetic work using mitochondrial DNA has revealed that all Unisexual *Ambystoma* descend from a common ancestor, thus Unisexual *Ambystoma* form a monophyletic clade despite relying on various sperm donors and having nuclear DNA that is similar to their local sperm donor species.

Ploidy: The number of sets of chromosomes an organism possesses (e.g., diploid – two sets, triploid – three sets of chromosomes, tetraploid – four sets of chromosomes, pentaploid – five sets of chromosomes).

Realized dispersal distance: The distance that an individual has travelled to from its natal population.

Species at Risk Act (SARA): The federal legislation that provides protection to species at risk in Canada. This act establishes Schedule 1 as the legal list of wildlife species at risk. Schedules 2 and 3 contain lists of species that at the time the Act came into force needed to be reassessed. After species on Schedule 2 and 3 are reassessed and found to be at risk, they undergo the SARA listing process to be included in Schedule 1.

Species at Risk in Ontario (SARO) List: The regulation made under section 7 of the *Endangered Species Act, 2007* that provides the official status classification of species at risk in Ontario. This list was first published in 2004 as a policy and became a regulation in 2008.

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List of abbreviations

COSEWIC: Committee on the Status of Endangered Wildlife in Canada
COSSARO: Committee on the Status of Species at Risk in Ontario
CWS: Canadian Wildlife Service
ERCA: Essex Region Conservation Authority
ESA: Ontario's *Endangered Species Act, 2007*
ISBN: International Standard Book Number
MNRF: Ontario Ministry of Natural Resources and Forestry
NCC: Nature Conservancy of Canada
SARA: Canada's Species at Risk Act
SARO: Species at Risk in Ontario

Appendix

Table A1. Summary of NatureServe Conservation Status Ranks for the Small-mouthed Salamander (NatureServe 2017).

Jurisdiction	**Conservation Status Rank**
Global	G5
Canada	N1
Ontario	S1
USA	N5
Alabama	S3
Arkansas	S5
Illinois	S5
Indiana	S4
Iowa	S3
Kansas	S5
Kentucky	S5
Louisiana	S5
Michigan	S1
Mississippi	S5
Missouri	S5
Nebraska	S1
Ohio	SNR
Oklahoma	S5
Tennessee	S5
Texas	S5
West Virginia	S1

*See Conservation Status Rank in the Glossary for the meaning of each ranking level.

Part 3 – *Blue Racer, Lake Erie Watersnake and Small-mouthed Salamander and the Unisexual Ambystoma (Small-mouthed Salamander dependent population)* – *Ontario Government Response Statement*, prepared by the Ontario Ministry of the Environment, Conservation and Parks, 2019

Ministry of the Environment, Conservation and Parks
2019

Blue Racer, Lake Erie Watersnake and Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population)

Ontario Government

Response Statement

Protecting and Recovering Species at Risk in Ontario

Species at risk recovery is a key part of protecting Ontario's biodiversity. *The Endangered Species Act, 2007* (ESA) is the Government of Ontario's legislative commitment to protecting and recovering species at risk and their habitats.

Under the ESA, the Government of Ontario must ensure that a recovery strategy is prepared for each species that is listed as endangered or threatened. A recovery strategy provides science-based advice to government on what is required to achieve recovery of a species.

Within nine months after a recovery strategy is prepared, the ESA requires the Ontario government to publish a statement summarizing the government's intended actions and priorities in response to the recovery strategy. The response statement is the government's policy response to the scientific advice provided in the recovery strategy. In addition to the strategy, the government response statement considered (where available) input from

Ontario

Indigenous communities and organizations, stakeholders, other jurisdictions, and members of the public. It reflects the best available local and scientific knowledge, including Traditional Ecological Knowledge where it has been shared by communities and Knowledge Holders, as appropriate and may be adapted if new information becomes available. In implementing the actions in the response statement, the ESA allows the government to determine what is feasible, taking into account social, cultural and economic factors.

The recovery strategies for the Blue Racer (*Coluber constrictor foxii*), the Lake Erie Watersnake (*Nerodia sipedon insularum*) and the Small-mouthed Salamander (*Ambystoma texanum*) in Ontario were completed on March 2, 2015. On May 30, 2018, an updated and expanded recovery strategy for Small-mouthed Salamander (*Ambystoma texanum*) and Unisexual Ambystoma (Small-mouthed Salamander dependent population) (*Ambystoma laterale – texanum*) was finalized. Unisexual Ambystoma (Small-mouthed Salamander dependent population) are also referred to as Small-mouthed Salamander dependent unisexuals in this document. Given their similar distribution and threats, the recovery efforts for the Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander, and Small-mouthed Salamander dependent unisexuals are addressed collectively in a single government response statement, which has been updated following the completion of the updated recovery strategy noted above. The combined government response statement also recognizes the importance of collaborative implementation of recovery actions with partners on Pelee Island. This GRS does not aim to outline additional habitat protection for the four species; at this time, the general habitat protection under the ESA already in place will continue to apply.

Blue Racer habitat. Photo by Joe Crowley

The Blue Racer is a large, non-venomous snake that can grow up to 1.5 m in length. Adult Blue Racers are greyish-blue in colour with a white, cream or bluish-white belly and a characteristic black mask. Juveniles have dark blotches along their body that eventually fade completely.

Pelee Island

The Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander, and Small-mouthed Salamander dependent unisexuals are all found on Pelee Island. Within Canada, Blue Racer, Small-mouthed Salamander and Small-mouthed Salamander dependent unisexuals are known to occur exclusively on Pelee Island. Within Canada, the largest population of Lake Erie Watersnake occurs on Pelee Island. Pelee Island is located in the western basin of Lake Erie and has a vast amount of biodiversity and a rich cultural heritage. The community of Pelee Island celebrates its natural history. The Township of Pelee works with private landowners and partner organizations to create and expand nature reserves on the island and works to integrate other conservation-focused initiatives.

The Official Plan for the Township of Pelee outlines in the overall objectives the importance of understanding the value of the island's natural heritage, of fostering stewardship of the natural environment, and of protecting and enhancing the natural environment of the island. An environmental advisory committee for Pelee Island has also been formed to bring together representatives from the municipality, non-governmental organizations, the local conservation authority and provincial ministries to cooperate on issues of

Lake Erie Watersnake habitat. Photo by Joe Crowley

The Lake Erie Watersnake is a non-venomous, highly-aquatic snake that is rarely found far from the shoreline. It averages between 59 and 88 cm and is pale grey to dark brown in colour, with ranging patterns of darker brown or reddish blotches on the back and sides that often connect to form a banding pattern.

environmental importance. The Pelee Island community actively collaborated to support the Nature Conservancy of Canada (NCC) in purchasing over 10% of the island (435 ha) for the proactive preservation of priority conservation lands. Additional lands owned by a variety of land owners and managers are also in conservation ownership for a total of 18% of the island set aside for conservation purposes. The municipality, private landowners and NCC have also taken multiple additional steps to protect and support biodiversity on Pelee Island:

- In order to reduce road impacts to species, the municipality has significantly lowered speed limits on almost all roads on the island.
- Through the updating of waste disposal methods, the Township of Pelee has allowed for previous retaining ponds that were constructed to progress into functioning wetlands.
- All municipal infrastructure projects include site-specific collaboration with the local conservation authority, local Indigenous communities and organizations, and pertinent provincial and federal ministries.
- The municipality has intentionally created endangered species habitat such as snake hibernacula.
- To benefit both terrestrial and aquatic species, many stretches of shoreline habitat are being actively preserved and restored using native vegetation and materials.

The Small-mouthed Salamander is a medium-sized, heavy-bodied salamander that is dark brown to greyish-black with gray-blue patches that resemble lichen on its tail and sides. It can grow to a maximum length of about 18 cm and has a relatively small head and a short, narrow snout.

Small-mouthed Salamander and Unisexual Amybstoma (Small-mouthed Salamander dependent population) habitat. Photo by Joe Crowley

- Many private landowners continue to preserve natural habitat, construct and protect wetlands, plant native species, and use low impact farming practices on their individual properties to support biodiversity and the natural heritage of Pelee Island.
- With the support of the municipality, NCC has secured key natural areas including three alvars, critical shoreline and forested swamp areas. NCC also continues to restore agricultural lands to create habitat corridors and buffers and enhance connectivity for species.
- NCC has implemented a community-based conservation plan to protect key biodiversity features and functions, while supporting continuation of existing land uses and expansion of the island's ecotourism-based economy.
- The municipality, community members, NCC and other partners collaborate to exchange knowledge, promote the island's unique wildlife, interpret the natural surroundings for visitors and promote natural heritage events.

There are a variety of land uses on Pelee Island, including agriculture, hunting, recreation and tourism. Given the island formation, a finite amount of land is available to carry out all activities, which may result in competing land uses. The community's health, as well as prosperity, fundamentally rely on biodiversity and the ecosystem services it provides, such as food, clean water, fresh air and fertile soil. All of these factors highlight the importance of mobilizing partnerships and collectively working to conserve biodiversity while supporting local economic sustainability.

Protecting and Recovering the Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population)

The Blue Racer, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population) are listed as endangered species under the ESA, which protects both the animals and their habitat. The ESA prohibits harm or harassment of endangered and threatened species and damage or destruction of their habitat without authorization. Such authorization would require that conditions established by the government be met.

The Lake Erie Watersnake is listed as special concern under the ESA. The species was downlisted provincially from endangered to special concern on June 2, 2017, based on the Committee on the Status of Species at Risk in

The Unisexual Ambystoma (Small-mouthed Salamander dependent population), which co-exist with Small-mouthed Salamanders, are intermediate in appearance to other mole salamander species it co-exists with but cannot be readily distinguished from these species without genetic testing.

Ontario's (COSSARO) assessment. The species is included in this GRS to foster continued stewardship and in recognition of the value of collective efforts to conserve biodiversity.

A collaborative, stewardship first approach that partners the municipality, the provincial and federal governments, and local partners is intended to meet both the needs of the community and of the species that help contribute to the island's biodiversity, including Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander and Small-mouthed Salamander dependent unisexuals.

Blue Racer

The historical distribution of the Blue Racer in North America ranges from extreme southwestern Ontario, west to Minnesota, south to Illinois and east to Ohio. In the United States, the only states with current populations of the Blue Racer are Ohio, Indiana, Illinois, Michigan, Wisconsin and Iowa. In Canada, Blue Racers have disappeared from the mainland in southwestern Ontario and this species is now known to only occur on Pelee Island. Blue Racers inhabit forest edges and dry, open to semi-open habitat types such as alvars, savannahs, grasslands and thickets. They exhibit high fidelity to hibernation sites, which are usually underground cavities that are accessed through cracks and fissures in the bedrock.

The primary threat to the Blue Racer is habitat loss, largely due to succession of vegetation communities. Historically, clearing of land for agriculture and development posed a major threat but has been less significant in recent years. As woody plants succeed in the ecosystem, suitable habitat features for the species disappear, such as open canopies, dry open to semi-open areas, and edge habitat. As is the case with most snake species, road mortality and persecution are also significant threats to the Blue Racer. Working together to reduce negative perceptions of snakes is an important component of conserving biodiversity and addressing these threats for all snake species. It is possible that chemical contamination poses a threat to the species and that introduced Wild Turkeys (*Meleagris gallopavo*) may pose a threat as a potential new predator, though the extent of these potential threats is currently unknown. Continuing to increase the level of knowledge and understanding of interactions between introduced Wild Turkeys and Blue Racers will be of value.

Population estimates for the Blue Racer have not been completed since 2002, when the combined population size for three study sites on Pelee Island was estimated to be approximately 140 adult Blue Racers.

The possible population range identified through this study was 59 to 284. Hatchlings and juveniles have been observed as recently as 2015, suggesting that the population is successfully reproducing. However, anecdotal evidence from some research and site visits since 2002 suggest the Canadian population of the Blue Racer may have experienced further decline in recent years, and a decline in overall habitat quality and quantity has also been noted at several occupied sites on the island.

Given the small population size found in 2002, anecdotal evidence of potential decline since that time, and the threats to the Blue Racer and its habitat, approaches to recovery should focus on working together to increase the level of knowledge of the species, increase the amount of suitable habitat available for the Blue Racer and minimize threats to the species to enable natural increases in the species' population.

Government's Recovery Goal for the Blue Racer

The government's goal for the recovery of the Blue Racer in Ontario is to maintain the species' distribution and ensure a viable, self-sustaining population.

Lake Erie Watersnake

The Lake Erie Watersnake is a subspecies of the Northern Watersnake (*Nerodia sipedon*) and is endemic to the islands of Lake Erie and a small peninsula on the Ohio mainland. Previously listed as endangered in Ontario, the species was downlisted to special concern in June 2017 based on updated information that informed COSSARO's assessment. In Ontario, Lake Erie Watersnakes are known to occur on Pelee, East Sister, and Middle Islands. This species was previously known to also occur on Hen, North Harbour and Middle Sister Islands. Recent data suggest that it is likely extirpated from North Harbour and Middle Sister Islands. However, surveys have not occurred on Hen Island, which is privately owned, since the early 1990s. As a result, the 2016 Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status report identifies that the species' status on Hen Island is currently unknown. Hen, East Sister, North Harbour, and Middle Sister Islands all lie northwest of Pelee Island in Lake Erie, while Middle Island lies south of the southwest corner of Pelee Island.

Lake Erie Watersnakes are highly aquatic and rarely travel inland more than 50 m from the shoreline during the active season, although they will travel greater distances inland to hibernation sites. Adult snakes may hibernate singly or communally, using underground cavities, burrows, or human-made structures such as old wells or building foundations.

As indicated in scientific literature, significant threats to snakes such as the Lake Erie Watersnake are road mortality and persecution. The colouration of Lake Erie Watersnakes can make them difficult to see against unpaved or dust covered roads. Additionally, fear or dislike of snakes can foster negative human behaviours that may result in harm to individual snakes. Habitat loss due to shoreline development, vegetation clearing, increased presence of shoreline invasive species such as Phragmites (European Common Reed) (*Phragmites australis* ssp. *australis*), and removal of winter hibernation habitat is also a significant threat to the species. Other possible threats to the Lake Erie Watersnake include environmental contaminants and adverse effects of high-density nesting or roosting areas of waterbirds, such as Double-crested Cormorants (*Phalacrocorax auritus*), on habitat.

Populations of the Lake Erie Watersnake experienced historical declines, but may have stabilized in recent years; there is insufficient data to document population trends of Lake Erie Watersnake in Canada. An increase in the abundance of the invasive Round Goby (*Neogobius melanostomus*), which has become an important food source for the Lake Erie Watersnake, has shown to have increased populations in the United States. It is unknown whether there has been a similar effect in Canada due to potential differences in the magnitude of threats that are faced by the species. In 2016, the Committee on the Status of Endangered Wildlife in Canada estimated the number of mature individuals on Pelee Island to be 3,286, and estimated approximately another 200 individuals inhabiting the other islands. Approaches to recovering the Lake Erie Watersnake will focus on minimizing the threats of accidental and intentional human-caused mortality by increasing public awareness and understanding on managing its habitat to support the current abundance and distribution of the species in Ontario.

Government's Recovery Goal for the Lake Erie Watersnake

The government's goal for the recovery of the Lake Erie Watersnake is to maintain the current abundance and distribution of the species in Ontario.

Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population)

The Small-mouthed Salamander ranges from eastern Texas to western Alabama and across the central United States, reaching its northern range in Michigan, northern Ohio and Pelee Island in Ontario. The global population is thought to exceed 100,000 but is unknown. In Canada, the species is only known to occur on Pelee Island. Small-mouthed Salamander dependent unisexuals have been found in Michigan, Indiana and Ohio, and several Lake Erie islands. The full global distribution and population are uncertain because

genetic testing is required to identify these animals and this has not occurred for many populations. In Canada, the Small-mouthed Salamander dependent unisexuals are only known to occur on Pelee Island.

Small-mouthed Salamanders, Unisexual Ambystoma (Small-mouthed Salamander dependent population) and Blue-spotted Salamanders (*Ambystoma laterale*) (not at risk) all co-occur on Pelee Island. Unisexual Ambystoma (Small-mouthed Salamander dependent population) is a genetically distinct, all-female salamander lineage that depends on the other two salamander species to carry out reproduction.

Small-mouthed Salamander and Small-mouthed Salamander dependent unisexuals in Ontario are known historically to occur at five breeding sites on Pelee Island, but the most recent survey efforts (2015-2017) found Small-mouthed Salamanders and Small-mouthed Salamander dependent unisexuals at only three of those five breeding sites. These surveys did, however, identify three additional breeding sites in use by the two species on Pelee Island for a total of six confirmed sites. The status of one additional breeding site, and the current population abundance, are unknown.

The Small-mouthed Salamander and Small-mouthed Salamander dependent unisexuals are members of the Mole Salamander family (*Ambystomatidae*), a family name that refers to the biological characteristic of spending most of their time underground or beneath cover except when breeding.

All Unisexual Ambystoma (Small-mouthed Salamander dependent population) salamanders are females and have a unique reproductive strategy whereby the sperm from male Small-mouthed Salamanders or Blue-spotted Salamanders is needed to initiate egg development. Their offspring are unique in that they are also all females and are all considered Unisexual Ambystoma (Small-mouthed Salamander dependent) regardless of what species' sperm initiated egg development. While the sperm may or may not be incorporated into the Small-mouthed Salamander dependent unisexual egg, the species does not appear to be able to reproduce in the absence of a Small-mouthed Salamander or Blue-spotted Salamander. Therefore, the persistence of the Unisexual species is dependent on the presence of the other salamander species.

It is thought that these three species that make up the salamander complex on Pelee Island were isolated together in the area roughly 4000 years ago. Small-mouthed Salamander dependent unisexuals vastly outnumber both Small-mouthed and Blue-spotted Salamanders, making up over 80 percent

of all the Ambystoma salamanders on the island. Recent survey efforts examined more than 830 samples (adults and larvae) on Pelee Island collected from 2015 to 2017 and found that unisexuals made up over 95 percent of the sample (Hossie and Murray 2017).

The habitat needs of both species include: fish-free, shallow water bodies that retain water from March through July, used for breeding, and adjacent suitable terrestrial areas that are shaded and provide soft moist soils, logs, rocks and leaf litter that are used for cover, shelter and overwintering.

The main threats to the species are habitat degradation, loss and fragmentation. This includes the temporary or permanent loss of water from breeding sites during critical periods, and the loss of forest canopy cover, rotting logs and other ground cover. Small-mouthed Salamanders and Small-mouthed Salamander dependent unisexuals rely on wetlands site and ephemeral pools of water (i.e., temporary pools that form in the spring and typically dry up in the summer) for breeding; therefore, activities and climate conditions that affect the hydrology of the habitat and surrounding areas also pose a threat. Threats from invasive species, such as Phragmites, can also reduce suitable habitat conditions for the species. While environmental contaminants (e.g., pesticides, de-icing salt) are known to affect amphibians, the local impacts of environmental contaminants on Small-mouthed Salamander and Small-mouthed Salamander dependent unisexuals are unknown. Additional potential threats to the species include disease (e.g., ranaviruses, chytrid fungi) and predation and habitat alteration caused by Wild Turkeys. As the relative impacts of many of these potential and known threats on local populations are currently unknown, further research is necessary to support recovery actions for the species.

The Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent) populations on Pelee Island are small and the salamanders themselves are difficult to distinguish from other salamander species without the assistance of genetic testing. Continuing to manage the salamander complex will support recovery for all associated salamander species at risk. Given the lack of population estimates, there is a need to focus on conducting inventories of recent breeding sites and monitoring population trends and habitat usage. Approaches to recovery will focus on working in collaboration with the local community to monitor current populations, manage current habitat effectively, increase the amount of suitable habitat available for Small-mouthed Salamander and dependent unisexuals, and increase our knowledge of potential threats to the species.

Government's Recovery Goal for the Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population)

The government's goal for the recovery of the Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population) is to ensure long-term viability and persistence of the Ontario populations by managing threats and increasing population abundance, distribution and connectivity.

Actions

Protecting and recovering species at risk is a shared responsibility. No single agency or organization has the knowledge, authority or financial resources to protect and recover all of Ontario's species at risk. Successful recovery requires inter-governmental co-operation and the involvement of many individuals, organizations and communities. In developing the government response statement, the government considered what actions are feasible for the government to lead directly and what actions are feasible for the government to support its conservation partners to undertake.

Government-led Actions

To help protect and recover the Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population) the government will directly undertake the following actions:

- Explore opportunities to work collectively with the Township of Pelee, including the Pelee Island Environmental Advisory Committee, the federal government and local partners to develop an integrated (landscape/place-based) approach to managing species at risk with consideration of ecosystem values and sustainable resources on Pelee Island. This may include:
  - developing a strategic plan for species at risk and their habitats on Pelee Island;
  - continuing to implement the Ontario Invasive Species Strategic Plan to address the invasive species (e.g., Phragmites) that threaten Lake Erie Watersnake, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population);
  - continuing to implement Ontario's *Invasive Species Act* to address the invasive species identified in the Act (e.g., Phragmites) that threaten Lake Erie Watersnake, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population);

- supporting the coordination of provincial and federal species at risk legislation (i.e., ESA and *Species at Risk Act* (SARA)), in order to collaboratively continue to protect Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population) and their habitats; and,
- educating other agencies and authorities involved in planning and environmental assessment processes on the ESA.

- Explore opportunities to work collectively with the Township of Pelee, including the Pelee Island Environmental Advisory Committee, the federal government and local partners to integrate approaches to stewardship and implementation of recovery activities including:
  - encouraging collaboration, and establishing and communicating annual priority actions for government support in order to reduce duplication of stewardship efforts;
  - supporting conservation, agency, municipal and industry partners, and Indigenous communities and organizations to undertake activities to protect and recover Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population). Support will be provided where appropriate through funding, agreements, permits (including conditions) and advisory services;
  - undertaking communication and outreach to increase public awareness of species at risk in Ontario; and,
  - encouraging the submission of Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population) data to the Ontario's central repository through the citizen science projects that they receive data from (e.g., the Ontario Reptile and Amphibian Atlas) and directly through the Natural Heritage Information Centre.
- Continue to monitor, protect and manage habitat for the four species in protected areas on Pelee Island (e.g., Lighthouse Point and Fish Point Provincial Nature Reserves). Continue to work collaboratively with local partners to enhance and restore habitat for species at risk within these protected areas.

Government-supported Actions

The government endorses the following actions as being necessary for the protection and recovery of the Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population). Actions identified as "high" may be given priority consideration for funding under the Species at Risk Stewardship Program. Where reasonable, the government will also consider the priority assigned to these actions when reviewing and issuing authorizations under the ESA. Other organizations are encouraged to consider these priorities when developing projects or mitigation plans related to species at risk.

Focus Area: **Habitat Management**
Objective: Work collaboratively to increase habitat quality for the Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population).

Habitat loss and degradation is a significant threat to all four species. A landscape level approach to habitat management for the species recognizes the finite amount of land available on Pelee Island. Collectively working to develop and implement best management practices will support habitat management and restoration for the four species, particularly for the Blue Racer, Small-mouthed Salamander and Small-mouthed Salamander dependent unisexauls as habitat is very limited. Without active management of Blue Racer habitat, the open to semi-open habitat succeeds (e.g., shrubs and trees grow in) over time and becomes unsuitable for the species. In the case of Small-mouthed Salamander and the Small-mouthed Salamander dependent unisexuals, the species rely on ephemeral pools and wetlands and suitable adjacent terrestrial areas. As a result, activities impacting the hydrology or tree canopy of these areas could have substantial consequences for these species. Cooperative, preventative efforts to manage habitat for suitability over the long-term will greatly assist in reducing these impacts.

Actions:

1. **(High)** Using community knowledge and species expertise, develop, promote and implement best management practices to manage existing habitat for the Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population) including:
   - prescribed burns to prevent woody succession in Blue Racer habitat, with consideration for the safety of neighbouring properties, snakes and other rare species present on-site;

- targeted removal of native or invasive woody vegetation in Blue Racer habitat, with consideration for other species at risk, using appropriate and approved methods;
- removal of invasive species such as Phragmites along shoreline habitat for Lake Erie Watersnake and at known breeding sites for Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population);
- managing vegetation to support suitable habitat conditions and maintaining appropriate wetland and forested habitat features such as cover objects and forest cover for Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population);
- buffering against potential site-level effects of environmental contaminants on water quality in Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population) breeding habitat; and,
- managing existing and new infrastructure, such as drainage works, in a way that reduces the negative effects on Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population) habitat, with additional consideration for neighbouring properties.

2. Collaborate with community members and organizations to strategically increase the amount of suitable habitat available for Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population) by:

Blue Racer (High)

- identifying and assessing existing habitat and identifying candidate areas for habitat enhancement, restoration and creation where there are willing partners;
- creating a mosaic of suitable habitat types such as grassland, savannah and edge habitat, with a focus on increasing connectivity between suitable habitat patches;
- creating hibernation, nesting and shelter habitats and monitoring and documenting their effectiveness;

Lake Erie Watersnake

- identifying and assessing existing habitat and identifying candidate areas for habitat enhancement, restoration and creation where there are willing partners;
- restoring shoreline habitat and increasing structural heterogeneity, and increasing connectivity between areas of habitat;
- creating suitable hibernation and shelter habitats and monitoring and documenting their effectiveness;

Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population) (High)

- identifying and assessing existing habitat and identifying sites adjacent to or between known locations for potential habitat enhancement, restoration and creation where there are willing partners; and,
- enhancing, restoring and creating suitable habitat such as ephemeral pools and surrounding forested areas in appropriate areas.

3. **(High)** Work with local partners to maintain adequate water levels and quality, and hydrology that sustain the breeding sites and migratory routes for Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population). This may include buffering for the potential effects of climate change on water levels in the future and exploring opportunities to support hydrology at a watershed scale (e.g., restoring riparian habitat).

Focus Area: **Awareness and Threat Management**
Objective: Work in partnership with the Pelee Island community to reduce threats to the Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population) through increasing public awareness, promoting local stewardship of the species and their habitats, and implementing threat mitigation techniques.

Landowners, local residents and visitors to Pelee Island have an important role to play in the protection and recovery of the Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population). Increasing public awareness and promoting local stewardship are critical to addressing key threats such

as road mortality and persecution. Efforts to increase awareness should build off of work completed to date by conservation partners and other jurisdictions, such as the resources and programs developed in the U.S. to support Lake Erie Watersnake recovery. Steps taken in the future to mitigate threats to the species and their habitat can build on research conducted in the coming years. A continued collaborative approach that focuses on stewardship of the species and their habitat will support the effective implementation of protection and recovery actions.

Actions:

4. **(High)** Collaborate with local organizations and initiatives to reduce threats to the species, including road mortality and persecution. For example:
   - developing programs to reduce road mortality, which may include installing signs and publicizing the need for cautious driving, particularly in areas of high mortality for these species;
   - producing educational materials to increase public awareness, such as promoting the need to share the shoreline with Lake Erie Watersnakes; and,
   - implementing techniques to reduce rates of road mortality (e.g., ecopassages, barrier fencing, traffic calming measures), particularly in areas of high mortality for these species.
5. Promote local stewardship of the Blue Racer and the Lake Erie Watersnake that includes:
   - developing social marketing strategies to help influence public perceptions and behaviours that negatively affect snake populations;
   - producing stewardship publications to highlight success stories and engage the public in snake conservation; and,
   - increasing awareness of incentive programs and how landowners can benefit from protecting and restoring Blue Racer and Lake Erie Watersnake habitat.

Focus Area: **Inventory and Monitoring**
Objective: Improve knowledge of species' population trends, habitat usage and distribution.

Little is known about the current abundance, local distribution, habitat usage, and population trends of Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population). A greater understanding of the four

species' current population abundance is essential to support the ability to monitor progress and effectiveness of recovery actions and population trends over time. Further information on these topics, as well as additional surveying for potential presence at historical and potential locations would contribute to greater understanding of the status of the four species.

Actions:

6. Collaborate with local partners and community members to develop and implement survey and monitoring programs to:

Blue Racer (High) and Lake Erie Watersnake

- estimate the population abundance and distribution of the Blue Racer and the Lake Erie Watersnake and monitor trends over time;
- monitor changes in Blue Racer and Lake Erie Watersnake use and suitability of habitat;
- identify areas with high rates of road mortality between occupied habitats;
- survey for the Lake Erie Watersnake on other Lake Erie islands (e.g., Hen, Middle Sister and North Harbour Islands), where feasible, in order to determine if the species is still present in these areas;

Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population) (High)

- estimate the population abundance and distribution of both salamander species at known sites;
- estimate the proportion of each species relative to the salamander complex;
- monitor suitability of habitat including terrestrial (e.g., canopy cover, soil moisture and cover object availability) and aquatic (e.g., water level, pH, pollutants and fish presence) features;
- monitor population trends and monitor changes in genetic composition and recruitment of the salamander complex over time;
- identify areas with high rates of road mortality between occupied habitats; and,
- survey for the two species at potential sites with suitable habitat in order to identify additional populations and refine knowledge on the distribution of the salamander species.

Focus Area: **Research and Population Management**
Objective: Increase knowledge of threats to the species, species-specific habitat requirements and ecological limitations.

Knowledge gaps related to specific habitat requirements and the significance of threats currently exist for all four species. Investigating and filling these knowledge gaps will help to better inform the implementation of recovery actions for these species, such as habitat management efforts and road mortality reduction techniques. Improving our knowledge of the salamander complex on Pelee Island, including genetic composition and any associated limitations, will support future recovery efforts. Increasing our understanding of potential emerging threats, such as disease and climate change, will also support effective mitigation if needed in the future. For both Blue Racer and the two salamander species, impacts of potential diseases could lead to significant impacts given their small population sizes.

Actions:

7. Investigate the structural, thermal and chemical properties of hibernation and nest/gestation sites to inform the creation and maintenance of these sites for the Blue Racer and the Lake Erie Watersnake. Assess the effectiveness of created hibernation habitats.
8. Research Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population) habitat use (e.g., breeding sites, migration routes and overwintering sites) and habitat connectivity (including dispersal barriers).
9. Investigate the effectiveness of techniques to create breeding ponds for the two salamander species, including the factors that influence the quality of created breeding habitats.
10. Investigate the effects and severity of known and potential threats to Blue Racer and Lake Erie Watersnake, and identify potential mitigation measures as appropriate, including:
    - examining the potential effects of Double-crested Cormorants and Wild Turkeys on the species and/or their habitat; and,
    - investigating the potential effects of disease (e.g., Snake Fungal Disease) and other identified threats to the species and their habitat.

11. Investigate the effects and severity of known and potential threats to Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population), and identify potential mitigation measures as appropriate, including:
    - investigating the extent that environmental contaminants are directly or indirectly affecting the productivity and/or survival rates of the two salamander species;
    - examining the potential effects on the salamander complex of predation by Wild Turkeys and habitat alteration caused by the turkeys;
    - investigating the potential effects of climate change on the species and their habitat, and the relationship between habitat suitability and hydrology; and,
    - investigating the potential effects of disease (e.g., ranaviruses, chytrid fungi), and parasites (e.g., trematode) on Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population).
12. Conduct assessments to determine population targets for achieving self-sustaining and genetically viable Blue Racer, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent) populations in Ontario.
13. Investigate the ecological relationships in the Ambystoma salamander complex on Pelee Island to assess potential demographic constraints to species' recovery (e.g., related to reproductive output, recruitment, and survival in the larval and adult life stages).
14. Investigate the potential need for, and feasibility of, assisted recruitment techniques to support the recovery goal for Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population). If found to be feasible and necessary, implement, evaluate, adapt and improve recruitment techniques with consideration for the species' ecology and the salamander complex as a whole. An example of a priority recruitment technique is:
    - exploring the potential benefits and need for a cost-effective head-starting protocol/program (e.g., reproductive monitoring, artificial incubation of eggs, and release of juveniles).

Implementing Actions

Financial support for the implementation of actions may be available through the Species at Risk Stewardship Program. Conservation partners are encouraged to discuss project proposals related to the actions in this response statement with program staff. The Ontario government can also advise if any authorizations under the ESA or other legislation may be required to undertake the project.

Implementation of the actions may be subject to changing priorities across the multitude of species at risk, available resources and the capacity of partners to undertake recovery activities. Where appropriate, the implementation of actions for multiple species will be co-ordinated across government response statements.

Reviewing Progress

The ESA requires the Ontario government to conduct a review of progress towards protecting and recovering a species not later than five years from the publication of this response statement. The review will help identify if adjustments are needed to achieve the protection and recovery of the Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population).

Acknowledgement

We would like to thank all those who participated in the development of the recovery strategies for the Blue Racer, Lake Erie Watersnake, Small-mouthed Salamander and Unisexual Ambystoma (Small-mouthed Salamander dependent population) for their dedication to protecting and recovering species at risk.

For additional information:
Visit the species at risk website at ontario.ca/speciesatrisk
Contact the Natural Resources Information Centre
1-800-667-1940
TTY 1-866-686-6072
mnr.nric.mnr@ontario.ca