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

Recovery Strategy for the Tiger Salamander (*Ambystoma tigrinum*) Southern Mountain population in Canada

Tiger Salamander, Southern Mountain population

2017

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

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[1] http://sararegistry.gc.ca/default.asp?lang=En&n=24F7211B-1

RECOVERY STRATEGY FOR THE TIGER SALAMANDER (*Ambystoma tigrinum*) SOUTHERN MOUNTAIN POPULATION IN CANADA

2017

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 British Columbia has given permission to the Government of Canada to adopt the *Recovery Plan for the Blotched Tiger Salamander (*Ambystoma mavortium*) in British Columbia* (Part 2) 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 recovery strategy.

The federal recovery strategy for the Tiger Salamander[2] (*Ambystoma tigrinum*) Southern Mountain population in Canada consists of two parts:

Part 1 – Federal Addition to the *Recovery Plan for the Blotched Tiger Salamander (*Ambystoma mavortium*) in British Columbia*, prepared by Environment and Climate Change Canada.

Part 2 – *Recovery Plan for the Blotched Tiger Salamander (*Ambystoma mavortium*) in British Columbia*, prepared by the Southern Interior Reptile and Amphibian Working Group for the British Columbia Ministry of Environment.

[2] This species is currently referred to as the Western Tiger Salamander (*Ambystoma mavortium*) by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2012) and is referred to as the Blotched Tiger Salamander (*Ambystoma mavortium*) provincially. All three names refer to the same population.

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Part 2 – *Recovery Plan for the Blotched Tiger Salamander (*Ambystoma mavortium*) in British Columbia*, prepared by the Southern Interior Reptile and Amphibian Working Group for the British Columbia Ministry of Environment.

Part 1 – Federal Addition to the *Recovery Plan for the Blotched Tiger Salamander (*Ambystoma mavortium*) in British Columbia*, 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)[3] agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of recovery strategies for listed Extirpated, Endangered, and Threatened species and are required to report on progress within five years after the publication of the final document on the SAR Public Registry.

The Minister of Environment and Climate Change is the competent minister under SARA for the Tiger Salamander, Southern Mountain population, and has prepared the federal component of this recovery strategy (Part 1), as per section 37 of SARA. To the extent possible, it has been prepared in cooperation with the Province of British Columbia, as per section 39(1) of SARA. SARA section 44 allows the Minister to adopt all or part of an existing plan for the species if it meets the requirements under SARA for content (sub-sections 41(1) or (2)). The Province of British Columbia provided the attached recovery plan for the Blotched Tiger Salamander (*Ambystoma mavortium*) (Part 2) as science advice to the jurisdictions responsible for managing the species in British Columbia. It was prepared in cooperation with Environment and Climate Change Canada.

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 Tiger Salamander, Southern Mountain 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 the species, including identification of critical habitat to the extent possible. It provides all Canadians with information to help take action on species conservation. When critical habitat is identified, either in a recovery strategy or an action plan, SARA requires that critical habitat then be protected.

[3] http://registrelep-sararegistry.gc.ca/default.asp?lang=en&n=6B319869-1#2

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 federal 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 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.

[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.

Acknowledgements

The development of this recovery strategy addition was coordinated by Kella Sadler, Matt Huntley, and David Cunnington (Environment and Climate Change Canada, Canadian Wildlife Service - Pacific Region (ECCC CWS-PAC). Kristiina Ovaska and Lennart Sopuck (Biolinx Environmental Research Ltd.) compiled information for the first draft of this recovery strategy under contract with Environment and Climate Change Canada. Substantial input and/or collaborative support was provided by Orville Dyer (B.C. Ministry of Forest, Lands and Natural Resource Operations), Jared Hobbs (Hemmera Envirochem Inc.), Karl Larsen (Thompson Rivers University), Sara Ashpole (St. Lawrence University), Mike Sarrell (Ophiuchus Consulting), Lisa Tedesco (B.C. Ministry of Forests, Lands, and Natural Resource Operations), Christine Bishop (ECCC- Science and Technology), Purnima Govindarajulu, Peter Fielder (B.C. Ministry of Environment), and Dave Trotter (B.C. Ministry of Agriculture), and Paul Johanson and Andres De Vleeschauwer (ECCC CWS – National Capital Region). Sean Butler and Danielle Yu (ECCC CWS-PAC) provided additional assistance with mapping and figure preparation.

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 Plan for the Blotched Tiger Salamander (*Ambystoma mavortium*) in British Columbia* (Part 2 of this document, referred to henceforth as "the provincial recovery plan") and/or to provide updated or additional information.

The Tiger Salamander (*Ambystoma tigrinum*) was originally assessed by COSEWIC in November 2001 as three separate populations: Great Lakes population (Extirpated), Prairie / Boreal population (Not at Risk), and Southern Mountain population (Endangered). In November 2012, Tiger Salamander was split into two separate species, Eastern Tiger Salamander (*Ambystoma tigrinum*) and Western Tiger Salamander (*Ambystoma mavortium*), each with two different designatable units (populations); designatable units are considered Wildlife Species under SARA and are assessed separately. The two Western Tiger Salamander (*Ambystoma mavortium*) designatable units include the Prairie / Boreal population (assessed as Special Concern), and the Southern Mountain population (assessed as Endangered). Following the COSEWIC assessment, Environment and Climate Change Canada carried out consultations with the public and stakeholders on the populations eligible for a change in status and analyses of the socioeconomic impact of the proposed regulatory changes. Once the analyses are completed, the Minister of the Environment will make recommendations to the Governor in Council for decision. Until Schedule 1 of SARA is amended, the species' remains Tiger Salamander (*Ambystoma tigrinum)* Southern Mountain population. The name Blotched Tiger Salamander, used in the provincial recovery plan, refers to the same population as Tiger Salamander (*Ambystoma tigrinum)* Southern Mountain population (SARA), and Western Tiger Salamander (*Ambystoma mavortium*) Southern Mountain population (COSEWIC 2012). Henceforth, all references in this document to "Tiger Salamander" in B.C. refers to the same population.

Under SARA, there are specific requirements and processes set out regarding the protection of critical habitat. Therefore, statements in the provincial recovery plan referring to protection of survival/recovery 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.

1. Critical Habitat

This section replaces "Section 7.1: Description of the Species' Survival/Recovery Habitat" in the provincial recovery plan.

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. The provincial recovery plan for Tiger Salamander

includes a description of the biophysical attributes of survival/recovery habitat. This science advice was used to inform the following critical habitat sections in this federal recovery strategy.

Critical habitat is partially identified in this recovery strategy. A schedule of studies (Section 1.2) has been included that identifies the activities required to complete the identification of critical habitat in supporting the population and distribution objectives.

Critical habitat for Tiger Salamander Southern Mountain population is identified in this document to the extent possible; as responsible jurisdictions and/or other interested parties conduct research to address knowledge gaps, the existing critical habitat methodology and identification may be modified and/or refined to reflect new knowledge.

1.1 Identification of the Species' Critical Habitat

Geospatial location of areas containing critical habitat

Critical habitat for Tiger Salamander Southern Mountain population is identified in three geographic areas in the southern interior of British Columbia. These three geographic areas align with those described in the provincial recovery plan (i.e., Figure 3 of that document):

- Okanagan-Similkameen (Figures 1 & 2)
- Midway (Figure 3)
- Grand Forks (Figure 4)

Critical habitat for Tiger Salamander Southern Mountain population is based on all available verified occurrence records[5] for the species. Within the three geographic areas where it occurs, Tiger Salamander requires both aquatic breeding habitat and surrounding terrestrial habitat (for foraging, overwintering, and refuge) to complete life history functions. Together, the aquatic habitat and surrounding terrestrial habitat form the "core" critical habitat that is essential for the persistence of the local population. Core critical habitat is identified to encompass these movements and regular seasonal migration routes between aquatic and terrestrial habitat. Longer movements of Tiger Salamander beyond core critical habitat may occur across additional upland habitat. These dispersal movements are not part of regular seasonal habitat use but allow for colonization of new breeding sites, and/or recolonization of those that are not available each year; as such they are required to maintain long-term persistence and gene flow among populations. The additional terrestrial habitat required to meet this species' need is termed "connectivity" critical habitat.

[5] All verified records of Tiger Salamander Southern Mountain population (environmental DNA sampling, radio telemetry studies, and incidental observations of live animals and roadkills) were included regardless of the method used, date of collection, or life stage.

The area of terrestrial habitat around a breeding pond that is used by Tiger Salamander during seasonal migrations requires additional research in B.C.; however existing data and anecdotal observations suggest that most are found within 1 km of the nearest wetland (Sarell 2004, Dyer 2016 unpubl. data). Trenham et. al (2001) investigated demography and interpond dispersal in the California Tiger Salamander, and found that approximately 75% of salamanders were seasonally migrating (returning to the same pond), and that there was a 25% dispersal probability (to different ponds). Searcy and Shaffer (2011) used pitfall trap captures to calculate a density distribution of California Tiger Salamanders around two breeding ponds. Projecting from those results, approximately 75% of the migrating population would be protected by a median distance of 1 km. Further, genetic analyses of Tiger Salamanders in Yellowstone National Park (Spear et al. 2005) found that gene flow appeared to diminish among breeding sites separated by greater than 1 km. This finding aligns with the above supposition that distances > 1 km represent less-frequent inter-pond dispersals, rather than seasonal migrations around same ponds. Movement capabilities of Tiger Salamanders are estimated to be a maximum of 2.2 km (based on Orloff (2011) study of California Tiger Salamander).

The area containing critical habitat for Tiger Salamander Southern Mountain population is delineated based on sequential application of the following methods:

(1) selection of wetland features of known breeding sites or potential breeding sites[6] associated with verified records;

(2) application of a 1 km distance around selected wetland features, delineated to represent the essential aquatic and terrestrial areas required by the species for life history functions;

(3) application of minimum convex polygons[7] around groups of overlapping essential aquatic and terrestrial areas to create "**core**" critical habitat;

(4) application of a 2.2 km distance around selected wetland features (identified in step (1)) to account for the estimated maximum movement capabilities of Tiger Salamanders, and identification of "**connectivity**" critical habitat between essential aquatic and terrestrial areas (identified in step (2)) wherever not already identified as "core" critical habitat; and,

(5) geospatial exclusion of any areas above 1250 m in elevation[8].

Biophysical features and attributes of "core" critical habitat

The biophysical features and attributes required for Tiger Salamander life history functions in core habitat areas (as outlined in the provincial recovery plan, and as

[6] Potential breeding sites were identified as any wetland features within 1 km of verified records.
[7] A minimum convex polygon is the smallest shape, drawn with straight line segments, which will surround all essential terrestrial areas as identified in step 2. As an analogy, picture an elastic stretched around a group of pegs on a peg board.
[8] The highest elevation that Tiger Salamander has been reported in B.C. is 1250 m.

summarized in Table 1) overlap biophysically, geospatially, seasonally, and across life history stages. Within the geospatial areas containing core critical habitat, only clearly unsuitable areas that do not support the species in any life history stage (i.e., do not contain any of the biophysical features and attributes required by the species at any time) are not identified as core critical habitat.

Table 1. Summary of essential functions, biophysical features, and key attributes of Tiger Salamander core critical habitat (including aquatic breeding and terrestrial/upland features).

Life stage	Function	Biophysical Feature(s)	Attributes
Adults and juveniles; eggs; larvae	Courtship, mating, egg-laying; foraging, development, and sometimes overwintering (larvae)	Vernal Ponds (seasonal and temporary wetlands)	• wet areas at any time having these features: -shallow areas of less than 1 m depth, required for development of eggs and larvae -emergent vegetation (e.g., grasses, sedges, rushes), sticks, or other debris, required to provide egg attachment surfaces - rocks, aquatic plants, coarse woody debris, or other cover objects, required to provide refuge -invertebrate (zooplankton, ostracods, aquatic insects, mollusks, leeches, and crayfish) and/or small vertebrate prey (tadpoles, small fishes, and other salamanders including conspecifics) • dry areas that become wet areas under the right conditions, identified at any time by: depressions with bare mud, sedges, rushes, or other hydrophilic plants
Adults and juveniles; neotenes[9]; eggs; larvae	Courtship, mating, egg-laying; foraging, development and sometimes overwintering (larvae)	Lakes and permanent water bodies (with stationary or very slowly moving water)	• shallow areas less than 1 m depth, required for development of eggs and larvae • emergent vegetation (e.g., grasses, sedges, rushes), sticks, or other debris, required to provide egg attachment surfaces • rocks, aquatic plants, coarse woody debris, or other cover objects, required to provide refuge • invertebrate (zooplankton, ostracods, aquatic insects, mollusks, leeches, and crayfish) and/or small vertebrate prey (tadpoles, small fishes, and other salamanders including conspecifics) • deeper water areas (>1 m) used by neotenes • optimally, an absence of predatory fish (sport fish, goldfish (*Carassius auratus*), and fish used for mosquito control or other purposes)
Adults and juveniles (metamorphosed)	Foraging, overwintering, seasonal migrations	Grassland, shrub-steppe, open forest	• friable (easily crumbled) soils that permit burrowing • invertebrate and small vertebrate prey (e.g., earthworms, insects, mollusks, frogs, and occasionally small birds) • self-made burrows; mammal burrows [e.g. pocket gopher, ground squirrel, badger]; surface cover objects, such as rocks, coarse woody debris, etc.

[9] Neotenes are sexually mature individuals that retain larval characteristics, such as gills, and live in permanent bodies of water.

Biophysical attributes of "connectivity" critical habitat

The biophysical features and key attributes required for Tiger Salamander life history functions in connectivity habitat areas are outlined in the provincial recovery plan, and summarized in Table 2. Within the geospatial areas containing connectivity critical habitat, only clearly unsuitable areas that do not support the needs of adult and juvenile dispersal are not identified as connectivity critical habitat.

Table 2. Summary of essential functions, biophysical features, and general attributes of Tiger Salamander connectivity critical habitat.

Life stage	Function	Biophysical Feature(s)	Attributes
Adults, and juveniles (metamorphosed)	Dispersal among water bodies and subpopulations	Grassland, shrub-steppe, open forest	• friable (easily crumbled) soils that permit burrowing; may also move over patches of other substrate types (including human-modified habitats) • invertebrate and small vertebrate prey (e.g., earthworms, insects, mollusks, frogs, and occasionally small birds) • self-made burrows; mammal burrows [e.g. pocket gopher, ground squirrel, badger]; surface cover objects, such as rocks, coarse woody debris, etc.

The areas containing core and connectivity critical habitat for Tiger Salamander Southern Mountain population are presented in Figures 1-4. Core critical habitat for Tiger Salamander Southern Mountain population occurs within the shaded pink polygons shown on each map where the core habitat biophysical features and attributes described in this section occur. Connectivity critical habitat for Tiger Salamander Southern Mountain population occurs within the shaded yellow polygons shown on each map where the connectivity habitat biophysical features and attributes described in this section occur. Within these polygons, only clearly unsuitable habitats are not identified as critical habitat. Examples of clearly unsuitable habitats include: (i) existing permanent infrastructure (buildings, extensive spans of artificial surfaces, running surface of major paved roads having high traffic volumes); (ii) large fast flowing rivers; and, (iii) elevations over 1250 m.

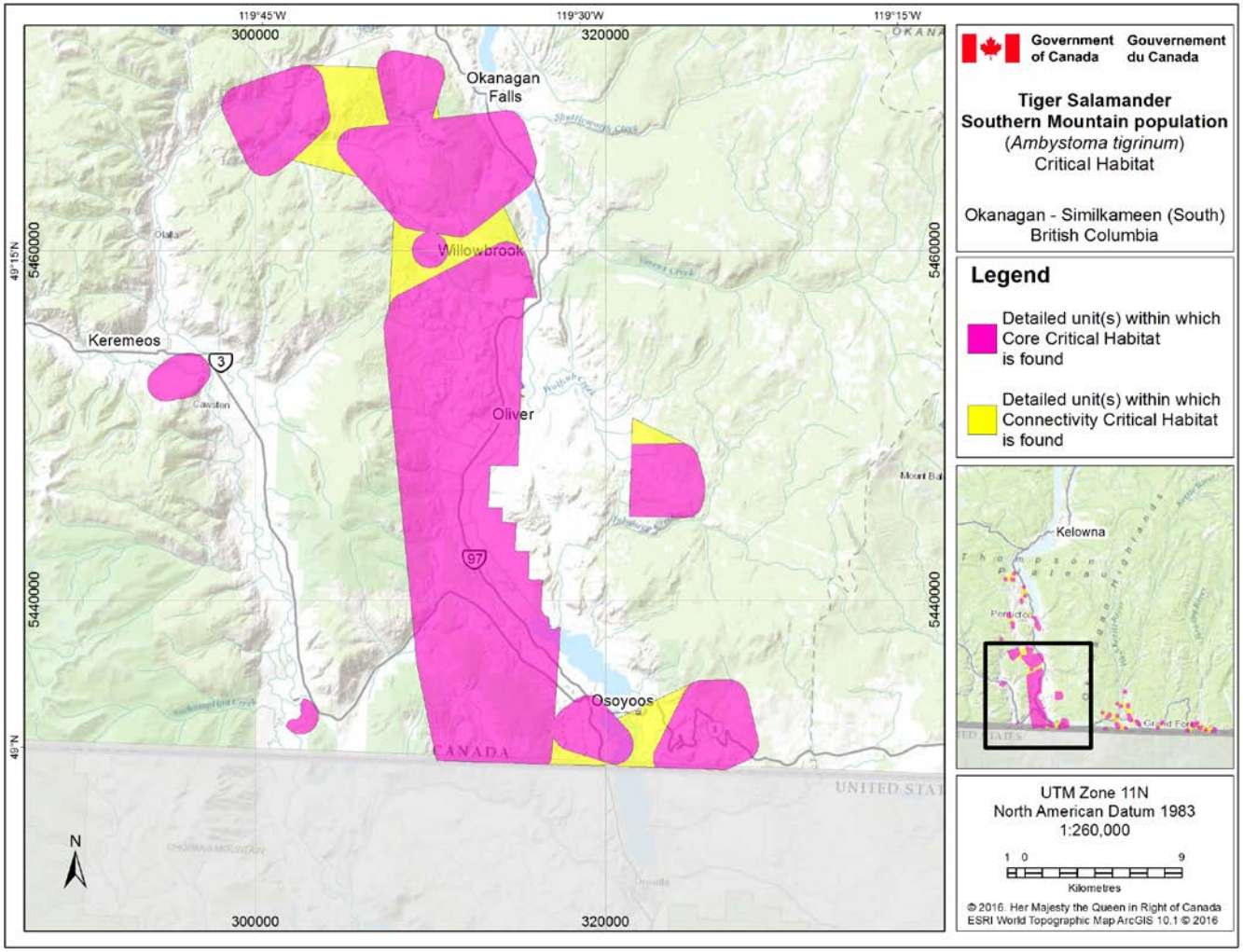

Figure 1. Critical habitat for the Tiger Salamander Southern Mountain population in the Okanagan-Similkameen (south) areas, B.C. is represented by the shaded pink polygons (areas containing “core” critical habitat) and the shaded yellow polygons (areas containing “connectivity” critical habitat), except where clearly unsuitable habitats (as described in Section 1.1) occur.

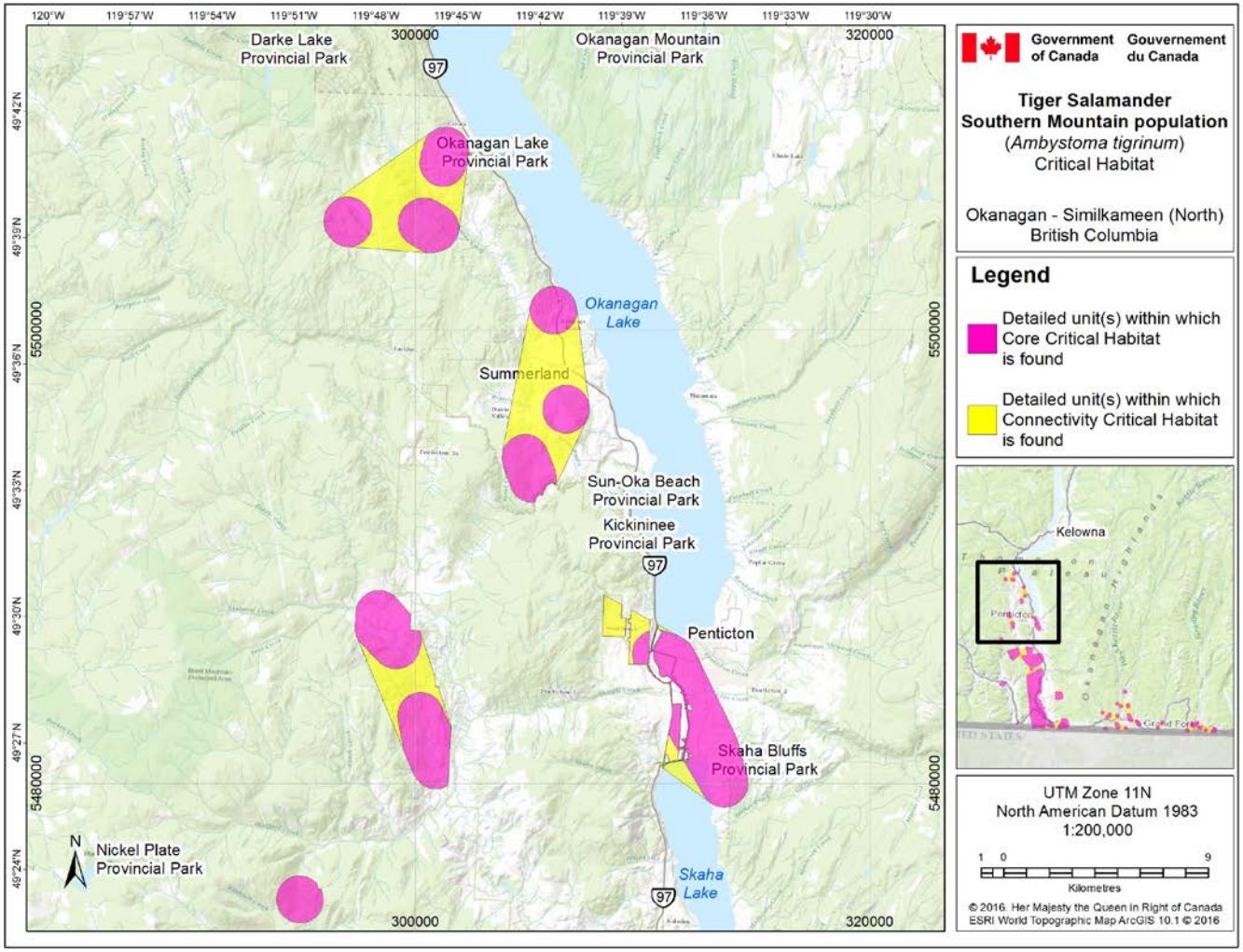

Figure 2. Critical habitat for the Tiger Salamander Southern Mountain population in the Okanagan-Similkameen (north) areas, B.C. is represented by the shaded pink polygons (areas containing “core” critical habitat) and the shaded yellow polygons (areas containing “connectivity” critical habitat), except where clearly unsuitable habitats (as described in Section 1.1) occur.

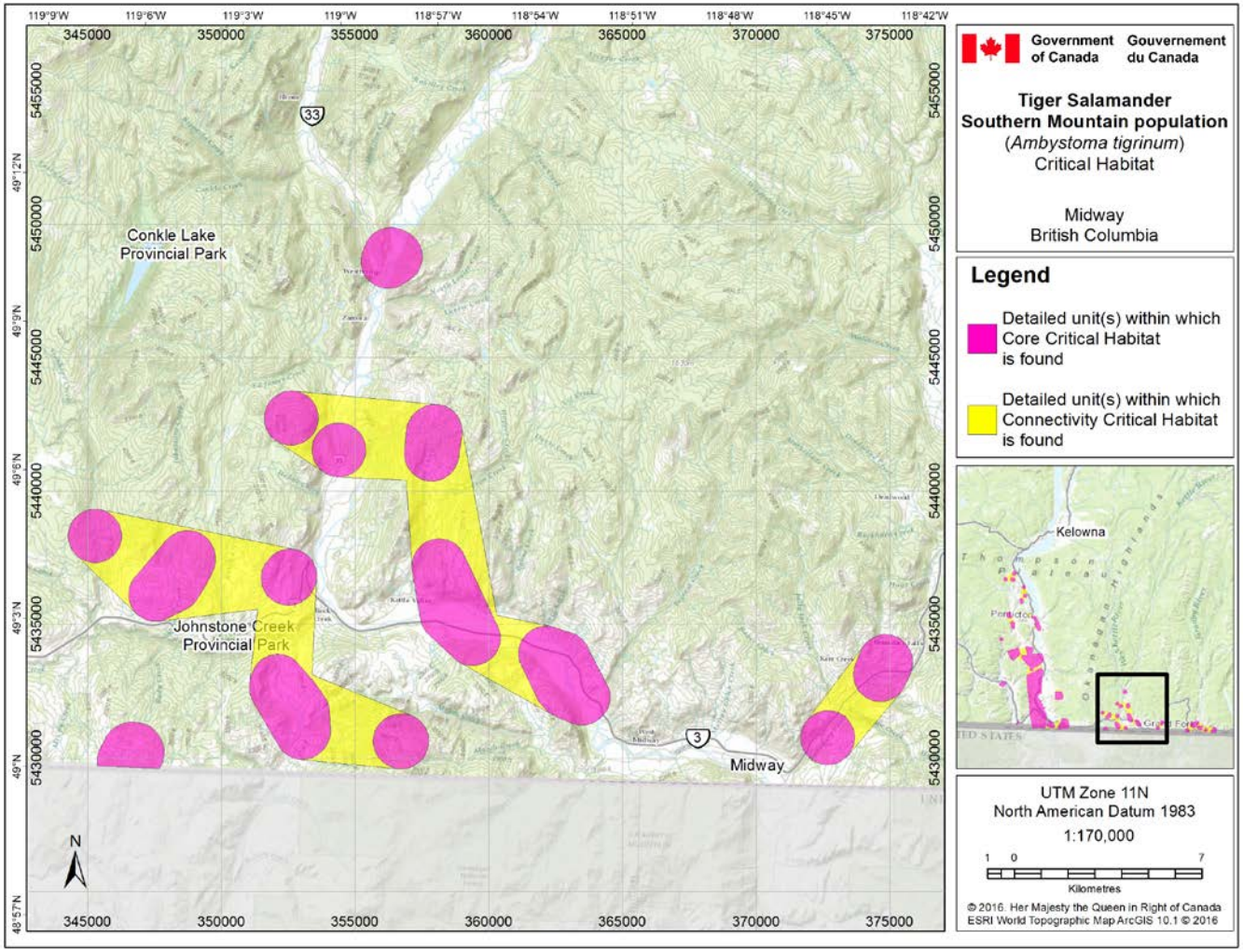

Figure 3. Critical habitat for the Tiger Salamander Southern Mountain population in the Midway area, B.C. is represented by the shaded pink polygons (areas containing “core” critical habitat) and the shaded yellow polygons (areas containing “connectivity” critical habitat), except where clearly unsuitable habitats (as described in Section 1.1) occur.

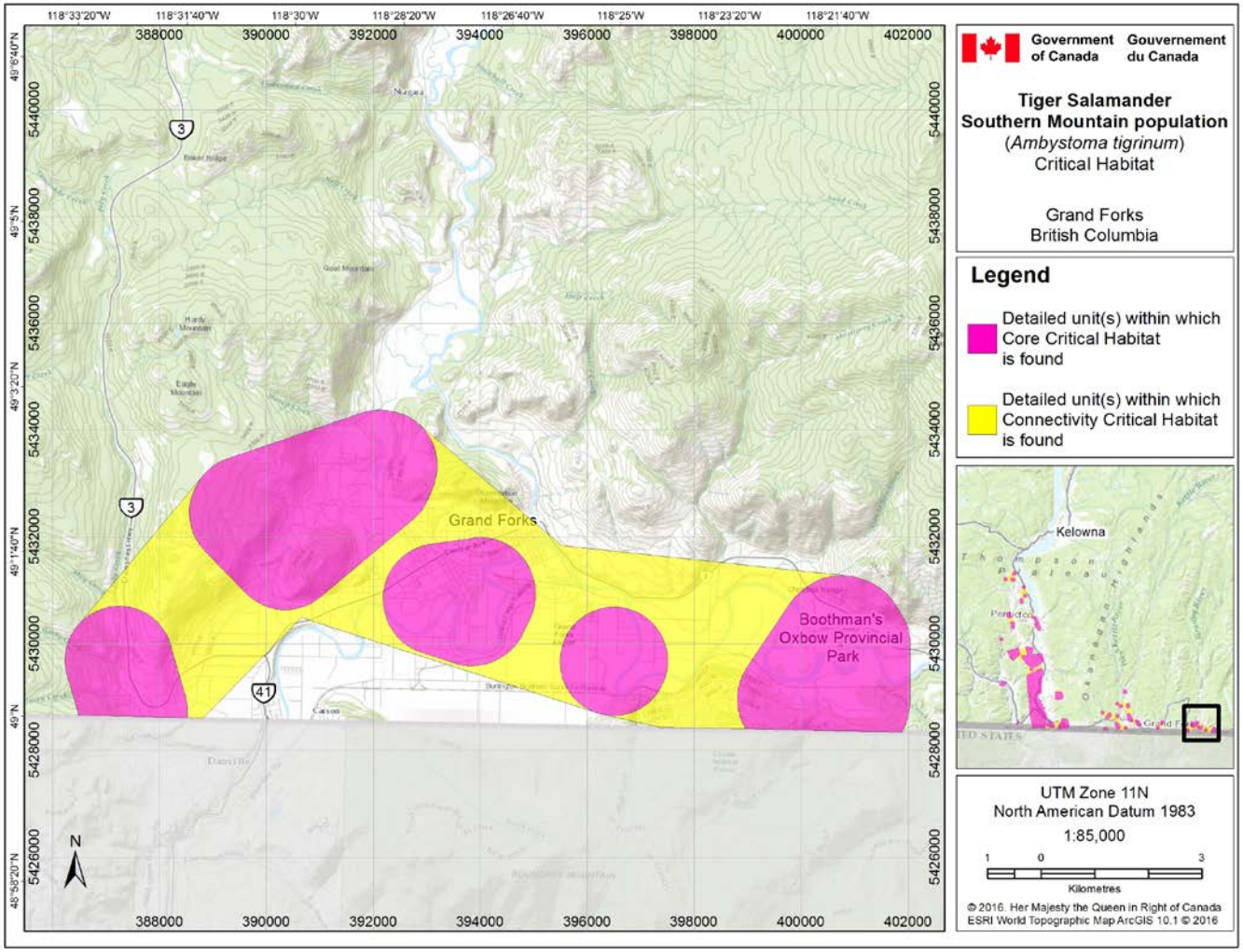

Figure 4. Critical habitat for the Tiger Salamander Southern Mountain population in the Grand Forks area, B.C. is represented by the shaded pink polygons (areas containing “core” critical habitat) and the shaded yellow polygons (areas containing “connectivity” critical habitat), except where clearly unsuitable habitats (as described in Section 1.1) occur.

1.2 Schedule of Studies to Identify Critical Habitat

The following schedule of studies (Table 3) outlines the activities required to complete the identification of critical habitat for Tiger Salamander Southern Mountain population. This section addresses parts of critical habitat that are known to be missing from the identification based on information that is available at this time. Actions required to address future *refinement* of critical habitat (such as fine-tuning boundaries, and/or providing greater detail about use of biophysical attributes) are not included here. Priority recovery actions to address these kinds of knowledge gaps are outlined in the recovery planning table in the adopted provincial recovery plan.

Table 3. Schedule of Studies to Identify Critical Habitat for Tiger Salamander Southern Mountain population.

Description of activity	Rationale	Timeline
Work with applicable organizations to complete the identification of critical habitat for Tiger Salamander	Critical habitat has not been identified for a portion of lands in the south Okanagan. This activity is required such that sufficient critical habitat is identified to meet the population and distribution objectives.	2017-2022
Geospatially map all permanent and seasonal wetland features within the known range of Tiger Salamander	The geospatial area containing critical habitat is based on wetland features of known breeding sites or potential breeding sites. Geospatial location information for potential breeding sites is incomplete, particularly in areas outside of the south Okanagan.	2017-2022

1.3 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 were degraded, either permanently or temporarily, such that it would not serve its function when needed by the species. Destruction may result from a single or multiple activities at one point in time or from the cumulative effects of one or more activities over time. The provincial recovery plan provides a description of limitations and potential threats[10] to Tiger Salamander. Activities described in Table 4 include those likely to cause destruction of critical habitat for the species; however, destructive activities are not limited to those listed.

[10] Threat classification is based on the IUCN-CMP (International Union for Conservation of Nature–Conservation Measures Partnership) unified threats classification system (www.conservationmeasures.org).

Table 4. Activities likely to result in destruction of Critical Habitat for Tiger Salamander Southern Mountain population.

Description of activity	Rationale	Additional Information; related IUCN threat
Land conversion for residential and commercial development and agriculture in core or connectivity critical habitat	This activity can result in the direct loss of core critical habitat, or could degrade habitat to a point where it no longer meets the needs of the species. Habitat loss or degradation could occur through soil compaction and/or the alteration of moisture regimes (e.g., impounded drainage, or reduced water flow to wetlands through ditching or diversion of subsurface water by built structures) in core critical habitat; see also next row. Can destroy connectivity critical habitat by fragmentation of habitats needed for dispersal.	IUCN-CMP Threat 1.1, 2.1, 2.3, 4.1, 7.2. Urbanization and agricultural development (orchards, vineyards) is ongoing and is most notable in the Okanagan Valley. Ongoing human developments and increase in related activities/infrastructure are likely to result in destruction of Tiger Salamander habitat.
Activities such as: filling in wetlands; diversion of water; and operation of water control devices or irrigation practices that result in rapid water level changes	Results in habitat loss or degradation of core critical habitat for Tiger Salamander by altering drainage patterns thereby disrupting natural ecological processes and destroying wetland breeding sites, e.g., premature drying (prior to metamorphosis) during the breeding period.	IUCN-CMP Threat 1.1, 2.1, 2.3, 7.2. Alterations in hydrological characteristics can be caused by housing developments, agriculture, roads, or management of water/dams. Does not need to occur within the bounds of critical habitat to cause destruction (e.g. upstream run-off, or alteration in broad-scale drainage patterns).
Development and/or maintenance or modification of existing structures, road building, expansion, upgrading, or installation of other types of barriers to salamander movement without installation of mitigations such as safe movement passages and fencing in core and/or connectivity critical habitat	Can destroy core and/or connectivity critical habitat outright; can reduce and/or destroy habitat needed to maintain dispersal within or between core habitat areas.	IUCN-CMP Threat 4.1 Road densities are high, and increasing, throughout much of the Tiger Salamander range in B.C., therefore road maintenance and construction activities are likely to result in destruction of critical habitat.

Description of activity	Rationale	Additional Information; related IUCN threat
Inappropriate level and concentration of livestock use, i.e., that results in significant adverse effects[11] [12] in core critical habitat	Overgrazing in core critical habitat by livestock can result in loss of suitable habitat for Tiger Salamander. Trampling of habitat can lead to the loss of emergent vegetation, soil compaction that makes habitat unsuitable for burrowing and/or create deep hoof prints that make the habitat unsuitable for movements (including seasonal migrations and dispersal), to the extent that the habitat is no longer suitable. Indirect impacts may include hydrological changes and increased influx of pollutants and/or sedimentation.	IUCN-CMP Threat 2.3, 9.3 Allowing cattle access to riparian areas and shallow wetland areas in core critical habitat is most likely to result in destructive impacts. Although activities during the breeding period (generally March to August) are most likely to result in direct destructive impacts, destruction of core habitat attributes can be caused at any time of year.
Deliberate introduction of predatory fish or American Bullfrogs (*Lithobates catesbieanus*) in core critical habitat	Predatory influence of introduced fish or American Bullfrogs can cause waterbody habitats to be unsuitable for breeding Tiger Salamanders.	IUCN-CMP Threat 8.1, 6.1 The threat from introduced fish is widespread, current and severe. American Bullfrogs were introduced to localized areas of the South Okanagan but are currently believed to be eradicated. Introduced species can result in the prevalence of diseases associated with introductions (such as Chytridiomycosis caused by the chytrid fungus *Batrachochytrium dendrobatidis,* or *Ambystoma tigrinum* virus).

[11] Significant adverse effects are those that negatively impact the species' survival and recovery. Success of the species' survival and recovery will be assessed against the adopted population and distribution (recovery) objective and associated performance measures, in that the abundance of Tiger Salamander Southern Mountain population is maintained as stable or increasing within each of the three geographic areas where it occurs.

[12] Additional research is required to determine what level of livestock use is considered destructive to Tiger Salamander, i.e. the level at which the features and attributes necessary for long-term persistence are destroyed. However, it is clear that intensive stocking rates would be likely to result in destruction of critical habitat.

Description of activity	Rationale	Additional Information; related IUCN threat
Activities related to the control of invertebrate pests or invasive plant species, or to improve crop production that are not in accordance with provincial best management practices[13], where available.	Tiger Salamanders are sensitive to pollutants; thus, activities within or outside the area of critical habitat that cause contaminants to enter the wetland are likely to result in damage or destruction. Release of pollutants can result in loss of the water quality required for survival, growth, and successful reproduction in core critical habitat. Pollutants known to be of concern for Tiger Salamanders include atrazine, chlorpyrifos and malathion based pesticides (Larsen et al 1998; Henson-Ramsay et al. 2008; Kerby and Storfer 2009). Note: Depending on the location, and timing/frequency of application, in some very specific circumstances (e.g., invasive plant removal, and/or restoration of habitat for the species), the targeted application of herbicides may result in a neutral or potential net benefit to Tiger Salamander. Appropriate application (i.e., in line with best management practices, and with consideration of the species' life history) is essential to avoid destruction.	IUCN-CMP Threat 9.3 Use/application of agricultural chemicals is prevalent, particularly in the South Okanagan. Effects can be direct or cumulative. The cumulative threat from pollution is likely more serious at lower elevations, where human developments are concentrated. Does not need to occur within the bounds of critical habitat to cause destruction (e.g. may include on-site activities, and/or drift from adjacent areas).
Damaging recreational activities (e.g., mudbogging and other off-road vehicle use) in core critical habitat	Off-road use of vehicles in core critical habitat can compact soils, making them less suitable for burrowing. In and around wetlands, this activity can reduce emergent vegetation, alter the shoreline, degrade substrates in the water body, and alter hydrology, making wetlands less suitable for Tiger Salamander Recreational use can also increase the risk of invasive plant introductions via unclean/contaminated footwear, vehicles, or other equipment.	Related IUCN-CMP Threat 6.1, 8.1 Although specific information on the prevalence and location of these activities within core critical habitat is lacking, any off-road vehicle use is in riparian areas and shallow wetland areas (whether they are permanent, or ephemeral) within core critical habitat is likely to result in destruction of critical habitat. Activities during the breeding period (generally March to August) are most likely to result in direct destructive impacts; however destruction of core habitat attributes can be caused at any time of year.

[13] E.g. see "Best Management Practices for Invasive Plants in Parks and Protected Areas of British Columbia"

2. Statement on Action Plans

One or more action plans for Tiger Salamander Southern Mountain population will be posted on the Species at Risk Public Registry by 2022.

3. Effects on the Environment and Other Species

This section replaces the “Effects on Other Species” section in the provincial recovery plan.

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*[14]. 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[15] (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.

Many endangered or threatened species occupy the same range and use similar wetland or grassland and shrub-steppe habitats to Tiger Salamander in the arid interior belt of British Columbia. These species include the Great Basin Spadefoot (*Spea intermontana*; Threatened) with overlapping use of core critical habitat (i.e., aquatic water bodies for breeding and surrounding terrestrial habitat for foraging and overwintering) and/or connectivity critical habitat for dispersal. Other species at risk that might benefit from Tiger Salamander Southern Mountain population conservation include the Pallid Bat (*Antrozous pallidus*; Threatened), American Badger (*Taxidea taxus*; Endangered), Burrowing Owl (*Athene cunicularia*; Endangered), Sage Thrasher (*Oreoscoptes montanus*; Endangered), Great Basin Gophersnake (*Pituophis catenifer deserticola*; Threatened), Behr’s Hairstreak butterfly (*Satyrium behrii*; Threatened), Showy Phlox (*Phlox speciosa*; Threatened), Rusty Cord-moss (*Entosthodon rubiginosus*; Endangered), and Alkaline Wing-nerved Moss (*Pterygoneurum kozlovii;* Threatened). Recovery planning activities for Tiger Salamander Southern Mountain

[14] www.ceaa.gc.ca/default.asp?lang=En&n=B3186435-1
[15] www.ec.gc.ca/dd-sd/default.asp?lang=En&n=CD30F295-1

population will be implemented with consideration for all co-occurring species and their habitats, such that inadvertent negative impacts are avoided.

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Part 2 – *Recovery Plan for the Blotched Tiger Salamander (*Ambystoma mavortium*) in British Columbia*, prepared by the Southern Interior Reptile and Amphibian Working Group for the British Columbia Ministry of Environment

Recovery Plan for the Blotched Tiger Salamander (*Ambystoma mavortium*) in British Columbia

Prepared by the Southern Interior Reptile and Amphibian Working Group

September 2016

Updated – April 2017

About the British Columbia Recovery Series

This series presents the recovery documents that are prepared as advice to the Province of British Columbia on the general approach required to recover species at risk. The Province prepares recovery documents to ensure coordinated conservation actions and to meet its commitments to recover species at risk under the *Accord for the Protection of Species at Risk in Canada* and the *Canada–British Columbia Agreement on Species at Risk*.

What is recovery?

Species at risk recovery is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of a species' persistence in the wild.

What is a provincial recovery document?

Recovery documents summarize the best available scientific and traditional information of a species or ecosystem to identify goals, objectives, and strategic approaches that provide a coordinated direction for recovery. These documents outline what is and what is not known about a species or ecosystem, identify threats to the species or ecosystem, and explain what should be done to mitigate those threats, as well as provide information on habitat needed for survival and recovery of the species. This information may be summarized in a recovery strategy followed by one or more action plans. The purpose of an action plan is to offer more detailed information to guide implementation of the recovery of a species or ecosystem. When sufficient information to guide implementation can be included from the onset, all of the information is presented together in a recovery plan.

Information in provincial recovery documents may be adopted by Environment and Climate Change Canada for inclusion in federal recovery documents that the federal agencies prepare to meet their commitments to recover species at risk under the *Species at Risk Act*.

What's next?

The Province of British Columbia accepts the information in these documents as advice to inform implementation of recovery measures, including decisions regarding measures to protect habitat for the species.

Success in the recovery of a species depends on the commitment and cooperation of many different constituencies that may be involved in implementing the directions set out in this document. All British Columbians are encouraged to participate in these efforts.

For more information

To learn more about species at risk recovery in British Columbia, please visit the B.C. Ministry of Environment Recovery Planning webpage at:
<http://www.env.gov.bc.ca/wld/recoveryplans/rcvry1.htm>

Recovery Plan for the Blotched Tiger Salamander (*Ambystoma mavortium*) in British Columbia

Prepared by the Southern Interior Reptile and Amphibian Working Group

September 2016

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Cover photograph

Steve Cannings

Additional copies

Additional copies can be downloaded from the B.C. Ministry of Environment Recovery Planning webpage at:

<http://www.env.gov.bc.ca/wld/recoveryplans/rcvry1.htm>

Publication information

This is an updated version of the September 2016 edition of this document.
See **Updates** for specific changes to the document.

Update

Updated April 4, 2017. The only change made to the original posting (September 2016) was to correct the credit given for the cover photograph. Steve Cannings is now correctly credited for this photograph.

Disclaimer

This recovery plan has been prepared by Southern Interior Reptile and Amphibian Working Group, as advice to the responsible jurisdictions and organizations that may be involved in recovering the species. The B.C. Ministry of Environment has received this advice as part of fulfilling its commitments under the *Accord for the Protection of Species at Risk in Cana*da and the *Canada–British Columbia Agreement on Species at Risk.*

This document identifies the recovery strategies and actions that are deemed necessary, based on the best available scientific and traditional information, to recover the Blotched Tiger Salamander population in British Columbia. Recovery actions to achieve the goals and objectives identified herein are subject to the priorities and budgetary constraints of participatory agencies and organizations. These goals, objectives, and recovery approaches may be modified in the future to accommodate new findings.

The responsible jurisdictions and all members of the working group have had an opportunity to review this document. However, this document does not necessarily represent the official positions of the agencies or the personal views of all individuals on the working group.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that may be involved in implementing the directions set out in this plan. The B.C. Ministry of Environment encourages all British Columbians to participate in the recovery of the Blotched Tiger Salamander.

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EXECUTIVE SUMMARY

Blotched Tiger Salamander (*Ambystoma mavortium*) is a relatively large (adults 20 cm or longer) North American, heavy-bodied amphibian with a characteristic colour pattern of large yellow or whitish blotches, on both the sides and back, on a black or grey background. Aquatic larvae are olive-green with large heads and long feathery gills that are longer than their heads. Under certain circumstances (five known wetlands in British Columbia), some individuals remain permanently aquatic, becoming very large (~ 33 cm) and sexually mature while retaining the larval body form, including gills, through a process termed "neoteny." These adults continue to inhabit permanent wetlands throughout their lives.

This species occurs in south-central British Columbia in three geographic areas: Okanagan - Similkameen, Midway and Grand Forks. Tiger salamanders breed in both permanent and temporary lakes and ponds. Metamorphosed juveniles and adults depend on terrestrial habitats, including arid grassland, shrub–steppe, and open ponderosa pine or Douglas-fir forests, where they spend most of their time underground often in rodent burrows. Their active season is from March through October.

The overall province-wide threat impact for this species is High to Very High. This overall threat impact considers the cumulative impacts of multiple threats. Threats include direct harm and habitat fragmentation from roads, predation from non-native species (fish, amphibians), disease-causing organisms, pollution, agricultural activities causing habitat loss and pollution, housing and urban area development, dams and water management, and climate change (drought).

The Blotched Tiger Salamander was designated as Endangered in British Columbia by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) because of its small area of occupancy, severely fragmented population, declines in habitat quality, and impacts by serious threats. It is referred to as Western Tiger Salamander, Southern Mountain population, in COSEWIC documents. It is listed, under its former name Western Tiger Salamander (*Ambystoma tigrinum*), as Endangered in Canada under Schedule 1 of the *Species at Risk Act*. The Blotched Tiger Salamander is ranked S2 (Imperiled/Red-listed) by the Conservation Data Centre and Priority 2 under Goal 3 of the B.C. Conservation Framework. It also is listed under the *Forest and Range Practices Act*, Identified Wildlife Management Strategy, as a species that requires special management attention to address the impacts of forest and range activities. It is protected under British Columbia's *Wildlife Act* from capture and killing. Recovery is considered to be biologically and technically feasible.

The recovery goal is to maintain or increase the abundance of Blotched Tiger Salamander in each of the three geographic areas where it occurs and to ensure connectivity within these areas.

The following objectives are necessary to conserve the Blotched Tiger Salamander in the short term (next 5 years).

1. Secure core habitat (breeding wetlands and associated terrestrial habitat) for Blotched Tiger Salamander in each of the three geographic areas that it occupies.

2. Maintain or increase connectivity across the landscape within and among adjacent known subpopulations[1].
3. Address knowledge gaps, such as: distribution, habitat requirements, population structure and biological processes across the landscape, water use and declining water tables, climate change, road mortality, disease, pollution, pesticides and herbicides, invasive species, and effectiveness of recovery actions.

[1] Subpopulations are defined as geographically or otherwise distinct groups in the total population between which little demographic or genetic exchange occurs.

RECOVERY FEASIBILITY SUMMARY

The recovery of the Blotched Tiger Salamander in British Columbia is considered technically and biologically feasible based on the following four criteria that Environment and Climate Change Canada uses to establish recovery feasibility.

1. Individuals of the wildlife species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance.
   YES. Breeding subpopulations exist in the three occupied areas (Okanagan - Similkameen, Midway, and Grand Forks) within the Blotched Tiger Salamander's provincial range. Because of their high reproductive output, tiger salamanders have potential to recover relatively rapidly provided that suitable breeding habitats are available (Semlitsch 1983) and sources of direct and indirect mortality are managed favorably.

2. Sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration.
   YES. Although suitable wetland breeding wetlands and associated terrestrial habitats have declined in area, suitable habitat still remains in all three occupied areas within the range. Habitat area can be increased through restoration (i.e., re-establishing wetlands) and threat reduction (i.e., removal of invasive fish in wetland breeding habitat) projects.

3. The primary threats to the species or its habitat (including threats outside Canada) can be avoided or mitigated.
   YES. The primary threats can be avoided or mitigated. The main threats include direct harm from roads, predation from invasive non-native species (fish, amphibians), disease-causing organisms, pollution, and agricultural activities causing habitat loss. Road mortality can be reduced by fencing and culverts. Invasive, non-native bullfrogs can be controlled. Pollution can be reduced through education and use of best practices.

4. Recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable time frame.
   YES. Recovery techniques, such as habitat protection, habitat management, threat mitigation, stewardship approaches, and reliable inventory methods, are available to recover the population.

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1 COSEWIC* SPECIES ASSESSMENT INFORMATION

Assessment Summary – November 2012
Common Name: Western Tiger Salamander – Southern Mountain Population**
Scientific Name: *Ambystoma mavortium***
Status: Endangered
Reason for Designation: This large salamander has a range restricted to southern British Columbia which mostly overlaps with populated and modified agricultural areas in the South Okanagan Valley. The species has suffered loss of available breeding habitat through wetland draining, contamination, and stocking with fish. Salamander habitats are fragmented by roads and urban and agricultural developments that continue to expand, resulting in disruption of migration routes, mortality through roadkill, and loss of upland habitat for terrestrial adults. Increased drought and lowering water tables, as well as introduced Bullfrogs, also threaten this species.
Occurrence: British Columbia
Status History: The Tiger Salamander (*Ambystoma tigrinum*) was originally assessed by COSEWIC in November 2001 as three separate populations: Great Lakes population (Extirpated), Prairie / Boreal population (Not at Risk), and Southern Mountain population (Endangered). In November 2012, Tiger Salamander was split into two separate species, Eastern Tiger Salamander (*Ambystoma tigrinum*) and Western Tiger Salamander (*Ambystoma mavortium*), each with two different populations that received separate designations. The Southern Mountain population of the Western Tiger Salamander was assessed as Endangered.

* Committee on the Status of Endangered Wildlife in Canada.
** Common and scientific names reported in this recovery plan follow the naming conventions of the B.C. Conservation Data Centre, which may be different from names reported by COSEWIC.

2 SPECIES STATUS INFORMATION

Blotched Tiger Salamander[a]		
Legal Designation:		
FRPA:[b] Species at Risk OGAA:[b] Species at Risk	B.C. *Wildlife Act*:[c] Schedule A	SARA:[d] Schedule 1 – *A. tigrinum* (Southern Mountain Population) endangered (2003).
Conservation Status[e]		
B.C. List: Red B.C. Rank: S2 (2010)	National Rank: NNR	Global Rank: G5T4 (1996)
Other Sub-national Ranks:[f] Oregon S2?		
B.C. Conservation Framework (CF)[g]		
Goal 1: Contribute to global efforts for species and ecosystem conservation.		Priority:[h] 4
Goal 2: Prevent species and ecosystems from becoming at risk.		Priority: 6
Goal 3: Maintain the diversity of native species and ecosystems.		Priority: 2
CF Action Groups:[g]	Habitat Protection, Habitat Restoration, Private Land Stewardship, Species and Population Management	

[a] Data source: B.C. Conservation Data Centre (2014) unless otherwise noted.
[b] Species at Risk = a listed species that requires special management attention to address the impacts of forest and range activities on Crown land under the *Forest and Range Practices Act* (FRPA; Province of British Columbia 2002) and/or the impacts of oil and gas activities on Crown land under the *Oil and Gas Activities Act* (OGAA; Province of British Columbia 2008) as described in the Identified Wildlife Management Strategy (Province of British Columbia 2004).
[c] Schedule A = designated as wildlife under the B.C. *Wildlife Act*, which offers it protection from direct persecution and mortality (Province of British Columbia 1982).
[d] Schedule 1 = found on the List of Wildlife Species at Risk under the *Species at Risk Act* (SARA). The tiger salamander population in British Columbia (previously named *Ambystoma tigrinum*) was listed as Endangered on SARA schedule 1, under its previous name *Ambystoma tigrinum.* Due to a recent taxonomic name change, (*A. tigrinum* to *A. mavortium*), as per COSEWIC 2012, the species is a candidate for future listing under its new name (*Ambystoma mavortium*, or Western Tiger Salamander, Southern Mountain population).
[e] Red: Includes any indigenous species or subspecies that have, or are candidates for, Extirpated, Endangered, or Threatened status in British Columbia; S = subnational; N = national; G = global; T = refers to the subspecies level; 2 = imperilled; 4 = apparently secure; 5 = demonstrably widespread, abundant, and secure; NR = unranked.
[f] Data source: NatureServe (2015) for subspecies *A. m. mavortium*.

[g] See B.C. Ministry of Environment (2009) for information regarding current Conservation Framework prioritization and action sorting tools. A. *tigrinum* was assessed in 2011 but, after the taxonomic name change, A. *mavortium* was not updated in in the Conservation Framework database. The ranks did not change; therefore the 2011 assessment is used in this document.
[h] Six-level scale: Priority 1 (highest priority) through to Priority 6 (lowest priority).

3 SPECIES INFORMATION

3.1 Species Description

Blotched Tiger Salamander (*Ambystoma mavortium*) is a relatively large (adults 20 cm or longer) North American, heavy-bodied amphibian with a characteristic colour pattern of large yellow or whitish blotches, on both the sides and back, on a black or grey background (Jones *et al.* [eds.] 2005; Matsuda *et al*. 2006) (Figure 1). Aquatic larvae are olive-green with large heads and long feathery gills that are longer than their heads. Under certain circumstances (only five known wetlands in British Columbia), some individuals remain permanently aquatic, becoming very large (~ 33 cm) and sexually mature while retaining the larval body form, including gills, through a process termed “neoteny.”

Figure 1. Blotched Tiger Salamander (D. Cunnington).

3.2 Populations and Distribution

3.2.1 Global Distribution and Abundance

Two species of tiger salamander exist in North America: (1) the Western Tiger Salamander (*A. mavortium*; Crother [ed.] 2012), and (2) the Eastern Tiger Salamander (*A. tigrinum*). Western Tiger Salamanders are widely distributed in western North America, ranging from southwest Canada, including Saskatchewan, Alberta, and British Columbia, to central and western United States (COSEWIC 2012; Figure 2).

The population in British Columbia is part of the *A. m. melanostictum* subspecies of Western Tiger Salamander and is referred to as the "Blotched Tiger Salamander" in this recovery plan. The Blotched Tiger Salamander is isolated from other populations (and subspecies) of *A. mavortium* by the Rocky Mountains. This disjunct population occurs in south-central British Columbia (Figures 2 and 3), Washington State, Oregon, and Idaho. In British Columbia, the Blotched Tiger Salamander occupies the northern portion of this distribution and comprises approximately 15% of the disjunct distribution of this subspecies.

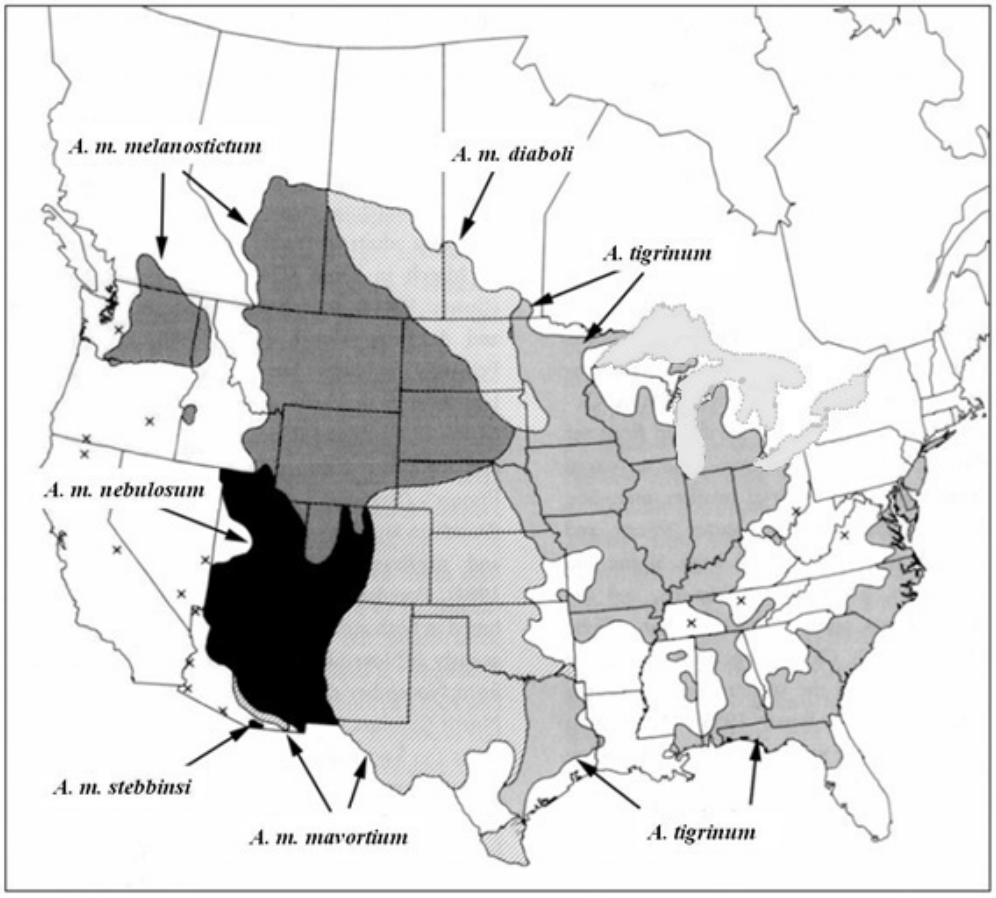

Figure 2. North American distribution of the Western Tiger Salamander (*Ambystoma mavortium*) and the Eastern Tiger Salamander (*Ambystoma tigrinum*) (from COSEWIC 2012).

3.2.2 Distribution and Abundance

In British Columbia, the Blotched Tiger Salamander is restricted to three geographic areas: Okanagan - Similkameen, Midway, Grand Forks (Figure 3). These three geographic areas appear to be disjunct in British Columbia but may be connected through habitat in the United States. Survey efforts over the past decade have helped to clarify the distribution of these salamanders, including the discovery of several new breeding wetlands. The overall area of occupancy is thought to be declining (COSEWIC 2012), but detailed data on population and distribution trends are lacking. A decline in the area of occupancy over the past 30 years is inferred from apparent extirpations at historical breeding wetlands, combined with extensive habitat loss and continuing threats from roadkill, fish introductions, pollution, and other sources of direct and indirect mortality (COSEWIC 2012).

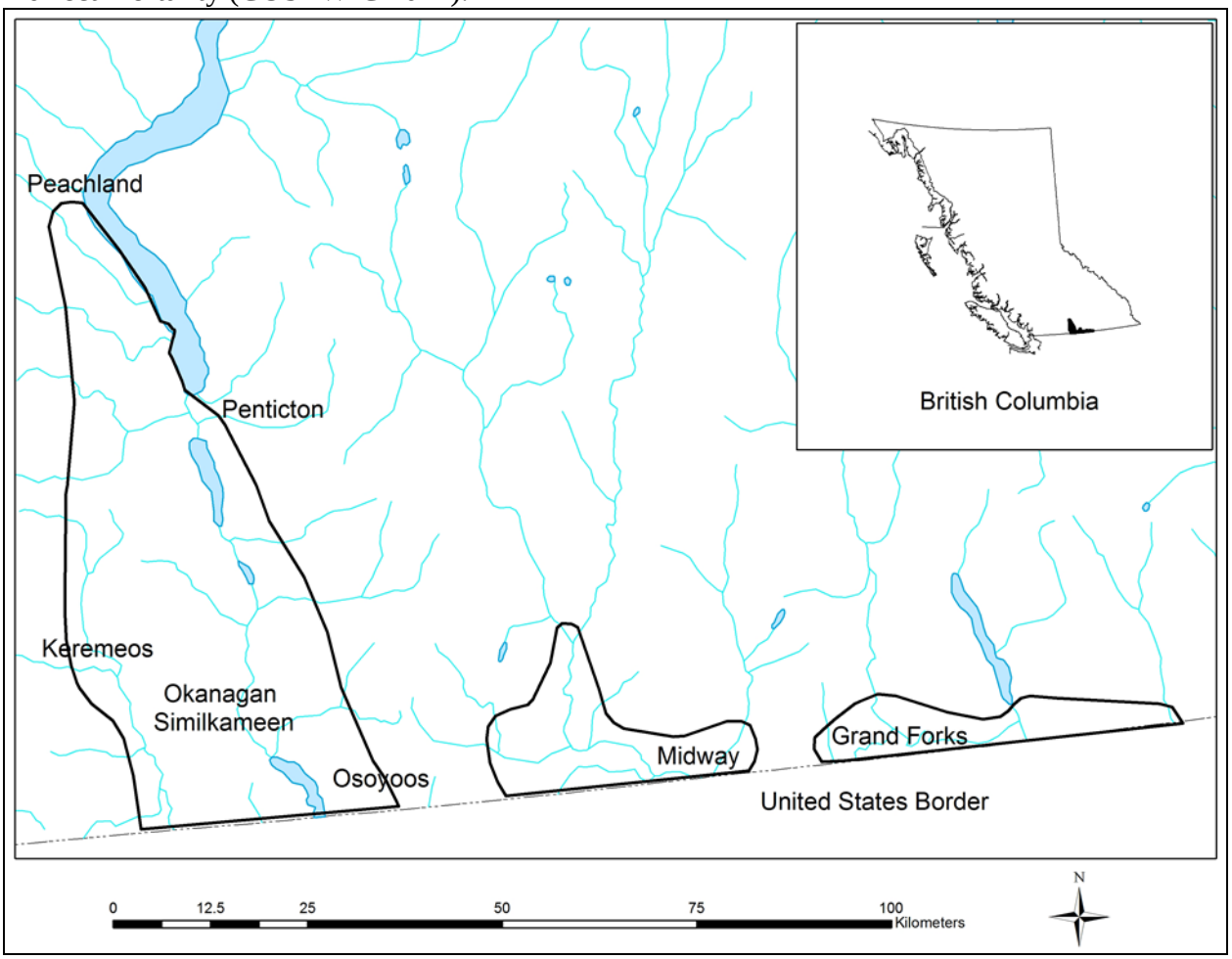

Figure 3. Blotched Tiger Salamander distribution in British Columbia (Ministry of Environment).

Eighty-six breeding wetlands are known for the Blotched Tiger Salamander in British Columbia (COSEWIC 2012). Of these, 68 wetlands are still in use as at least one life stage has been observed since 2001. The extent of occurrence is 5054 km^2, as calculated by COSEWIC (2012). The calculated area of occupancy index is 232–464 km^2, a range that reflects whether only records from aquatic breeding wetlands (smaller value) or all observation records (larger value) were included. Additional, undiscovered breeding wetlands with associated terrestrial habitat

likely exist. These wetlands may be most efficiently detected with new, more sensitive environmental DNA (eDNA) survey methods (Hobbs and Vincer 2015).

The number of breeding adults ranges between 2500 and 10 000 individuals (B.C. Conservation Data Centre 2014), but no robust, formal population estimates exist. Studies of tiger salamanders from other areas indicate that the number of breeding adults varies greatly among subpopulations and years, ranging from a few to hundreds of adults per breeding wetland (COSEWIC 2012). This variability is likely influenced by annual changes in precipitation, which affects the amount or quality of wetland breeding habitat quality and/or environmental conditions in particular years.

3.3 Habitat and Biological Needs of the Blotched Tiger Salamander

The following subsections and Tables 1–5 summarize important features of the aquatic and terrestrial habitat required by the Blotched Tiger Salamander for different life functions. For more detailed descriptions and additional references, see COSEWIC (2012). The Blotched Tiger Salamander occupies arid habitats at low (~ 280 m above sea level) to mid-elevations (up to about 1250 m) within the province's dry, southern interior region (COSEWIC 2012). Similar to other semi-aquatic amphibians, Blotched Tiger Salamanders require both aquatic breeding habitat and terrestrial habitat to complete their life history functions. Together, these areas form the core habitat that is essential for the persistence of the population (Semlitsch and Bodie 2003). Although the core habitat includes seasonal movement routes between aquatic and terrestrial habitat (Semlitsch and Bodie 2003; Rittenhouse and Semlitsch 2007), additional terrestrial habitat is required to allow dispersal movements across the landscape.

3.3.1 Aquatic Habitat

Function: Courtship, mating, egg-laying, egg and larval development, and foraging

Courtship, mating, egg-laying, and development of eggs and larvae take place in either vernal ponds (seasonal and temporary wetlands) or permanent waterbodies with stationary or very slowly moving water. Eggs are laid singly, or in small clusters (up to 5000 eggs/female), in aquatic habitats shortly after the first heavy, spring rains (Matsuda *et al*. 2006) when air temperatures reach about 12°C (Sarell, pers. comm., 2016). Generally, adults arrive at ponds in March and April to breed and then return to upland habitats in May (Richardson *et al*. 2000b). Larvae hatch from eggs within 10–21 days, and continue to occupy aquatic habitats until July or August when most transform into terrestrial forms, although some may overwinter in the wetland as larvae and transform the next year. During the transformation process gills become reduced, as the salamanders begin to breathe air, and then disappear altogether. In some cases, larvae do not transform but remain in a wetland permanently and become sexually mature adults (neotenes) while retaining larval characteristics (gills). Some vernal ponds may appear to be unsuitable breeding wetlands for many years (because of severe droughts, fluctuating water tables, or other factors), but these ephemeral features may be very important for long-term viability of salamanders in British Columbia. Blotched Tiger Salamander require a mosaic of breeding wetlands with different water depths distributed across the landscape to ensure persistence of the population (Richardson *et al*. 2000a).

Breeding wetlands in the province range from 0.01 to 33.2 ha in area (mean = 2.36 ha, median = 0.48 ha, *n* = 87 wetlands; two large lakes [Farleigh and Brent] excluded) (Sopuck, pers. comm., 2014). Vernal ponds with few predators have the potential to produce a large number of recruits in years when conditions are optimal, whereas deeper waterbodies may be the only source of recruits in drought years (Richardson *et al.* 2000a). Tiger salamanders tolerate alkaline and slightly saline water (Gasser and Miller 1986), as well as nutrient-rich waterbodies (Miller and Larsen 1986; Matsuda *et al.* 2006). Small larvae feed on nematodes, ostracods, and copepods, whereas as larger larvae feed on insects, crayfish, snails, and other larvae (Matsuda *et al*. 2006). Most larvae will metamorphose into terrestrial adults during their first year, but some may spend up to 3 years in a wetland before metamorphosing (Wissinger and Whiteman 1992). Some metamorphosed individuals may continue to use wetlands, presumably for foraging (Welsh 2015).

Neotenes[2] require permanent or semi-permanent waterbodies, and survival rates are highest in the absence of predatory fish. In areas outside the province, this life history mode is often prevalent in the cool waters of high-altitude lakes and ponds (Bizer 1978). Little is known of the specific habitat needs for neotenes in British Columbia, although they may require habitats similar to those used by adults and juveniles in permanent waterbodies; however, neotenes may also use deeper water areas, including large lakes.

Functions and features of Blotched Tiger Salamander aquatic habitat are presented in tables 1, 2 and 3.

Table 5. Summary of essential functions and features of Blotched Tiger Salamander aquatic habitat in British Columbia.

Life stage(s)	Function[a]	Feature(s)[b]
Adults (metamorphosed)	Courtship, mating, egg-laying, foraging	• Vernal ponds (seasonal and temporary wetlands) • Lakes and permanent waterbodies with stationary or very slowly moving water
Eggs	Development	• Vernal ponds (seasonal and temporary wetlands) • Lakes and permanent waterbodies with stationary or very slowly moving water
Larvae	Foraging, development, and (sometimes) overwintering	• Vernal ponds (seasonal and temporary wetlands) • Lakes and permanent waterbodies with stationary or very slowly moving water
Adults (neotenes)	Courtship, mating, egg-laying; foraging	• Lakes and permanent waterbodies that are deep enough to prevent freezing

[2] Neotenes are sexually mature individuals that retain larval characteristics such as gills. Permanently aquatic neotenes are large (often in excess of 300 mm long) but otherwise similar to larvae.

[a] Function: a life-cycle process of the species (e.g., for animals, can include spawning, breeding, denning, nursery, rearing, feeding/foraging, and migration).
[b] Feature: the essential structural components of the habitat required by the species.

Table 6. Attributes and descriptions for the feature: Vernal ponds (seasonal and temporary wetlands).

Attribute [a]	Description
Availability	Retains water at least 5 months, from mid-March through August, to allow development from egg to metamorphosis
Persistence	May be dry for several years but can be identified by the wetland basin (depression with bare mud or sedges, rushes, or other hydrophilic plants), which continues to provide breeding wetlands in some years; important for subpopulation persistence across the landscape over time
Elevation	Up to 1250 m
Depth	Extensive shallow areas less than 1 m present in which warm water allows for rapid development of eggs and larvae, and invertebrate prey concentrate
Shoreline	Gently sloping in at least portions of the waterbody, creating shallows (see above); presence of emergent vegetation or, alternatively, sticks or other debris used for egg attachment
Refuges	Rocks, aquatic plants, or other objects used for shelter from predators
Food	Availability of invertebrate (zooplankton, ostracods, aquatic insects, mollusks, leeches, and crayfish) and/or small vertebrate prey (tadpoles, small fishes, and other salamanders including conspecifics) of appropriate size for these gape-limited predators
Other	Optimally, an absence of predatory fish (sport fish, goldfish [*Carassius auratus*], and fish used for mosquito control or other purposes)

[a] Attribute: the building blocks or *measurable* characteristics of a feature.

Table 7. Attributes and descriptions for the feature: Lakes and permanent waterbodies.

Attribute [a]	Description
Availability	Retains water at least 5 months, from mid-March through August, to allow development from egg to metamorphosis; all year for neotenes
Depth	Shallow areas less than 1 m deep in which warm water allows for rapid development of eggs and larvae; neotenes also use deeper water areas
Elevation	Up to 1250 m
Shoreline	Gently sloping in at least portions of the waterbody, creating shallows (see above); presence of emergent vegetation or, alternatively, sticks or other debris used for egg attachment
Refuges	Rocks, aquatic plants, or other objects used for shelter from predators
Food	Availability of invertebrate (zooplankton, ostracods, aquatic insects, mollusks, leeches, and crayfish) and/or small vertebrate prey (tadpoles, small fishes, and other salamanders including conspecifics) of appropriate size for these gape-limited predators
Predators	Optimally, an absence of predatory fish (sport fish, goldfish, and fish used for mosquito control or other purposes); some coexistence may occur with neotenes

[a] Attribute: the building blocks or *measurable* characteristics of a feature.

3.3.2 Terrestrial (upland) Habitat Surrounding Wetlands

Function: Foraging, overwintering, seasonal migrations

Outside the breeding period, metamorphosed juveniles and adults use grassland, shrub–steppe, and open forest habitats for foraging, seasonal migration, and overwintering (COSEWIC 2012); terrestrial habitats are therefore required year-round. Detailed habitat use information for Blotched Tiger Salamander in British Columbia is limited, although research on similar species in other areas likely can be used as a surrogate for habitat use in this province. Terrestrial adults require deep, friable soils for burrowing and also often use existing mammal burrows (e.g., Northern Pocket Gopher [*Thomomys talpoides*]) as retreat sites (Vaughan 1961; Welsh 2015; Richardson *et al*. 2000b). Metamorphosed juveniles may remain along shorelines or move to upland habitats and use burrows similar to adults. Searcy *et al*. 2013 reported habitat use was positively associated with drier vegetation and slightly higher ground that was less likely to be inundated by precipitation.

Richardson *et al*. (1998, 2000a, b) used surgically implanted radio-telemetry transmitters in studies of adult Blotched Tiger Salamanders over two field seasons at White Lake in the South Okanagan. In 1998, 14 radio-tracked adult salamanders moved less than 150 m from their capture wetlands over a 4-month period (Richardson *et al*. 2000a). In 1999, 12 radio-tracked adults moved less than 500 m from their capture wetlands (Richardson *et al*. 2000b). The impact of implanted transmitters on tiger salamander movement during the study is not known and juveniles were not included in the study.

Blotched Tiger Salamanders have been observed at distances greater than 1 km from the nearest known wetland (Sarell, pers. comm., 2016). In 2013, 268 recently metamorphosed, mostly roadkilled, Blotched Tiger Salamander were observed on roads at White Lake, near Penticton (Dyer, pers. comm., 2016). Ninety-one (34%) were observed on roads that were greater than a 500 m straight-line distance from White Lake. Ten (4%) were observed at distances greater than 1000 m, and the farthest confirmed movement was 1140 m. This information suggests that most of the subpopulation remains within 1 km of this breeding site.

More extensive studies that focused on the California Tiger Salamander (*Ambystoma californiense)* using pitfall-trapping arrays instead of implanted telemetry show movements of more than 500 m around wetlands are common for some age classes (Trenham *et al*. 2001; Trenham and Shaffer 2005; Orloff 2011; Searcy and Shaffer 2011; Searcy *et al*. 2013). The following information for the California Tiger Salamander, a closely related species that also uses similar habitats, appears to be reasonably consistent with research and anecdotal observations made in British Columbia and may be used as a surrogate for Blotched Tiger Salamander.

Trenham and Schaffer (2005) used 1 year of pitfall-trapping data from one pond to estimate the occupancy area around the wetland. For example, distances of 150 m, 490 m and 620 m around the wetland encompassed 50%, 90%, and 95%, of the adult population, respectively. Distances of 390 m, 600 m and 650 m encompassed 50%, 90%, and 95% of the juvenile (i.e., past the first winter but not a sexually mature adult) population, respectively. These authors estimate that a 630 m band of habitat around the wetland was likely to provide sufficient terrestrial habitat for

all terrestrial life-cycle functions, including adults, juveniles, and recently metamorphosed salamanders.

Searcy and Shaffer (2011) used different mathematical methods to create models using two ponds with 5 years of pitfall-array data, which included adults, juveniles, and recently metamorphosed animals. These authors recommend habitat areas with radii around the wetland of 562 m, 1501 m and 1897 m to protect 50%, 90%, and 95%, respectively, of the reproduction value at an average pond. "Reproduction value" was calculated as the probability of recently metamorphosed juveniles, older juveniles, and adults reaching maturity to breed, based on observed survivorship values. Extrapolating from their graph (Figure 3B) of the density of reproductive value and distance from shoreline, a 1000 m distance encloses approximately 75% of the population. Searcy and Shaffer (2011) also recalculated data from Trenham *et al.* (2001) and Trenham and Shaffer (2005), estimating that 95% of adults were within 829 m of shore and that 95% of the population was within 1677 m.

Searcy *et al.* (2013) also calculated that terrestrial habitat areas around wetland breeding wetlands averaging 556 m, 1486 m, and 1849 m radius would protect habitat for 50%, 90%, and 95% of their study populations, respectively. This calculation was based on 2 years data on two ponds, which were also used by Searcy and Shaffer (2011).

The extent of terrestrial habitat that tiger salamanders require around breeding ponds may vary both with the configuration and quality of terrestrial habitat. For example, Searcy *et al.* 2013 reported variation in adult and juvenile salamander density and distance from breeding wetlands between wetlands and between years for the California Tiger Salamander.

The spatial pattern of terrestrial habitat also appears to vary by age class. Trenham and Shaffer (2005) reported adults were more numerous near the wetland and decreased in abundance with distance from the wetland. Juveniles increased within a 10–400 m distance from the wetland then decreased to zero at 800 m. These authors estimate that 50% of adult tiger salamanders were within 150 m of the breeding wetland and 95% were within 620 m. Searcy *et al.* 2013 found similar results with juvenile numbers increasing from the wetland to 500 m and adults decreasing with distance from the wetland. Both age classes were more dispersed in a dry year after a substantial increase in reproductive success the previous year.

Trenham and Schaffer (2005) developed a model to estimate population viability impacts of decreasing habitat around a wetland breeding wetland. Habitat areas with less than a 60 m radius around the breeding wetland resulted in extinction within 100 years. Habitat areas with a 200 m and 400 m radius resulted in population declines of 90–100% and 50%, respectively. Population decline accelerated if habitat areas had less than a 600 m radius around a breeding wetland. The model was more sensitive to adult and juvenile population reductions than to reproduction variation, suggesting that maintaining a substantial amount of terrestrial habitat for both of these life stages is necessary to maintain the population.

Although habitat use distances vary widely, movement data in British Columbia and genetic data from Yellowstone (Spear *et al*. 2005 described below) for Blotched Tiger Salamander suggest most tiger salamanders are within about 1000 m of breeding wetlands. This distance is also

supported by detailed studies of California Tiger Salamanders (i.e., extrapolations from Searcy and Shaffer 2011). Longer distance movements may be associated with dispersal (see below).

Functions and features of Blotched Tiger Salamander terrestrial habitat are presented in tables 4 and 5.

Table 8. Summary of essential functions and features of Blotched Tiger Salamander terrestrial habitat in British Columbia.

Life stage(s)	Function[a]	Feature(s)[b]
Adults juveniles and metamorphs	Foraging, overwintering, and seasonal migrations	Grassland, shrub–steppe, open forest

[a] Function: a life-cycle process of the species (e.g., for animals, can include spawning, breeding, denning, nursery, rearing, feeding/foraging and migration; flowering, fruiting, seed dispersing, germinating, seedling development).
[b] Feature: the essential structural components of the habitat required by the species.

Table 9. Attributes and descriptions for the feature: Grassland, shrub–steppe, open forest.

Attribute [a]	Description
Availability	All year
Elevation	Up to 1250 m elevation
Habitat types	Grassland, shrub-steppe, open forest
Distance from breeding habitat	Most terrestrial habitat occurs within a band of about 1000 m around breeding wetlands
Substrate	Terrestrial habitat contains friable (easily crumbled) soils that permit burrowing
Food	Invertebrate and small vertebrate prey (e.g., earthworms, insects, mollusks, frogs, and occasionally small birds) must be available in both living and dispersal habitats
Corridor	Absence of insurmountable barriers to movement that intersect migration routes (e.g., large, fast rivers and large lakes; dense urban centres; extensive spans of artificial surfaces, such as sod-forming grass lawns or major roads with high traffic volumes)
Refuge	Refugia, (e.g., self-made burrows; mammal burrows [e.g. pocket gopher, ground squirrel, badger]; surface cover objects, such as rocks, coarse woody debris, etc.) are important for both living and dispersal habitats

[a] Attribute: the building blocks or *measurable* characteristics of a feature.

Function: Dispersal among waterbodies and terrestrial habitats

For pond-breeding amphibians, connectivity through suitable terrestrial habitat is required among breeding wetlands to permit dispersal movements across the landscape and to ensure that population processes at a broader scale remain functional (Semlitsch 2002; Trenham and Shaffer 2005). Trenham *et al*. (2001) investigated demography and inter-pond dispersal in the California Tiger Salamander and found that 45 of 198 (22%) breeding adults dispersed to nearby ponds (within 670m). Dispersers included males and females, first time breeders and experienced breeders. Well-connected breeding wetlands, even those that may only be available in some years, are important because they facilitate colonization and help to maintain meta-populations across the landscape (Semlitsch 1998, 2000, 2002). Characteristics of dispersal habitat for the Blotched Tiger Salamander are largely unknown, but should contain refuges from the elements and predators and should not have substantial barriers to movement. Insurmountable barriers to movements listed by NatureServe (2014) for *Ambystoma* in general include: heavily traveled

roads; roads with a barrier that is impermeable to salamanders; wide, fast rivers; and areas of intensive development dominated by buildings and pavement (Hammerson 2004).

Data on movements of other aquatic-breeding amphibians suggest that under optimal conditions, individuals of many species can travel several kilometres across terrestrial habitat (Marsh and Trenham 2001). Ambystomatid salamanders as a group are somewhat less mobile than other groups (Semlitsch 1998), but this generalization does not seem to apply for grassland species (Searcy *et al*. 2013), such as tiger salamanders. Upland movements of California Tiger Salamanders are at least twice as long as movements reported for forest-dwelling species of *Ambystoma* and are among the longest reported for any salamanders (Searcy *et al*. 2013). In 2004, the U.S. Fish and Wildlife Service accepted 2092 m as a maximum observed migration distance for California Tiger Salamander (in Searcy and Shaffer 2011). Orloff (2011) reported a potential migration distance up to 2200 m from the nearest pond in the suspected direction of travel from a pitfall array. Searcy and Shaffer (2011) estimated 95% of the population's reproductive potential was within 1867 m of a breeding wetland based on a regression model. Searcy and Shaffer (2011) calculated a seasonal ecophysiological maximum migration distance (i.e., the yearly modeled maximum distance of movement during suitable weather) of 2484 m. Dispersal movements by juvenile or adult salamanders may take more than one active season (Trenham *et al*. 2001; Semlitsch 2008). Such inter-pond dispersal movements by salamanders in arid environments are important in maintaining viable meta-populations (Orloff 2011).

Genetic analyses of Blotched Tiger Salamanders in Wyoming's Yellowstone National Park showed an overall high degree of differentiation among salamanders from different breeding ponds across the landscape, implying limited movements and gene flow in the mountainous landscape (Spear *et al.* 2005). Gene flow appeared to diminish among breeding wetland separated by greater than 1 km. The greatest gene flow between breeding wetland was along hypothetical dispersal paths that followed straight-line topographic routes, avoiding high elevations but crossing open shrub habitat and riparian areas.

As described in the preceding section, the best available information suggests that most tiger salamanders in British Columbia are within about 1000 m of breeding wetlands. Longer distance movements associated with dispersal likely occur, but have not been well-studied. Existing data suggests a maximum observed movement distance of around 2100-2200 m (Searcy and Shaffer 2011, Orloff 2011). However, habitat and environmental differences can greatly influence population structure across the landscape and, more research is needed on this topic to support recovery of the Blotched Tiger Salamander in British Columbia.

Functions and features of Blotched Tiger Salamander dispersal habitat are presented in tables 5 and 6.

Table 10. Summary of essential functions and features of Blotched Tiger Salamander dispersal habitat in British Columbia.

Life stage(s)	Function[a]	Feature(s)[b]
Adults juveniles and metamorphs	Dispersal (among waterbodies and terrestrial features)	Grassland, shrub–steppe, open forest

[a] Function: a life-cycle process of the species (e.g., for animals, can include spawning, breeding, denning, nursery, rearing, feeding/foraging and migration; flowering, fruiting, seed dispersing, germinating, seedling development).
[b] Feature: the essential structural components of the habitat required by the species.

Table 11. Attributes and descriptions for the feature: Grassland, shrub–steppe, open forest.

Attribute [a]	Description
Availability	All year
Elevation	Up to 1250 m elevation
Habitat types	Grassland, shrub-steppe, open forest
Distance from breeding habitat	Most dispersal habitat occurs between approximately 1 km and 2.2 km from a breeding wetland
Substrate	Dispersal habitat contains friable (easily crumbled) soils that permit burrowing; dispersal routes may include areas of other substrates
Food	Invertebrate and small vertebrate prey (e.g., earthworms, insects, mollusks, frogs, and occasionally small birds)
Corridor	Absence of insurmountable barriers to movement that intersect migration routes (e.g., large, fast rivers and large lakes; dense urban centres; extensive spans of artificial surfaces, such as sod-forming grass lawns or major roads with high traffic volumes)
Refuge	Refugia, (e.g., self-made burrows; mammal burrows [pocket gopher, ground squirrel, badger]; surface cover objects, such as rocks, coarse woody debris, etc.) are important for both living and dispersal habitats

[a] Attribute: the building blocks or *measurable* characteristics of a feature.

3.4 Ecological Role

Tiger salamanders are top predators where they occur in naturally fishless waterbodies. They transport biological energy from aquatic breeding wetlands to terrestrial uplands, performing an important ecosystem function (Gibbons *et al.* 2006; Regester *et al.* 2006 a, b). Tiger salamanders are prey for larger animals and predators of invertebrates and small vertebrates in both aquatic and terrestrial ecosystems.

3.5 Limiting Factors

Limiting factors are generally not human-induced and include characteristics that make the species less likely to respond to recovery/conservation efforts (e.g., inbreeding depression, small population size, and genetic isolation).

Survival rates of tiger salamanders up to metamorphosis are characteristically low and variable among both breeding wetlands and years, resulting in an uneven pattern of recruitment across the landscape through time (Richardson *et al.* 2000a; review in COSEWIC 2012). Adults can be relatively long-lived in captivity (16–25 years) (COSEWIC 2012). In the wild, most die before

age 6 with only a small percentage (~ 7%) reaching 16 years of age (COSEWIC 2012). For an amphibian, a relatively long life enables populations to withstand the short periods of low or no recruitment that result from droughts or other adverse environmental conditions. Nevertheless, many breeding wetlands in the province have dry periods of more than 10 years, making lifespan and high natural mortality a limiting factor. Neotenic populations in permanent waterbodies may act as sources for repopulating shallow wetlands after prolonged drought.

Tiger salamanders have a complex life history, including aquatic eggs and larvae, terrestrial metamorphosed juveniles and adults and, under some circumstances, aquatic neotenes. Although these different life stages and alternate developmental paths allow the salamanders to successfully exploit their arid environment, it also exposes them to a higher number of potential natural threats.

4 THREATS

Threats are defined as the proximate activities or processes that have caused, are causing, or may cause in the future the destruction, degradation, and/or impairment of the entity being assessed (population, species, community, or ecosystem) in the area of interest (global, national, or subnational) (Salafsky *et al.* 2008). For purposes of threat assessment, only present and future threats are considered.[3] Threats do not include limiting factors, which are presented in Section 3.5.[4]

[3] Past threats may be recorded but are not used in the calculation of threat impact. Effects of past threats (if not continuing) are taken into consideration when determining long-term and/or short-term trend factors (Master *et al.* 2012).

[4] It is important to distinguish between limiting factors and threats. Limiting factors are generally not human-induced and include characteristics that make the species or ecosystem less likely to respond to recovery/conservation efforts (e.g., inbreeding depression, small population size, and genetic isolation).

4.1 Threat Assessment

The threat classification below is based on the IUCN–CMP (World Conservation Union–Conservation Measures Partnership) unified threats classification system and is consistent with methods used by the B.C. Conservation Data Centre. For a detailed description of the threat classification system, see the Open Standards website (Open Standards 2014). Threats may be observed, inferred, or projected to occur in the near term. Threats are characterized here in terms of scope, severity, and timing. Threat "impact" is calculated from scope and severity. For information on how the values are assigned, see Master *et al.* (2012) and table footnotes for details. Threats for the Blotched Tiger Salamander were assessed for the entire province (Table 6).

Table 6. Threat classification table for Blotched Tiger Salamander in British Columbia.

Note: a description of the threats included in this table are found in section 4.2.

Threat #[a]	Threat description	Impact[b]	Scope[c]	Severity[d]	Timing[e]
1	Residential & commercial development	Low	Small	Serious	High
1.1	Housing & urban areas	Low	Small	Serious	High
1.2	Commercial & industrial areas	Negligible	Negligible	Extreme	High
1.3	Tourism & recreation areas	Negligible	Negligible	Extreme	High
2	Agriculture & aquaculture	Low	Large	Slight	High
2.1	Annual & perennial non-timber crops	Low	Small	Moderate	High
2.3	Livestock farming & ranching	Low	Large	Slight	High
4	Transportation & service corridors	High–Medium	Pervasive	Serious–Moderate	High
4.1	Roads & railroads	High–Medium	Pervasive	Serious–Moderate	High
4.2	Utility & service lines	Negligible	Negligible	Negligible	High

Threat #[a]	Threat description	Impact[b]	Scope[c]	Severity[d]	Timing[e]
5	Biological resource use	Negligible	Negligible	Slight	High
5.1	Hunting & collecting terrestrial animals	Negligible	Negligible	Negligible	High
5.3	Logging & wood harvesting	Negligible	Negligible	Slight	High
6	Human intrusions & disturbance	Unknown	Unknown	Moderate	High
6.1	Recreational activities	Unknown	Unknown	Moderate	High
7	Natural system modifications	Low	Small	Extreme–Serious	High
7.1	Fire & fire suppression	Negligible	Negligible	Negligible	High
7.2	Dams & water management/use	Low	Small	Extreme–Serious	High
8	Invasive & other problematic species & genes	High–Medium	Pervasive	Serious–Moderate	High
8.1	Invasive non-native/alien species	High–Medium	Pervasive	Serious–Moderate	High
8.2	Problematic native species	Unknown	Unknown	Unknown	Unknown
8.3	Introduced genetic material	Unknown	Unknown	Unknown	Unknown
9	Pollution	Medium–Low	Large	Moderate–Slight	High
9.1	Household sewage & urban waste water	Unknown	Small	Unknown	High
9.3	Agricultural & forestry effluents	Medium–Low	Large	Moderate–Slight	High
11	Climate change & severe weather	Medium–Low	Restricted	Serious–Moderate	High
11.2	Droughts	Low	Restricted	Serious–Moderate	High

Threat #[a]	Threat description	Impact[b]	Scope[c]	Severity[d]	Timing[e]
11.3	Temperature extremes	Unknown	Unknown	Unknown	Unknown

[a] Threat numbers are provided for Level 1 threats (i.e., whole numbers) and Level 2 threats (i.e., numbers with decimals).
[b] **Impact** – The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of each threat is based on severity and scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population. The median rate of population reduction for each combination of scope and severity corresponds to the following classes of threat impact: Very High (75% declines), High (40%), Medium (15%), and Low (3%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity are unknown); Not Calculated: impact not calculated as threat is outside the assessment time (e.g., timing is insignificant/negligible [past threat] or low [possible threat in long term]); Negligible: when scope or severity is negligible; Not a Threat: when severity is scored as neutral or potential benefit.
[c] **Scope** – Proportion of the species that can reasonably be expected to be affected by the threat within 10 years. Usually measured as a proportion of the species' population in the area of interest. (Pervasive = 71–100%; Large = 31–70%; Restricted = 11–30%; Small = 1–10%; Negligible < 1%).
[d] **Severity** – Within the scope, the level of damage to the species from the threat that can reasonably be expected to be affected by the threat within a 10-year or three-generation time frame. For this species, a generation time of 6.5 years (COSEWIC 2012) was used, resulting in severity being scored over a 20-year time frame. Usually measured as the degree of reduction of the species' population. (Extreme = 71–100%; Serious = 31–70%; Moderate = 11–30%; Slight = 1–10%; Negligible < 1%; Neutral or Potential Benefit ≥ 0%).
[e] **Timing** – High = continuing; Moderate = only in the future (could happen in the short term [< 10 years or three generations]) or now suspended (could come back in the short term); Low = only in the future (could happen in the long term) or now suspended (could come back in the long term); Insignificant/Negligible = only in the past and unlikely to return, or no direct effect but limiting.

4.2 Description of Threats

The overall province-wide Threat Impact for this species is High to Very High.[5] This overall threat impact considers the cumulative impacts of multiple threats. Threats include: direct harm from roads, predation from introduced non-native species (e.g. fish, amphibians), disease-causing organisms, pollution, agricultural activities causing habitat loss, residential and commercial development, natural system modification, and climate change. Details are discussed below under the Threat Level 1 headings; negligible and unknown threats are discussed at the end of this section.

Threat 1. Residential & commercial development (threat impact: Low)

Developments have infilled or partially infilled wetland breeding wetlands, making them unusable for egg-laying or larval development or reducing their capacity to support salamanders. Buildings or impermeable surfaces (e.g., including thatch-forming lawns) cover terrestrial habitat, eliminating or reducing options for salamanders to dig or access underground burrows. An increase in urbanization is most notable in the Okanagan Valley. About one-half of the aquatic and terrestrial habitats in this area, and most of the habitat in the Kettle Valley, is on private land, which has a higher probability of development than Crown land. The probability of infilling wetland breeding wetlands over the next 10 years is relatively low. The province's *Water Sustainability Act* makes it illegal (unless authorized) to infill most wetlands that support tiger salamanders, but the practice does continue occasionally (Harrison and Moore 2013; Province of British Columbia 2014b Dyer, pers. comm., 2012). Housing developments may continue to degrade upland, migration, dispersal, and overwintering habitats. The Blotched Tiger Salamander spends most its life in terrestrial habitats. Although these salamanders may persist or continue to migrate through urban environments under some situations, at least two examples exist of local extirpations related to housing developments in the South Okanagan Valley (Ashpole, pers. comm., 2012). The lower-elevation habitats in which development is concentrated are more at risk than higher elevations. Where development occurs, the severity of impacts is predicted to be Serious.

Threat 2. Agriculture & aquaculture (threat impact: Low)

Orchards and vineyards are widespread within the species' range in the South Okanagan and Lower Similkameen river valleys and these activities have modified salamander habitats in the past. The Agricultural Land Reserve encourages agricultural developments, some of which can affect this species; however, it does provide some protection for habitat from urban development, which likely causes greater impacts to tiger salamanders. Previous agricultural developments have infilled wetlands, making them unusable for egg-laying or larval development or reducing capacity to support salamanders. Although this practice has decreased substantially, it still continues (Harrison and Moore 2013). The rate of natural land conversion to agriculture has slowed over the past decade, since much of the arable land is

[5] The overall threat impact was calculated following Master *et al.* (2012) using the number of Level 1 Threats assigned to this species where timing = High, which included two High–Medium, two Medium–Low, and three Low (Table 5).The overall threat impact considers the cumulative impacts of multiple threats.

already under cultivation, but agricultural developments are still expected to occur in some areas. Adult tiger salamanders still have the ability to burrow and survive in agricultural settings that do not grow thatch-forming grass; however, no information is available on relative survival or population density rates compared to natural habitats. In addition to habitat loss from land conversion, agricultural operations can result in occasional, accidental mortality from entrapment in irrigation structures (Sarell 1996; Ashpole, pers. comm., 2012).

Livestock ranching occurs over much of the Blotched Tiger Salamander's range (Dyer, pers. comm., 2012). The effects of cattle on salamander populations are related to trampling of nearshore aquatic vegetation and bottom substrate, soil compaction and burrow collapse, increased nutrients that may facilitate increased levels of pathogens (see summary in Sarell 2004), and reduced water volume caused by livestock drinking, especially in shallow ponds during drought years (Richardson, pers. comm., 2000). Trampling may result in direct mortality on eggs or larvae, loss of substrate for egg-laying, and loss of cover for larvae, particularly in shallow wetlands. Disease-related issues related to increased nutrients or health impacts related to habitat degradation are difficult to document and are unconfirmed in the province; however, if these situations occur, all aquatic phases of the population could be affected. Compaction and burrow loss may exclude these salamanders from small portions of their potential habitat. The creation or enhancement of dugouts for livestock-watering may provide breeding wetlands for amphibians although, if these dry out before metamorphosis, they may also create population sinks with high mortality of eggs or young. In years with substantial rainfall, effects on salamanders may be negligible, but in drought years when cattle concentrate at remaining water sources, adverse effects are expected to increase.

Threat 4. Transportation & service corridors (threat impact: High–Medium)

Where breeding wetlands are separated from upland habitat by busy roads, salamanders are vulnerable to road mortality during their seasonal migrations. Blotched Tiger Salamanders are particularly vulnerable because they may use wetlands and shallow ditches by roadsides as breeding wetlands (Clevenger *et al.* 2001). Porej *et al.* (2004) found that tiger salamanders (*A. t. tigrinum*) in Ohio were negatively associated with road density. Average total lengths of paved road were 2091 m (range: 1000–4600 m) within 1 km of wetlands in which tiger salamanders were present, and 4625 m (range: 1700–10 000 m) where tiger salamanders were not present. Road densities are high throughout much of the Blotched Tiger Salamander's range in the province. Almost all Blotched Tiger Salamander occurrences are within 1 km of a paved or gravel road (90% are within ~ 650 m of a road; 100% of breeding habitat is within 750 m of road (GIS analysis conducted by Dyer, pers. comm., 2012). Road mortality has been reported from many areas and can be high at some locations, depending on traffic volumes and other location-specific factors (Richardson *et al.* 1998; Crosby 2014). Dyer (pers. comm., 2015) counted 240 road killed metamorphs (recently metamorphosed from gill breathing aquatic to lung breathing terrestrial salamanders) at White Lake south of Penticton during 4 field visits between August 2 and 23, 2013. While mitigation using underpasses and drift fences can greatly reduce mortality (Crosby 2014), most roads within the Blotched Tiger Salamander's range are devoid of structures that would allow safe passage for amphibians. Population effects of road mortality are unstudied for this species. Tiger salamanders produce very large numbers of young in good years (e.g., Richardson [2000a] estimated that the White Lake area produced 7200 metamorphs in 1997). Therefore, the species may be able to sustain

apparently high losses of metamorphs under some circumstances. Nevertheless, road mortality may have more severe effects on some subpopulations. For example, road mortality that removes only a few breeding females when subpopulation numbers are low may be catastrophic. Lower-elevation habitats, where road density and traffic volumes are highest, are more at risk than higher elevations with lower road density and traffic volumes. A severity range of Serious–Moderate for the provincial population as a whole was deemed plausible based on expert opinion.

Threat 7. Natural system modifications (threat impact: Low)

Natural system modifications that pose threats to Blotched Tiger Salamanders include dams and water management/use. In the past, loss of breeding wetlands has resulted from water management and diversions (Sarell 1996). At least one breeding wetland has dried completely in over 1 year, partly because of water withdrawal for irrigation (Hobbs, pers. comm., 2016). Impacts from water withdrawal for irrigation or other purposes can cause breeding habitat reduction and direct mortality to larvae, if water levels decrease too far and cause mortality before metamorphosis. Salamander larvae have been sucked into unscreened water intakes causing mortality (Dyer, pers. comm., 2016). Human use or diversion of water may exacerbate impacts on breeding habitat from multi-year droughts. The severity of impacts depends on the type of water management practices and location-specific conditions at each breeding wetland.

Threat 8. Invasive & other problematic species & genes (threat impact: High–Medium)

Blotched Tiger Salamanders are exposed to threats from introduced fish, American Bullfrogs (*Lithobates catesbeianus*), and disease-causing organisms. The threat from introduced fish is widespread, current, and considerable. Introductions of sport fish, or other fish used for mosquito control, continue to occur in Blotched Tiger Salamander habitats or in nearby larger waterbodies from which these species can spread. The spread of non-native fish over the past 10–20 years has been extensive throughout the South Okanagan river valley (Herborg, pers. comm., 2012) and Boundary region (Tedesco, pers. comm., 2016). Legal stocking continues in previously stocked lakes and, although new stocking plans are currently not proposed within Blotched Tiger Salamander range, illegal stocking of perch, trout, and bass also takes place (Southern Interior Reptile and Amphibian Recovery Team 2008). An increase in fish introductions for mosquito control is expected for the next decade in response to concerns about West Nile virus. Predatory fish are known to prey on tiger salamander larvae, inhibit larval growth, alter behaviour, and cause extirpation at some breeding wetlands (see reviews in Wind 2005; COSEWIC 2012). Goldfish (*Carassius auratus*) and other small fish used for mosquito control on private lands prey on tiger salamander eggs. Declines and disappearances of Blotched Tiger Salamander from several lakes associated with fish introductions have been previously noted (Sarell 1996), and introductions of goldfish into Blotched Tiger Salamander breeding ponds for mosquito control are linked to their disappearance at some locations in the Okanagan valley (Ashpole *et al*. 2011).

American Bullfrogs have been introduced to the South Okanagan river valley and pose a potential threat to tiger salamanders mainly through predation (COSEWIC 2012). A 7-year bullfrog eradication project in this area has had good success, with no confirmed sightings

since 2010 (Ashpole and Govindarajalu, pers. comm., 2014); however, complete eradication is challenging and continued monitoring is required. New eDNA monitoring approaches may increase detectability and as well as lower costs.

Infectious diseases pose a potentially widespread and severe threat, but do not appear to currently affect Blotched Tiger Salamanders in British Columbia. Chytridiomycosis, caused by the fungus *Batrachochytrium dendrobatidis*, is an emerging infectious disease of amphibians that has been linked to precipitous declines and even extirpations of populations of several species in different parts of the world (Daszak *et al.* 1999). The fungus is geographically widespread in amphibians across the province, and also occurs in the South Okanagan River valley (Govindarajulu *et al*. 2013; Richardson *et al*. 2014), but whether it has caused disease outbreaks is unknown; co-stressors that may be needed to trigger epidemics are poorly understood. Another recently described chytrid fungus, *Batrachochytrium salamandrivorans*, from the Fire Salamander (*Salamandra salamandra*) in Europe (Martel *et al*. 2013), poses a new and potentially grave threat, if it undergoes a global spread similar to *B. dendrobatidis*.

Tiger salamanders are susceptible to highly infectious and lethal iridoviruses, including the *Ambystoma tigrinum* virus, which has caused significant mortality of Blotched Tiger Salamanders east of the Rocky Mountains (COSEWIC 2012). Highly virulent strains of this virus may be spread by salamander larvae used as fish bait and then released into the wild or from a variety of introduced fish species; die-offs have occurred across western North America (Jancovich et al. 2005). Although the effects can be locally devastating, subpopulations can recover, especially where re-colonization from the surrounding landscape is possible. Small Blotched Tiger Salamander subpopulations occupying fragmented habitats in the province are particularly vulnerable to extirpation, should disease outbreaks occur. The severity of the threat from the *A. tigrinum* virus was scored as "Unknown" because this virus is not known to occur in British Columbia. The issue is in need of more detailed research. Environmental DNA monitoring has been used in other areas and could help to clarify the threat here.

Threat 9. Pollution (threat impact: Medium–Low)

Amphibians are generally vulnerable to various contaminants because their semi-permeable skin and eggs readily absorb substances from the environment. Various chemicals, including herbicides, other pesticides, and fertilizers, may directly or indirectly affect all life stages of tiger salamanders, although salamander-specific ecotoxicology studies are sparse and not comprehensive (see reviews and references in Harfenist *et al*. 1989; Bishop 1992; Pauli *et al.* 2000; Sparling *et al*. 2010; COSEWIC 2012). Exposure to the pesticide chlorpyrifos and herbicide atrazine can increase susceptibility of tiger salamander larvae to infections and increased mortality from the *Ambystoma tigrinum* virus (Kerby and Storfer 2009). This may be an issue with other pesticide and herbicide combinations as well. The presence of this virus in the province is currently unconfirmed, but its presence is known in other parts of the species' range in Canada. In addition to direct mortality, exposure to contaminants can result in abnormal development, decreased reproductive output, or changes in behaviour that affect fitness (see reviews and references in Harfenist *et al*. 1989; Bishop 1992; COSEWIC 2012). *Bacillus thuringiensis* is a bacterium-based mosquito larvicide that is used regularly by

mosquito control programs in the Okanagan valley. This substance may affect larval salamanders by reducing prey species (mosquitoes and chironomids), but science-based field data on declines is sparse. Malathion is approved for use in treating adult mosquitos on a broad scale in an emergency situation (e.g., if the West Nile virus becomes a serious public health issue), but it is not currently used for this purpose in the Okanagan valley by regional government. It is used on private land, but the degree of use is not known.

Bishop *et al.* (2010) detected low concentrations of 17 agricultural chemicals in amphibian breeding wetlands at orchards in the South Okanagan River valley. Even though banned for decades, DDT derivatives were persistent and several other orchard chemicals were present in wetlands associated with both organic and chemically treated orchards. The hatching success of four amphibian species examined (Blotched Tiger Salamanders were not included) was lowest in orchards sprayed with pesticides and highest in non-agricultural reference locations, but there was much variability in responses according to species and reflecting location-specific conditions, including water chemistry. The threat from pollution may be more serious at low elevations, but new research suggests it may also affect high-elevation wetlands through airborne drift of chemicals (Davidson 2004).

Threat 11. Climate change & severe weather (threat impact: Medium–Low)

Drought can have substantial effects on tiger salamander breeding and reproductive success. Shallow wetlands can dry substantially or completely before salamanders can metamorphose, killing eggs and larvae. If wetlands are dry during the breeding season, salamanders will not be able to lay eggs. The water table has dropped significantly across the province's southern interior over the past 20 years, likely as a result of climate change and a series of drought years (Cohen 2004). Water tables in the Okanagan Basin are expected to continue to drop, while water demand is expected to increase (Cohen 2004). A substantial number of Blotched Tiger Salamander breeding wetlands have been dry or almost dry for most of the past decade (Dyer, pers. comm., 2012).

In addition to current climate extremes, global climate model projections for the Okanagan Basin in the 21st century indicate a continued increasing trend in both temperature (by 2–4°C) and winter precipitation (by 5–20%) by the 2050s. Summer precipitation is predicted to either remain the same or decrease (up to 30%, according to some models; Cohen 2004). A risk analysis by Bunnell *et al.* (2010) concluded that many small, shallow wetlands would continue to experience significant drying trends over the next decades as climate change progresses. Tiger salamanders also breed in more permanent waterbodies at less risk from drying, but many permanent wetlands are affected by fish introductions, reducing their potential to support this species (Bunnell *et al*. 2010). Although the most severe climate effects are not expected for several decades, adaptive planning should occur soon to maintain options.

Threats with "Negligible" impact

The threat assessment flagged several threats that were scored as "Negligible" in overall impact on the population but that could have local effects. Development of new commercial and industrial areas (Threat 1.2) or tourism and recreation areas (Threat 1.3) would result in habitat loss, although few such developments were anticipated in Blotched Tiger Salamander

habitat over the next 10 years. Utility and service line expansion or development (Threat 4.2) could affect salamanders in the construction phase (e.g., through entrapment in gas line trenches). Illegal collection of Blotched Tiger Salamanders for pets, fish bait, or other purposes (Threat 5.1) may occur occasionally but at low rates. Logging and wood harvesting (Threat 5.3), including salvage logging of wood damaged by the Mountain Pine Beetle, occurs mostly at higher elevations and affects less than 1% of the species' range. Fires (Threat 7.1) are thought to have a Negligible impact on the salamanders. Individuals probably survive fires in underground refuges, unless the fire is very hot and significantly raises soil temperatures. Fire suppression (Threat 7.1) is not an issue over the short term but may be over the long term if it results in conifer encroachment into grassland and open woodland habitats, decreasing habitat suitability for the salamanders.

Threats with "Unknown" impact

The threat assessment flagged several threats with "Unknown" impacts on the population (Table 6). These threats could be significant, but insufficient information is available at present to adequately assess them. Recreational activities (Threat 6.1), particularly all-terrain vehicle use in and around wetlands, could severely degrade breeding wetlands, hasten premature drying of ponds, collapse burrows, and result in mortality of eggs, larvae, or adults. Much uncertainty surrounds whether, where, and how often such activities occur in Blotched Tiger Salamander breeding habitats. Problematic native species (Threat 8.2) with unknown impacts include the *Ambystoma tigrinum* virus. No disease outbreaks have been reported in the province to date and the virus has not been searched for in British Columbia. If non-native tiger salamander species are released in breeding habitats of the Blotched Tiger Salamander, introduced genetic material (Threat 8.3) could become a problem through hybridization. Tiger salamanders of various species are occasionally sold illegally in the province, but the extent of this issue is unknown. Household sewage and urban waste (Threat 9.1.) may contain numerous pharmaceuticals, antibiotics, and other contaminants with largely unknown, but potentially harmful, effects on tiger salamanders. Blotched Tiger Salamander breeding wetlands could become contaminated through leakage from aging septic tanks; a few subpopulations breed in sewage lagoons. Temperature extremes (Threat 11.3) associated with climate change may pose problems for Blotched Tiger Salamanders. Gerick et al. (2014) suggested that the Great Basin Spadefoot (*Spea intermontana*) and two other amphibians might be at risk throughout a large portion of their range related to high temperatures. This may apply to tiger salamanders as well.

5 RECOVERY GOAL AND OBJECTIVES

5.1 Recovery (Population and Distribution) Goal

The recovery goal is to maintain or increase the abundance of Blotched Tiger Salamander in each of the three geographic areas where it occurs and to ensure connectivity within these areas.

5.2 Rationale for the Recovery (Population and Distribution) Goal

The Blotched Tiger Salamander has a naturally small distribution in Canada, where its range overlaps with the highly modified and densely populated landscape of the southern interior valleys of British Columbia. Expanding human developments and associated roads continue to affect habitat and reduce connectivity between and among the remaining occupied areas, further exacerbating population loss. Sufficient information to quantify long-term population and distribution/habitat targets for survival and recovery is not available because of a lack of baseline data on historical distributions and abundance, as well as data gaps regarding current population size and trends. It is assumed that all known subpopulations are necessary for the long-term persistence of the Blotched Tiger Salamander in the province.

COSEWIC (2012) recorded a 5054 km^2 extent of occurrence and 232–464 km^2 index of area of occupancy for the Blotched Tiger Salamander (i.e., the Southern Mountain Population of the Western Tiger Salamander) in British Columbia. The population is severely fragmented with an observed decline in habitat quantity and quality, an inferred decline in area of occupancy and population size, and extreme fluctuations in number of individuals. These quantitative criteria led to an assessment of Endangered.[6] The thresholds separating an "Endangered" assessment from an assessment as "Threatened" are an extent of occurrence greater than 5000 km^2, an index of area of occupancy greater than 500 km^2, and an absence of the combination of the species having few locations and (a) severe fragmentation, (b) continuing declines, and (c) extreme fluctuations (COSEWIC 2012).

Improving the species' condition may be possible in the future, provided that threats to the habitat and population can be substantially reduced and habitat connectivity increased, so that most of the population resides in habitat patches sufficiently large to support a viable population over the long term. Increasing connectivity among locations (e.g., by restoring or protecting habitat in the intervening areas and/or facilitating safe movements across roads) could be used to reduce fragmentation and maintain a "rescue effect" between subpopulations.

The immediate recovery goal is to prevent further loss and fragmentation of the species' small distribution range. More information about population size and trends across the landscape, and opportunities to mitigate threats, is needed to determine what is biologically and technically feasible for recovery, and to develop an appropriate long-term recovery goal for this species. In the short term, if additional naturally occurring subpopulations are discovered,

[6] Assessed as Endangered based on COSEWIC criteria: B1ab(ii,iii,v)c(iv)+2ab(ii,iii,v)c(iv).

they should be maintained. Restoring and protecting dispersal habitat lost because of human-induced fragmentation will be important for maintaining viable subpopulations within each of the three areas areas occupied by the salamanders in B.C.

5.3 Recovery Objectives

The following objectives are necessary to conserve the Blotched Tiger Salamander in the short term (next 5 years). The recovery objectives address reducing threats to the species and its habitats, and increasing connectivity, so that the population would no longer be severely fragmented. Breeding habitat is more limited in area than terrestrial habitat and is most limiting to population recovery, since it is the source area for all reproduction. Suitable terrestrial habitat extending at least 1000 m around aquatic breeding habitat is likely required for juvenile and adult survival. Thus, core habitat is defined as known breeding and terrestrial tiger salamander locations with a 1000 m terrestrial band of habitat around the wetland (see Section 3.3). Dispersal habitat between breeding and terrestrial habitat is important for repopulating locally extirpated areas and for long-term viability of subpopulations. Dispersal habitat through the United States may be important for maintaining subpopulations in Canada, but research is required for clarification. The objectives also tackle knowledge gaps related to the threats and needs associated with the species, so that factors influencing the viability of subpopulations can be addressed.

1. Secure core habitat (breeding wetlands and associated terrestrial habitat) for Blotched Tiger Salamander in each of the three geographic areas that it occupies.
2. Maintain or increase connectivity across the landscape within and among adjacent known subpopulations.[7]
3. Address knowledge gaps such as: distribution, habitat requirements, population structure, and biological processes across the landscape; water use and declining water tables; climate change; road mortality; disease; pollution; pesticides and herbicides; invasive species; and effectiveness of recovery actions.

Secure habitat is defined as Blotched Tiger Salamander habitat that is managed to maintain the species for a minimum of 100 years. It can include breeding, as well as terrestrial core and connectivity habitat where anthropogenic threats (direct and indirect effects) are addressed. Securing habitat will require a stewardship approach that engages the voluntary cooperation of landowners and managers on various land tenures to protect this species and the habitat it relies on. It may include stewardship agreements, conservation covenants, Ecological Gifts, voluntary sale of private lands by willing landowners, land use designations, protected areas, management agreements, and existing legislation.

[7] Subpopulations are defined as geographically or otherwise distinct groups in the total population between which little demographic or genetic exchange occurs.

6 APPROACHES TO MEET RECOVERY OBJECTIVES

6.1 Actions Already Completed or Underway

The following action groups are categorized according to the action sorting tool outlined in the B.C. Conservation Framework primer (see B.C. Ministry of Environment 2009). Status of the action group for this species is given in parentheses.

Compile Status Report (complete)

- COSEWIC report completed (COSEWIC 2012). Update due in 2022.

Planning (complete)

- Recovery strategy for British Columbia completed in 2008 (this document, 2016).

Habitat Protection and Private Land Stewardship (in progress)

- Inventory to identify locations for habitat protection continues (e.g., Sarell and Robertson 1994; Sarell et al. 1998; Sarell and Alcock 2004; Rebellato 2005; Tarangle and Yelland 2005; Hobbs and Vincer 2015, Ashpole, pers. comm., 2016)
- The Dominion Radio Astrophysical Observatory and The Nature Trust BC protect breeding wetlands and substantial terrestrial habitat at White Lake.
- Provincial parks and protected areas protect breeding wetlands and substantial terrestrial habitat (e.g., the Gilpin, White Lake Grasslands, and South Okanagan Grasslands Protected Areas).
- Eleven wildlife habitat areas (encompassing 301.1 ha) for this species were established on provincial Crown land in the South Okanagan River valley from 2005 to 2011 (B.C. Ministry of Environment 2014).
- New private land conservancies were established (e.g., The Nature Trust of BC's Twin Lakes Ranch; Ducks Unlimited Canada's Bobolink Meadows; Nature Conservancy of Canada's Sage and Sparrow and Kitt Carr Conservation Areas). Together, these areas protect 1073 ha of Blotched Tiger Salamander breeding and terrestrial habitat.
- Stewardship agreements were established through the South Okanagan Similkameen Stewardship Society with private landowners on 568 ha Blotched Tiger Salamander core habitat.
- The Okanagan Basin Water Board initiated the Okanagan Wetlands Strategy, designed to identify and protect or restore wetlands.
- The South Okanagan Similkameen Conservation Program and Regional District of Okanagan-Similkameen developed "Keeping Nature in our Future," a biodiversity strategy for the south Okanagan (South Okanagan Similkameen Conservation Program 2012). The strategy includes detailed conservation ranking maps, analyses by local government area, and recommendations for Environmentally Sensitive Development Permit Areas (White, pers. comm., 2016). A companion document on designing and implementing ecosystem connectivity in the Okanagan was produced (Latimer and Peatt 2014)

- The new provincial *Water Sustainability Act* has expanded definitions of a stream and associated aquatic ecosystem, including wildlife, that provide increased protection for Blotched Tiger Salamander breeding wetlands (Province of British Columbia 2014b).
- Guidelines for amphibian and reptile conservation during urban and rural land development in the province were updated (Province of British Columbia 2014a).
- Best management practices for amphibian and reptile salvages in B.C. (Ministry of Forests, Lands, and Natural Resource Operations, 2016).

Habitat Restoration (in progress)

- Underpasses (large culverts and directional fencing) were installed at the Highway 97 twinning project south of Oliver (Crosby 2014) to improve habitat connectivity.
- Two artificial wetlands have been created for Blotched Tiger Salamanders (Ashpole, pers. comm., 2016).
- Eleven Blotched Tiger Salamander breeding wetlands were fenced to exclude livestock on properties owned The Nature Trust, The Nature Conservancy of Canada, and on provincial Crown land.
- A 7-year bullfrog eradication project in the South Okanagan River valley has had good success, with no confirmed sightings since 2010 (Ashpole and Govindarajalu, pers. comm., 2014).

Species and Population Management (in progress)

- Invasive goldfish were successfully removed at one Blotched Tiger Salamander breeding wetland (Ashpole, pers. comm., 2016).
- Road mortality effectiveness research was conducted at the Highway 97 twinning project south of Oliver (Crosby 2014) and research is underway at Grand Forks (Tedesco 2014) and White Lake (Larsen, Winton; pers. comm., 2016).
- Master's thesis research has begun at White Lake into breeding success, testing of backpack telemetry for dispersers, monitoring of colour pattern change for individual recognition, and health monitoring for pit-tagged individuals (Larsen, Winton; pers. comm., 2016).

6.2 Recovery Planning Table

Table 7 summarizes the recommended recovery actions for the Blotched Tiger Salamander.

Table 7. Recovery actions for the Blotched Tiger Salamander.

Objective	Conservation Framework action group	Actions to meet objectives	Threat [a] or concern addressed	Priority [b]
1, 2	Habitat protection	Continue to inventory potential breeding wetlands and record sightings in terrestrial habitat, and road mortality to identify locations for habitat protection. Monitor locations to quantify and improve habitat protection effectiveness. eDNA may increase cost-effectiveness.	1.2; 2.1; 2.3; 4.1; 7.2	Essential
		Continue to improve habitat protection through existing land use designations and management agreements on Crown land (e.g., Wildlife Habitat Areas, Section 16 *Land Act* reserves, Protected Area Management, Range Use Plans).	2.3; 4.1; 7.2	Essential
		Continue working with First Nations to identify and implement opportunities for cooperative habitat conservation projects both on and off reserve land. Incorporate traditional ecological knowledge into recovery actions.	1.2; 2.1; 2.3; 4.1; 7.2	Essential
		Continue to work with local governments to incorporate habitat stewardship and protection into planning processes such as Official Community Plans, Environmentally Sensitive Development Permit Areas, zoning, bylaws, and park/recreation plans (e.g., South Okanagan Similkameen Conservation Program biodiversity strategy implementation).	1.1; 2.1; 4.1	Essential
		Continue to work with agricultural groups to reduce use of detrimental pesticides/herbicides and increase compliance with best practices.	2.1, 8.1, 9.3	Essential
		Identify locations where water use impacts tiger salamander larvae and develop options for protecting environmental flow needs.	2.3; 7.2; 11.2	Beneficial
1, 2	Private land stewardship	Continue to acquire and manage important habitat through purchase of private lands from willing vendors (e.g., Acquisitions by The Nature Trust; The Nature Conservancy of Canada; Ducks Unlimited; Southern Interior Land Trust).	1.1; 2.1; 2.3; 7.2	Essential
		Continue to implement stewardship agreements, conservation covenants, and best management practices on private lands through voluntary agreements (e.g., South Okanagan Similkameen Stewardship Society agreements).	1.1 2.1; 7.2; 8.1; 9.1	Essential
1, 2	Habitat restoration	Eliminate predatory fish at key locations (where feasible) and reduce the likelihood of continued illegal introductions through targeted outreach.	8.1	Essential

Objective	Conservation Framework action group	Actions to meet objectives	Threat [a] or concern addressed	Priority [b]
		Strategically restore or enhance breeding wetlands and improve terrestrial habitat by reducing thatch lawns and other physical barriers (where possible) in areas where loss of habitat and connectivity is seriously affecting population viability.	1.1 2.1; 11.2	Necessary
		Fence breeding wetlands, especially shallow wetlands where risk is highest, to reduce cattle impacts while maintaining livestock water through single point access (where appropriate) and off-site watering.	2.3	Necessary
		Identify "hot spots" where a high level of road mortality occurs and implement mitigation (where required); use adaptive management to identify effective actions to reduce or eliminate mortality and restore habitat connectivity.	4.1	Necessary
1, 2, 3	Species and population management	Continue to develop and deliver outreach materials to priority target audiences to increase understanding, support for, and implementation of other actions	1.1; 2.1; 2.3; 4.1; 7.2; 8.1; 9.3; 11.2	Essential
		Continue efforts to monitor for invasive American Bullfrogs and eliminate introduced populations in the South Okanagan River valley (if detected). Use new eDNA methods to increase effectiveness.	8.1	Essential
		Monitor for emerging infectious diseases (e.g., Ranavirus, *Ambystoma tigrinum* virus, Chytrid) and contain their spread (if identified). Explore eDNA monitoring methods.	8.1; 8.2	Necessary
		Clarify threats from drought, climate variation, and climate change on breeding ponds and identify options and priorities for addressing impacts (if necessary), including use of an adaptive management approach.	11.2	Necessary
		Continue to quantify threats from pollution, particularly agricultural chemicals, magnesium chloride on roads, and effects of West Nile virus control strategies.	9.3	Necessary
		Address knowledge gaps regarding movements, habitat use, population structure, meta-population dynamics, landscape connectivity, and effectiveness of threat mitigation actions through research.	1.1; 2.1; 2.3; 4.1; 7.2; 8.1; 11.2	Necessary
		Clarify potential impacts from ranching activities on breeding and terrestrial habitat; identify mitigation measures and implement priority actions through an action plan.	2.3	Beneficial
		Develop a population viability analysis to quantify population and habitat targets required for recovery.	1.1; 2.1; 2.3; 4.1	Beneficial

[a] Threat numbers according to the IUCN–CMP classification (see Table 6 for details).
[b] Essential (urgent and important, needs to start immediately); Necessary (important but not urgent, action can start in 2–5 years); or Beneficial (action is beneficial and could start at any time that was feasible).

6.3 Narrative to Support Recovery Planning Table

This plan will be implemented using a landscape conservation approach through various stewardship partnerships and existing legislation. Whenever possible, an ecosystem conservation approach will be used to protect and manage habitat for multiple species.

6.3.1 Habitat Protection, Restoration, and Private Land Stewardship

Inventory efforts focusing on potentially suitable wetlands within areas that have received low survey effort are needed, so that possible undocumented breeding wetlands are located and protected or managed appropriately. In addition, historically occupied locations need to be verified systematically across the species' range to establish whether subpopulations continue to occur at these or adjacent locations within the landscape. Use of new environmental DNA techniques will greatly facilitate the probability of detection. These techniques allow the detection of species from minute quantities of DNA contained in sloughed off skin or feces in water samples (Pilliod *et al.* 2013). Because small, temporary wetlands favoured by Blotched Tiger Salamanders may not be available or used each year, survey efforts should span breeding seasons in multiple years.

Securing habitat for core and connectivity habitat will be accomplished largely through acquisition from willing vendors, stewardship activities, local government development permits or bylaws on private lands, and land use designations or management on Crown lands. To make recovery activities successful, voluntary cooperation by landowners and managers of stewardship activities on various land tenures requires encouragement and support. This stewardship approach includes different kinds of activities, such as following guidelines or best management practices, conservation agreements and covenants, and ecological gifts. To be useful, protected habitat needs to be large enough and in adequate condition for this species to carry out its seasonal activities for all life stages.

6.3.2 Habitat Restoration

Habitat restoration and enhancement can be a useful tool in some cases and in areas where wetlands and associated terrestrial habitats are degraded by human activities. Blotched Tiger Salamanders readily use human-made waterbodies, but creation of such habitats should be conducted sparingly and with extreme care to avoid creating mortality sinks. Habitat creation should not be used as an excuse for not protecting existing natural habitat, which is always the preferred option. Restoration may include fencing to address livestock damage, and removal of sod-forming plants to increase access to subsurface habitat. Habitat restoration should also include improvement of effective and safe connectivity through road networks.

6.3.3 Species and Population Management

The recovery activities address knowledge gaps on terrestrial movements, habitat use, and population structure across the landscape to help quantify targets for habitat protection. In particular, information on terrestrial movements, population structure across the landscape, and characteristics of dispersal habitat are limited. This information is needed to adequately address

habitat and species protection needs, including the amount and type of upland habitat required for seasonal migration and dispersal movements, the optimal spatial configuration of breeding habitats in the landscape to help ensure population connectivity, and how these factors are expected to affect the viability of the population over the long term. Various methods ranging from mark-recapture studies to genetic analyses and population modeling are available to address these issues.

Management actions include mitigating impacts from significant threats such as fish introductions, continuing American Bullfrog eradication efforts, and developing strategies needed to detect and confine disease outbreaks should they occur. These actions also include clarification of impacts and development of effective management, compliance monitoring, and enforcement measures for threats from livestock ranching, pollution, mosquito larvicides, and climate change. Threat mitigation and clarification can often be conducted in the context of adaptive management; this approach should be deployed whenever feasible to ensure timely initiation of mitigation.

Targeted outreach activities are needed to gain support and collaboration from landowners and other stakeholders. This action includes the development and dissemination of best management practices and addressing mitigation of threats from various land use practices.

Techniques for re-establishing subpopulations include captive breeding and assisted migration. An assurance population is a population of animals that is kept in captivity and captive-bred to ensure a source of animals or genetic variation to help recover wild subpopulations, if needed. Assisted migration involves introducing or re-introducing a species to recover a geographic location that the species is unlikely to colonize without assistance. At this time, both assurance populations and assisted migration are considered unnecessary but may be reconsidered in the future. Both techniques require *Wildlife Act* permits and should be used with great care, based on a well-supported plan.

7 SPECIES SURVIVAL AND RECOVERY HABITAT

Survival/recovery habitat is defined as the habitat that is necessary for the survival or recovery of the species. This is the area that the species naturally occurs or depends on directly or indirectly to carry out its life-cycle processes or formerly occurred on and has the potential to be re-introduced.

7.1 Biophysical Description of the Species' Survival/Recovery Habitat

A description of the known biophysical features and their attributes of the species' habitat that are required to support its life-cycle processes (functions) are provided in Section 3.3. The habitat used by Blotched Tiger Salamander in British Columba has been incompletely documented (see Richardson *et al.* 1998, 2000a, b). Inferences can be made from the related California Tiger Salamander, which occurs in similar habitats and has been well studied

(Trenham and Schaffer 2005; Orloff 2011; Searcy and Shaffer 2011; Searcy *et al.* 2013), but local research is needed, particularly in regard to long-distance movements of adults in terrestrial environments. An improved understanding of this aspect of the species' ecology would facilitate more effective conservation of "upland" terrestrial habitats and ensure measures to promote and/or maintain connectivity between breeding wetlands are effective. Additional work required to address habitat knowledge gaps is included in the Recovery Action Table (Table 7).

7.2 Spatial Description of the Species' Survival/Recovery Habitat

The area of survival/recovery habitat required for a species is guided by the amount of habitat needed to meet the recovery goal. Although no fine-scale habitat maps are included with this document, it is recommended that the locations of survival/recovery habitat be described on the landscape to mitigate habitat threats and to facilitate the actions for meeting the recovery (population and distribution) goals.

8 MEASURING PROGRESS

The following performance measures provide a way to define and measure progress toward achieving the recovery (population and distribution) goal and recovery objectives. Performance measures are listed below for each objective.

- Blotched Tiger Salamander abundance is is maintained or increased in each of the three geographic areas it occupies in British Columbia.
- Connectivity, across the landscape within and among subpopulations is maintained or increased.
- Core breeding and terrestrial habitat is secured.
- A strategy to address knowledge gaps is developed by 2017 and work begun to address key knowledge gaps.

9 EFFECTS ON OTHER SPECIES

Many endangered or threatened species occupy the same range and use similar wetland or grassland and shrub–steppe habitats as Blotched Tiger Salamanders in the arid interior belt of British Columbia. The Great Basin Spadefoot (*Spea intermontana*; threatened) has substantial habitat overlaps with tiger salamanders. Western Painted Turtle (*Chrysemys picta*; special concern) overlaps wetland use at some locations. As a result of these similarities, extensive opportunities exist to use a multi-species approach for a more effective implementation of recovery activities. Conservation of the Blotched Tiger Salamander's habitat through the strategies outlined here will assist in protecting habitat for these and other native species and ecosystems. Other species at risk that might benefit from securing Blotched Tiger Salamander habitat include the Pallid Bat (*Antrozous pallidus*; threatened), American Badger (*Taxidea taxus*; endangered), Burrowing Owl (*Athene cunicularia*; endangered), Sage Thrasher (*Oreoscoptes montanus*; endangered), Great Basin Gophersnake (*Pituophis catenifer deserticola*; Threatened), Western Rattlesnake (*Crotalus*

oreganus), and Behr's Hairstreak butterfly (*Satyrium behrii*; threatened). Recovery conflicts between species are unlikely to occur. Blotched Tiger Salamanders are natural predators of the Great Basin Spadefoot and many invertebrates, but the protection of habitat should offset any possible negative effects from natural predation.

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