Recovery Strategy for the Tiger Salamander (*Ambystoma tigrinum*), Southern Mountain Population in British Columbia

Prepared by the Southern Interior Reptile and Amphibian Recovery Team

January 2008

About the British Columbia Recovery Strategy Series

This series presents the recovery strategies that are prepared as advice to the Province of British Columbia on the general strategic approach required to recover species at risk. The Province prepares recovery strategies to meet our 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 recovery strategy?

A recovery strategy represents the best available scientific knowledge on what is required to achieve recovery of a species or ecosystem. A recovery strategy outlines what is and what is not known about a species or ecosystem; it also identifies threats to the species or ecosystem, and what should be done to mitigate those threats. Recovery strategies set recovery goals and objectives, and recommend approaches to recover the species or ecosystem.

Recovery strategies are usually prepared by a recovery team with members from agencies responsible for the management of the species or ecosystem, experts from other agencies, universities, conservation groups, aboriginal groups, and stakeholder groups as appropriate.

What's next?

In most cases, one or more action plan(s) will be developed to define and guide implementation of the recovery strategy. Action plans include more detailed information about what needs to be done to meet the objectives of the recovery strategy. However, the recovery strategy provides valuable information on threats to the species and their recovery needs that may be used by individuals, communities, land users, and conservationists interested in species at risk recovery.

For more information

To learn more about species at risk recovery in British Columbia, please visit the Ministry of Environment Recovery Planning webpage at:

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

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Disclaimer

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

This document identifies the recovery strategies that are deemed necessary, based on the best available scientific and traditional information, to recover Tiger Salamander, Southern Mountain 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 objectives and findings.

The responsible jurisdictions and all members of the recovery team 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 recovery team.

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 strategy. The Ministry of Environment encourages all British Columbians to participate in the recovery of the Tiger Salamander, Southern Mountain population.

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EXECUTIVE SUMMARY

The Southern Mountain population of the Tiger Salamander was designated in 2001 by the Committee on the Status of Endangered Wildlife in Canada as Endangered. This population occurs in south-central British Columbia within the South Okanagan, Lower Similkameen, and Kettle River watersheds. Tiger salamanders breed in both permanent and vernal water bodies. Metamorphosed juveniles and adults depend on terrestrial habitats, including arid grassland, shrub-steppe, and open forest, where they usually live underground in rodent burrows. Some Tiger Salamanders do not metamorphose and become sexually mature while retaining larval body form, including gills, through a process termed neoteny. These adults continue to depend on wetlands throughout their lives.

Habitat loss, degradation, and associated fragmentation due to urban and agricultural development pose the greatest threats to Tiger Salamanders. Direct mortality from exotic species such as introduced fish and bullfrogs are also severe threats at many key sites. Pollution, mainly from agricultural chemicals, is a widespread and serious emerging threat. Road mortality and intensive grazing around shallow breeding sites in wetlands may impact local sites. Disease and climate change may have disastrous effects in the future and must be considered carefully.

The recovery goal is to ensure that there is sufficient, secure habitat to maintain a self-sustaining population, or populations, in each major watershed throughout the historic range of the Tiger Salamander in Canada.

Recovery objectives are to:

1. Secure a minimum of 154 ha of aquatic breeding habitat at known breeding sites and a minimum of 4000 ha of terrestrial habitat surrounding and connecting priority breeding sites by 2012. These habitat securement targets are deemed by the recovery team to be achievable, and necessary to support the species in the short term.
2. Address knowledge gaps related to the distribution, habitat requirements, population processes, terrestrial movements, threats, population viability, critical habitat, and long-term habitat securement targets by 2012.
3. Build sufficient understanding, knowledge, and support for habitat protection by stakeholders and the public by 2012.

Habitat securement 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, eco-gifts, voluntary sale of private lands by willing landowners, land use designations and management agreements, and/or protected areas.

One or more action plans will be completed by 2012.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

BACKGROUND

Species Assessment Information from COSEWIC

Date of Assessment: November 2001

Common Name (population): Tiger Salamander, Southern Mountain population

Scientific Name: *Ambystoma tigrinum*

COSEWIC Status: Endangered

Reason for Designation: Tiger Salamanders in this region have suffered greater than 50% loss of available breeding habitat, largely through degradation and stocking with predatory fish. Human population growth in the region is also resulting in significant loss of habitat for terrestrial adults.

Canadian Occurrence: B.C

COSEWIC Status History: Designated Endangered in November 2001. Assessment based on a new status report.

Description of the Species

Tiger Salamanders are large (up to 20 cm long), heavy-bodied amphibians with a characteristic colour pattern of large yellow or whitish blotches on a black or grey background (Leonard *et al.* 1993; Corkran and Thoms 1996). Aquatic larvae are olive-green and have a large head and long feathery gills. Under some circumstances in permanent water bodies, individuals reach sexual maturity while retaining larval body form, including gills, through a process termed neoteny (see photo on cover).

Tiger Salamanders have a complex life cycle. Eggs are laid in aquatic habitats shortly after the first, early spring rains. Larvae hatch from eggs within 10–21 days, and continue to occupy aquatic habitats until August when gills become reduced and they begin to breathe air, during metamorphosis. Juveniles and adults migrate to terrestrial habitats including grassland, shrub-steppe and open forest during late summer or early fall rains and generally live underground. They are excellent examples of a desert-adapted species with multiple life forms, which take advantage of different environmental conditions (COSEWIC 2001).

Populations and Distribution

Tiger Salamanders (*Ambystoma tigrinum*) are widely distributed in North America, ranging from southern Canada southward to Pueblo, Mexico, and across the continent to the east coast of the United States (NatureServe 2005). The Tiger Salamander ranges from southwest Canada, including Saskatchewan, Alberta, and British Columbia, to central and western United States. Canada has less than 5% of the global distribution of the Tiger Salamander.

A disjunct distribution of the Tiger Salamander occurs in Washington State, Oregon, Idaho, and south-central British Columbia (COSEWIC 2001) (Figure 1). The Southern Mountain population occupies the northern portion of this distribution in British Columbia, where it is restricted to the South Okanagan, Lower Similkameen, and Kettle River watersheds (Figure 2). It is not clear whether Tiger Salamanders in British Columbia are part of a single population or multiple populations. The range of the Southern Mountain population comprises approximately 15% of the disjunct distribution of this subspecies.

The Tiger Salamander has a ranking of “G5/T4” (“secure”) (NatureServe 2005). In Oregon, it has the status of S2? (“imperiled”; high degree of uncertainty) (NatureServe 2005). In Washington State, it has the status of S3 (“rare or uncommon”) (Hallock and McAllister 2005). In British Columbia, the Southern Mountain population is S2, Red-listed (“imperiled”) (BCMOE 2005a).

Both the extent of occurrence and area of occupancy of the Southern Mountain population are thought to be declining (Technical Summary in COSEWIC 2001), 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 sites, combined with extensive habitat loss within the area of occurrence. Of 41 historical breeding sites, only 16 were deemed suitable in 1996 (Sarell 1996, 2004).

As of August 2005, 57 occupied[1] breeding sites are known in the Southern Mountain population (BCMOE 2005b). The estimated area of occurrence is 1817 km^2 and the area of estimated occupancy is 7786 ha, consisting of 154 ha of aquatic breeding habitat and 7632 ha of terrestrial foraging habitat around these sites.[2] Additional, undiscovered breeding sites with associated terrestrial habitat might exist. The total number of breeding adults is speculatively estimated at a few hundred (COSEWIC 2001), but much uncertainty is associated with this figure.

Studies of Tiger Salamanders from other areas indicate that the number of breeding adults varies enormously among sites and years, ranging from a few animals to hundreds of adults per site (appendix 1, note i). This variability is likely related to habitat quality and/or environmental conditions in particular years.

[1] Occupied breeding sites refer to sites where breeding has been recorded during the past 15 years and are believed to be extant.

[2] Area of occupancy was estimated by BCMOE staff in August 2005 by adding a 630 m -wide area of upland habitat around each known aquatic breeding site. This area represents the upland habitat used by the majority of Tiger Salamanders at each breeding site based on a literature review on movements of Tiger Salamanders (see end note ii for details). The 57 sites were clustered within 33 broad areas as a result of overlapping areas of occupied upland habitat.

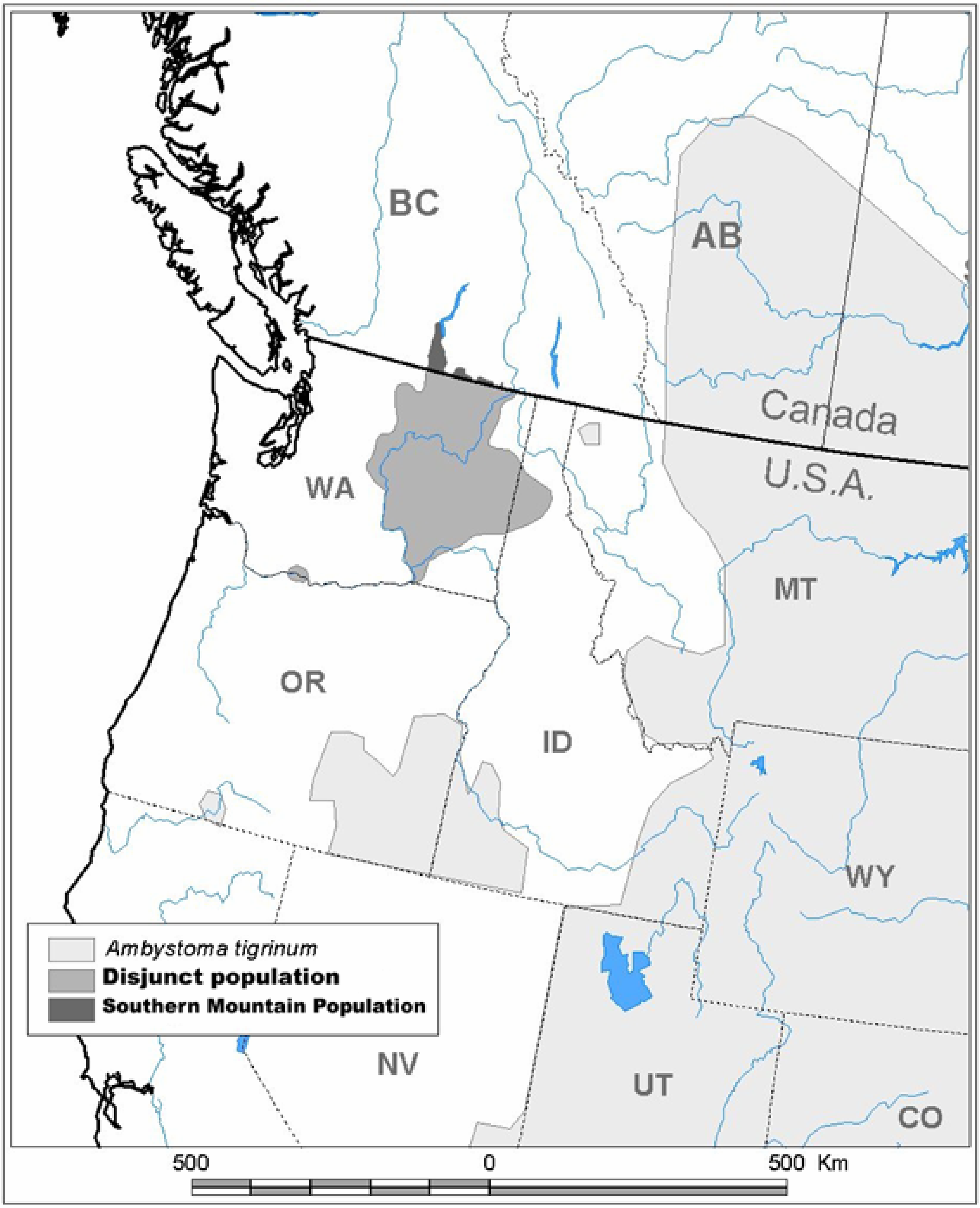

Figure 1. Range of the Tiger Salamander in western North America.

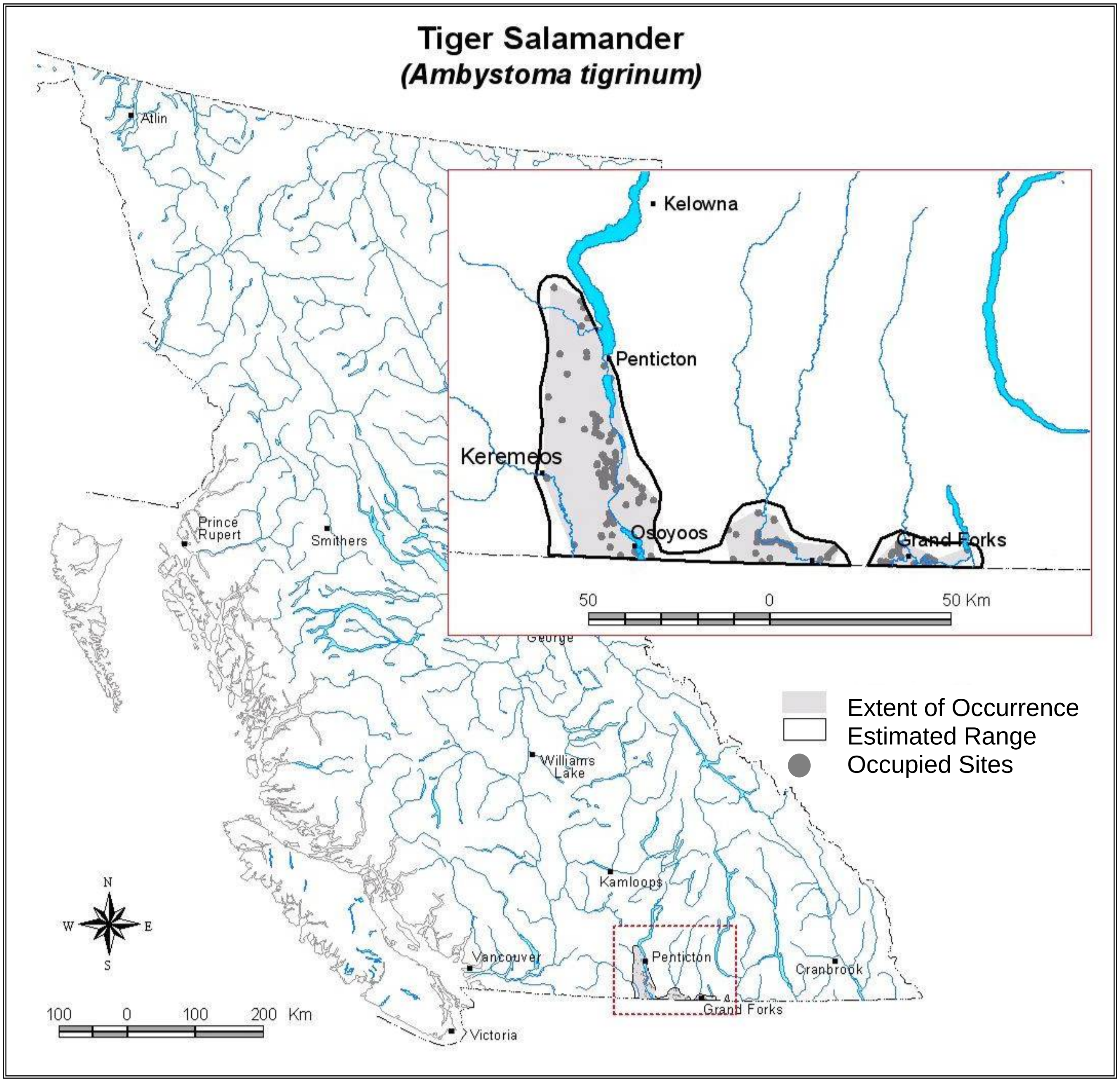

Figure 2. Range of the Southern Mountain population of the Tiger Salamander in British Columbia.

Needs of the Tiger Salamander

Habitat and biological needs

The Southern Mountain population occupies arid habitats at low- and mid-elevations (up to about 1250 m above sea level) within the dry interior region of British Columbia (COSEWIC 2001). Individual breeding sites in vernal pools (seasonal and temporary wetlands) may disappear either permanently or for many years due to ecological succession, severe droughts, or other factors. Therefore, populations require a mosaic of breeding sites of different water depths distributed across the landscape to ensure persistence (Richardson *et al*. 2000a). Important features of the aquatic and terrestrial habitat are outlined below. (See reviews in COSEWIC 2001 and Sarell 2004 for more detailed descriptions and references.)

Aquatic breeding habitat: Courtship, mating, egg-laying, and development of eggs and larvae take place in either vernal ponds or permanent water bodies. In British Columbia, currently known breeding sites range from 0.02 to 33.31 ha (mean = 3.48 ha, SD = 5.83 ha, n = 53, information on size lacking for remaining sites; BCMOE 2005b). Vernal ponds with few predators have the potential to produce a large number of recruits in years when conditions are optimal, whereas deeper water bodies may be the only source of recruits in drought years (Richardson *et al.* 2000a). Important features of breeding sites include persistence of water until larval development is complete (from mid-March to mid-August), shallow (generally <1 m) water depths along at least portions of the water body, soft bottom substrate, abundant emergent vegetation, suitable cover for metamorphs (amphibians that have recently transformed to the adult stage) along the shoreline, and absence of introduced fish (reviewed in COSEWIC 2001; Sarell 2004).

Aquatic habitat of neotenes: Neotenes require permanent or semi-permanent water bodies and do best in the absence of predatory fish. This life history mode is often prevalent in cool waters of high altitude lakes and ponds (Bizer 1978). Little is known of specific habitat needs of neotenes.

Terrestrial foraging, seasonal migration, and overwintering habitat (metamorphosed juveniles and adults): Outside the breeding period, terrestrial Tiger Salamanders use grassland, shrub-steppe, and open forest habitats (COSEWIC 2001). Important habitat features include friable soils that permit burrowing, rodent burrows for shelter, and availability of food (Semlitsch 1998; COSEWIC 2001; Sarell 2004). Coarse woody debris and other surface cover, especially near the shoreline of breeding sites, might also be important.

The extent of terrestrial habitat that salamanders require around breeding ponds is likely to vary both with the configuration and quality of terrestrial habitat. A review of available information for Tiger Salamanders from this and other areas suggests that a 630 m-wide band of terrestrial habitat around aquatic breeding sites is likely to provide sufficient terrestrial habitat for life history functions of local populations (Appendix 1, notes i, ii). However, it is unknown whether this amount of terrestrial habitat is sufficient to ameliorate edge effects resulting from land clearing or other disturbances or to filter out pollutants and ensure water quality. In addition, this terrestrial habitat adjacent to breeding sites does not include dispersal habitat that allows movements between subpopulations for those breeding sites that are farther than 1260 m from each other and have non-overlapping areas of upland habitat.

Dispersal habitat: For pond-breeding amphibians, connectivity through suitable terrestrial habitat is required among breeding sites to permit dispersal movements across the landscape and to ensure that population processes at a broader scale remain functional (Semlitsch 2002). Therefore, alternative breeding sites that allow for the colonization of new sites are vital for the persistence of the larger population (or metapopulation) across the landscape (Semlitsch 1998, 2000, 2002).

Data on movements of other aquatic-breeding amphibians suggest that under optimal conditions, individuals of many species can travel several kilometres across terrestrial habitat; however, ambystomatid salamanders in general are somewhat less mobile than are other groups (Appendix 1, note i, ii). Genetic and demographic analysis of populations for other species of aquatic amphibians suggest that distinct subpopulations occur at substantially shorter distances than suggested by maximum recorded movements, especially in human-modified landscapes (Appendix 1, note i, ii). Tiger Salamanders of the Southern Mountain population have been occasionally encountered in the terrestrial habitat far (up to 3 km) from the nearest water-body (anecdotal observation in Sarell 2004), and movements up to about 500 m by radio-tagged salamanders have been recorded (Richardson *et al.* 2000b).

Ecological role

Tiger Salamanders are prey for larger animals and predators of invertebrates and small vertebrates in both aquatic and terrestrial ecosystems, but their ecological role is poorly understood.

Limiting factors

Early survival rates of Tiger Salamanders up to metamorphosis are characteristically low and variable among both breeding sites and years, resulting in an uneven pattern of recruitment across the landscape through time (Richardson *et al.* 2000a; review in COSEWIC 2001). Adults can be relatively long-lived in captivity (20 years) but a few studies suggest that most wild salamanders appear to be between 1 and 3 years with a few living as long as 6 years. A long life may enable populations to withstand short periods of low or no recruitment resulting from droughts or other adverse environmental conditions. Neotenous populations in permanent water bodies may act as sources of dispersing young when prolonged droughts decimate populations in temporary pools and so contribute to the persistence of local populations.

Tiger salamanders have a complex life history, including aquatic eggs and larvae, terrestrial metamorphosed juveniles and adults, and under some circumstances, aquatic neotenous adults. While these different life history stages and alternate developmental paths allow the salamanders to successfully exploit their arid environment, they also make populations susceptible to disturbance by human activities and developments.

Threats

Description of threats

The following list of threats is compiled from reviews (COSEWIC 2001; Sarell 2004) and other sources, as indicated.

Habitat loss and degradation: Loss, fragmentation, and degradation of terrestrial and aquatic habitat by housing and agricultural developments are the most serious threats to Tiger Salamanders and continue to be widespread and severe throughout the range (Redpath 1990; Sarell 1996, 2004; COSEWIC 2001; Holmes 2003). Specific threats to aquatic habitats include conversion, by draining and infilling of wetlands and ponds, and degradation by water level reduction related to irrigation. Terrestrial habitats have been converted to orchards and vineyards, housing, and urban infrastructure including roads. These developments have fragmented habitats, creating potential disruption for dispersal and migration (Hitchings and Beebee 1997; Knutson *et al.* 1999; Guerry and Hunter 2002). Dispersal is essential for maintaining population dynamics across the landscape, and interruption of dispersal will increase the probability of local extirpations. Habitat degradation from intensive livestock use and all-terrain vehicle (ATV) use in wetlands occurs locally but impacts to Tiger Salamanders are unclear.

Exotic species: Predatory fish are known to prey on Tiger Salamander larvae, inhibit larval growth, alter behaviour, and cause extirpation at some breeding sites (COSEWIC 2001; Wind 2005). Neotenous populations are particularly vulnerable as they often occupy larger, permanent water bodies suitable for fish stocking. Impacts are widespread and severe. About 39% of 46 water bodies that historically supported Tiger Salamanders in British Columbia have been stocked with sport fish (D. Fraser, pers. comm., 2001). Legal stocking continues in previously stocked lakes but new stocking plans are not proposed within Tiger Salamander range at this time. However, illegal stocking of perch, trout, and bass continues (B. Jantz, pers. comm., 2006). The threat is widespread, current and severe. Bullfrogs may contribute to site extirpations in the Osoyoos area (S. Ashpole, pers. comm., 2006).

Pollution of breeding habitat: Amphibians in general are vulnerable to various contaminants due to their semi-permeable skin and eggs that readily absorb substances from the environment. In addition to direct mortality, exposure to contaminants can result in abnormal development, decreased reproductive output, or changes in behaviour that indirectly affect fitness (see reviews and references in Harfenist *et al.* 1989; Bishop 1992; COSEWIC 2001). Many compounds present in commonly used agricultural and household compounds can act as endocrine disruptors and have the potential to interfere with hormone signals of amphibians during sensitive developmental periods (Crump 2001). Ashpole (2004, unpublished data) correlated amphibian egg mortality and reduced survival with high levels of orchard pesticides in the South Okanagan 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. This threat is widespread and severe at low elevations and new research suggests it may impact high elevations through drift (S. Ashpole, pers. comm., 2006).

Accidental mortality: Where breeding sites are separated from upland habitat by busy roads, the salamanders are vulnerable to road mortality. Tiger Salamanders are particularly vulnerable because they tend to use wetlands and shallow ditches by roadsides (Clevenger *et al.* 2001). Road densities are high throughout much of the Tiger Salamander range and impacts are widespread but seasonal, during spring and late summer migrations. Road mortality may be moderate to severe at localized sites (Richardson *et al.* 1998). Entrapment in swimming pools and wastewater lagoons in the spring when adults are seeking water for breeding has been documented for a few individuals at a few locations (Sarell 1996).

Infectious disease: Infectious diseases are possible threats with widespread and severe impacts but have not yet been documented in this population of Tiger Salamanders. 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; Speare 2005). Infections have been reported from Tiger Salamanders in Arizona (Davidson *et al.* 2000, cited by Speare 2005). The fungus has been isolated from other amphibians (Leopard Frog, *Rana pipiens*) in British Columbia. Tiger Salamanders are also susceptible to highly infectious and lethal iridoviruses, which have been associated with epizootics in amphibians (Daszak *et al.* 1999). This threat is widespread and potentially severe but not known to be impacting Tiger Salamanders in the British Columbia at this time.

Climate and natural disasters: Global climate change is predicted to be associated with increased summer droughts and extreme climatic events (Gates 1993). Over the long term, water tables in the Okanagan basin are expected to drop, and small ponds used by amphibians may experience early drying or complete drying (Cohen *et al.* [eds.] 2004). Climate change impacts to Tiger Salamanders may be widespread and severe, if predictions are correct.

Actions Already Completed or Underway

- Inventory throughout B.C. Range (Orchard 1989; McGuinness and Taylor 1992; Sarell and Robertson 1994; Sarell *et al.* 1998; Sarell and Alcock 2004; C. Terbasket, pers. comm., 2005; Rebellato 2005; Tarangle and Yellend 2005).
- Management plan for the species (Sarell and Bryan 1995).
- Wildlife habitat use models for the South Okanagan-Similkameen (BC Environment 1998; Warman *et al.* 1998).
- Population ecology study in the White Lake Basin, 1997–1999 (Richardson *et al.* 2000a, 2000b).
- A portion of the habitat is protected: South Okanagan Grasslands Provincial Park created, White Lake Grasslands Provincial Park created, Kilpoola property acquired by The Nature Trust of BC.
- South Okanagan-Similkameen Conservation Program (SOSCP) established in 2000; Landscape Recovery Strategy in preparation; landowner contacts, best management practices and planning with local government, habitat acquisition, community outreach, and traditional ecological knowledge projects are ongoing.
- Public involvement through the Puddle Project (2002 to present).
- Toxicology research of selected breeding sites in the South Okanagan assessed (Ashpole 2004).
- Species account in Identified Wildlife Management Strategy, Version 2 (Sarell 2004).
- Best management practices made available to local government and signed off by Union of BC Municipalities (UBCM).
- Five Wildlife Habitat Areas (WHAs) covering 151 ha of aquatic and terrestrial habitat have been approved (2005).
- The “Puddles for Peepers” project is researching wetland creation options to replace destroyed breeding habitat for amphibians.

Knowledge Gaps

Inventory and monitoring research requirements: Additional surveys are needed to more accurately identify critical habitat, area of occupancy, and conservation needs.

- Inventory of additional, potential breeding sites, especially on private lands
- Monitoring of trends in population size, distribution, and structure at selected sites over time
- Inventory of water bodies with potential habitat for neotenes
- Inventory of terrestrial habitat for metamorphosed salamanders

Biological and ecological research requirements: Population dynamics need to be clarified, to direct habitat management and population viability assessment.

- Identify population processes at a landscape scale (i.e., metapopulation dynamics)
- Quantify size and spatial distribution of a self-sustaining population
- Quantify survivorship of all age-classes under different land use treatments
- Quantify dispersal capabilities including the extent of long distance movements
- Quantify degree of fidelity to individual breeding ponds and inter-pond movements
- Identify prevalence and importance of neotenes to population processes
- Characterize and quantify terrestrial habitat required to protect adequate amounts of foraging, overwintering, and migration habitat

Threat clarification research requirements: The following threats require clarification.

- Identify habitat loss or degradation threats from future housing or agricultural development to known breeding and terrestrial habitat
- Clarify the role of salamander predators, particularly introduced fish, in local, permanent water bodies
- Clarify threats from pollutants, particularly at breeding sites
- Identify barriers to movements of salamanders in terrestrial habitat
- Clarify the significance of threats from road mortality
- Clarify potential threats from intensive livestock use

RECOVERY

Recovery Feasibility

Recovery of the Tiger Salamander (Southern Mountain population) is technically and biologically feasible with moderate effort. A minimum of 57 breeding sites remain within the range of the Southern Mountain population. Tiger Salamanders are able to recover relatively rapidly due to their high reproductive output, provided that suitable breeding habitats are available (Semlitsch 1983).

Challenges to recovery include historical and continuing loss of terrestrial and aquatic habitat and the prevalence of introduced fishes throughout the species' range in British Columbia. Many mitigation options are available for reducing site-specific threats. If reintroduction is deemed necessary, translocation of individuals to new breeding ponds is feasible.

Table 1. Technical and biological feasibility

	Recovery criteria	Tiger Salamander
1.	Are individuals capable of reproduction currently available to improve the population growth rate or population abundance?	Yes
2.	Is sufficient habitat available to support the species or could it be made available through habitat management or restoration?	Yes
3.	Can significant threats to the species or its habitat be avoided or mitigated through recovery actions?	Yes
4.	Do the necessary recovery techniques exist and are they known to be effective?	Yes

Recovery Goal

Ensure that there is sufficient, secure[3] habitat to maintain a self-sustaining population, or populations, in each major watershed throughout the historic range of the Tiger Salamander in Canada.

Rationale for the Recovery Goal and Objectives

Sufficient information to quantify long-term population and habitat targets for the recovery goal is not available due to knowledge gaps. Short-term (2008–2012) targets are presented in the objectives below. These objectives are necessary to conserve the species in the short term, while knowledge gaps are addressed, and are believed to be achievable within 5 years based on recovery team consensus in the absence of strong scientific information. Approximately 154 hectares of aquatic breeding habitat represents the area of wetlands where breeding Tiger Salamanders have been reported and where habitat appears to be currently functional. Breeding habitat is more limited in area than terrestrial habitat and appears to have more numerous and more significant threats. It receives some protection from the *BC Water Act*. Four thousand hectares represents a portion of the terrestrial habitat required for foraging and living. Habitat securement is believed to be achievable for this area in 5 years based on existing Crown land designations and management processes and on current success rates for voluntary land acquisition and stewardship programs in the South Okanagan-Similkameen Conservation Program area. A portion of these habitats have been protected from destruction but other threats still need to be addressed.

Recovery Objectives

1. Secure a minimum of 154 ha of aquatic breeding habitat at known breeding sites and a minimum of 4000 ha of terrestrial habitat surrounding and connecting priority breeding sites by 2012. These habitat securement targets are deemed by the recovery team to be achievable, and necessary to support the species in the short term.
2. Address knowledge gaps related to the distribution, habitat requirements, population processes, terrestrial movements, threats, population viability, critical habitat, and long-term habitat securement targets by 2012.
3. Build sufficient understanding, knowledge, and support for habitat protection by stakeholders and the public by 2012.

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[3] Secure habitat is Tiger Salamander habitat that is managed to maintain the species for a minimum of 100 years. It includes suitably connected breeding, foraging, overwintering, and dispersal habitat where threats are addressed. Habitat securement 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, eco-gifts, voluntary sale of private lands by willing landowners, land use designations and management agreements, and/or protected areas.

Approaches Recommended to Meet Recovery Objectives

A broad strategy to address these threats will focus on habitat protection and management, public outreach, and research, including inventory and monitoring.

Recovery planning table

Table 2. Recovery planning table

Objective	Broad Strategy	Threat or Concern addressed	Priority	General steps
I	Habitat securement and management	Habitat loss and degradation	Urgent	Implement private landowner contact program to develop stewardship agreements and implement best management practices on private land.
			Urgent	Work with municipal and regional governments to incorporate habitat stewardship into planning processes such as Community Plans and bylaws.
			Urgent	Work with First Nations to identify and implement opportunities for cooperative habitat conservation projects both on and off reserves
			Urgent	Implement stewardship through existing land use designations and management agreements on Crown land.
			Urgent	Develop and implement a research program to clarify habitat needs, including critical habitat identification, and impacts from roads and intensive grazing.
			Necessary	Identify land ownership for known breeding sites and priority terrestrial habitat.
			Necessary	Continue species and habitat inventory.
			Necessary	Monitor known sites.
			Necessary	Reduce road mortality at high priority sites.
I	Habitat securement and management	Exotic species	Urgent	Continue to implement the existing strategy to eliminate introduced bullfrogs from the southern Okanagan Valley.
			Necessary	Eliminate illegally introduced fish at key sites where possible.
			Beneficial	Develop outreach to reduce or eliminate illegal fish introductions.

Objective	Broad Strategy	Threat or Concern addressed	Priority	General steps
II	Research	Pollution	Urgent	Continue research to quantify threats from pollution, particularly agricultural chemicals and effects of West Nile Virus control strategies.
			Urgent	Develop best management practices for mitigating impacts from agricultural chemicals and West Nile Virus control programs and implement priority actions through the Action Plan.
II	Research	Accidental mortality	Necessary	Develop a research program to quantify threats from road mortality and intensive grazing at shallow breeding sites, identify effective actions to reduce or eliminate mortality, and implement priority actions through the action plan.
II	Research	Infectious disease	Necessary	Develop research partnerships to assist with disease identification and containment options.
			Necessary	Monitor for emerging infections diseases.
			Urgent, if disease is identified.	Contain spread of infectious disease if identified.
II	Research	Knowledge gaps	Necessary	Use radio-telemetry and mark-recapture to clarify movement, habitat use, and metapopulation dynamics.
			Necessary	Conduct genetic studies to investigate population structure at landscape and broader spatial scales.
			Necessary	Use population viability analysis to clarify population and habitat targets for recovery.
			Necessary	Work with First Nations to identify traditional ecological knowledge.
			Beneficial	Clarify potential impacts from ranching activities, particularly on breeding habitat, at priority sites.
III	Outreach	N/A	Urgent	Develop and implement an outreach program, including the identification of target audiences, to increase recovery action awareness, support, and participation.

Performance Measures

- Measure progress toward the breeding habitat securement target of 154 ha by 2012 by quantifying the number of hectares secured in each type of securement category (i.e., number and area of wildlife habitat areas, stewardship agreements).
- Measure progress toward the terrestrial/connectivity habitat securement target of 4000 ha by 2012 by quantifying the number of hectares secured in each type of securement category.
- Determine if a written research strategy was developed by 2008 and key knowledge gaps have been addressed by 2012.
- Determine whether a written outreach strategy was developed by 2008 and support for recovery has increased within key stake holder groups.

Critical Habitat

Identification of the species' critical habitat

No critical habitat, as defined under the federal *Species at Risk Act* [S.2], is proposed for identification at this time. Critical habitat for the Tiger Salamander will be identified following completion of the schedule of studies.

Relatively little is known about Tiger Salamander population numbers or dynamics required to identify critical habitat. More definitive work must be completed before any specific sites can be formally proposed as critical habitat. It is expected that critical habitat will be proposed following completion of outstanding work required to identify specific habitat and area requirements for this species. Consultation and development of stewardship options with affected landowners and organizations will also be necessary. A "schedule of studies" to identify critical habitat is outlined below.

In general, Critical Habitat may include wetlands for breeding and associated grassland, shrub-steppe, and open forest to maintain terrestrial foraging habitat and connectivity among subpopulations to support viable populations across the landscape.

Recommended schedule of studies to identify critical habitat

Table 3. Schedule of studies

Description of activity	Outcome/Rationale	Timeline
Conduct research to quantify habitat requirements and use.	Quantification of dispersal distance and habitats, home range, foraging, breeding, and habitat connectivity requirements.	2008 to 2012
Inventory and monitor species distribution, abundance, occupied habitat, and potential recovery habitat.	Clarification of population size, distribution, persistence, movement barriers, land ownership, and site-specific threats.	2008 to 2012
Develop a population viability model.	Identification of options for establishing a network of managed habitat to support a viable population over a long term (>100 years).	Draft 2008 to 2009; final by 2012

Existing and Recommended Approaches to Habitat Protection

Habitat protection will be accomplished through voluntary stewardship agreements, conservation covenants, eco-gifts, sale of private lands by willing landowners, land use designations and management on Crown lands, and protected areas. A portion of the habitat securement target has been achieved on federal lands (Dominion Radio Astrophysical Observatory), provincial parks and protected areas (Gilpin, White Lake Grasslands, South Okanagan Grasslands), provincial Crown land through the Identified Wildlife Management Strategy, private land conservancies (The Nature Trust, Ducks Unlimited Canada) and private land stewardship agreements through The Land Conservancy.

Effects on Other Species

Many endangered or threatened species occupy the same range and use similar wetland or grassland and shrub-steppe habitats to Tiger Salamanders in the arid interior belt of British Columbia. These species include the Great Basin Spadefoot (*Spea intermontana*; threatened) with overlapping use of aquatic water bodies for breeding and surrounding terrestrial habitat for foraging and overwintering. Conservation of the Tiger Salamander's habitat through the strategies outlined here will assist in protecting habitat for this and other native species and ecosystems. Other species at risk that might benefit from habitat securement for the Tiger Salamander include the Pallid Bat (*Antrozous pallidus*; threatened), Badger (*Taxidea taxus*; endangered), Burrowing Owl (*Athene cunicularia*; endangered), Sage Thrasher (*Oreoscoptes montanus*; endangered), and Behr's Hairstreak butterfly (*Satyrium behrii*; threatened). Recovery conflicts between species are unlikely to occur. Tiger Salamanders are natural predators of spadefoots and many invertebrates, but the protection of habitat should offset any possible negative effects from predation.

Socio-economic Considerations

This species has no direct commercial value to humans, although in the past salamander larvae have been used as fish bait, an outdated practice that is now illegal. Initiatives are underway to document traditional aboriginal knowledge for amphibians by the South Okanagan-Similkameen Conservation Program Traditional Ecological Knowledge Team.

Recovery of this species and protection of threatened habitats will contribute to biodiversity, health, and functioning of the environment. They will also enhance opportunities for appreciation of special spaces and species, thereby contributing to overall social values in the South Okanagan and Lower Similkameen valleys. Protecting natural spaces, biodiversity, and recreation values provides value to the local economy. Recovery actions could potentially affect the private land development, agriculture and range, and recreation (i.e., fisheries and all-terrain vehicles) sectors. The magnitude of these effects is expected to be low due to a voluntary stewardship approach. Recovery actions will be focused mainly in the South Okanagan Valley but will also occur in the Lower Similkameen, Kettle River, and Granby watersheds.

Recommended Approach for Recovery Implementation

The strategy will be accomplished using a landscape conservation approach mainly through partnerships coordinated by the South Okanagan-Similkameen Conservation Program. A multispecies approach will also be used to protect wetland habitat for Tiger Salmanders, Great Basin Spadefoots, and Western Painted Turtles (*Chrysemys picta)* and upland habitats for Western Rattlesnakes (*Crotalus oreganus),* Sage Thrashers, Pallid Bats, and Behr's Hairstreaks.

There is a strong need to encourage and support the voluntary cooperation of landowners and managers in stewardship activities on various land tenures to make recovery activities successful. This stewardship approach includes different kinds of activities, such as: following guidelines or best management practices, land use designations on Crown lands, conservation agreements, covenants, eco-gifts, sale of private lands by willing landowners. To be useful, protected habitat needs to be large enough and in adequate condition for this species to carry out its seasonal activities and life cycles.

Statement on Action Plans

One or more action plans will be completed by 2012.

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APPENDIX 1 – ADDITIONAL INFORMATION

i. **Breeding population size**: In California, the mean estimated breeding population size of *A. californiense* in 10 ephemeral pools and cattle watering ponds over a 3-year period was 70 adults per breeding site (range: 3–327 adults per site; recalculated from Table 1 in Trenham *et al.* 2001). Pond size (from 0.04 to 0.125 ha) was unrelated to breeding population size, but the largest pond (0.37 ha) supported by far the largest population of salamanders (mean = 327 adults) (reanalysis of data from Tables 1 & 2 in Trenham *et al.* 2001). In South Carolina, the mean estimated number of breeding adults of *A. t. tigrinum* was 87 and 24 adults, respectively, in two shallow, 1-ha ponds monitored intensively for 4 years (Semlitsch 1983). Also in South Carolina, 1112 adults of *A. talpoideum* were observed to enter a shallow, 10-ha breeding site during two peak months of the breeding season in one year (Patterson 1978). In Colorado, the breeding population of *A. t. nebulosum* of 24 subalpine ponds was estimated to be 0.08 and 0.05 adults/m^2 of pond area (translating to 768 and 485 adults/ha) in permanent and semi-permanent breeding sites, respectively (Whiteman *et al.* 1994; values recalculated to exclude larvae). In addition to metamorphosed adults, these values include neotenous adults in permanent ponds.

ii. **Upland foraging habitat width around breeding sites**: Based on data on movement distances of six species of *Ambystoma* in different parts of the United States, including two studies on *A. tigrinum*, Semlitsch (1998) estimated that a buffer width of 164.3 m around breeding ponds would encompass 95% of the terrestrial habitat used by adult salamanders. Additional studies revealed similar or shorter movement distances for the Tiger Salamander and related species (Loredo *et al.* 1996; Trenham 2001). The California Tiger Salamander (*A. californiense*) moved nightly up to 129 m from breeding ponds to terrestrial shelter sites (mean distance moved by 59 adults was 35.9 m and by 49 juveniles, 26 m; Loredo *et al.* 1996). However, longer-term movements of the California Tiger Salamander sampled with pitfall traps at varying distances from one isolated breeding site revealed much greater movement distances, especially for subadults (Trenham and Shaffer 2005). A buffer zone of 630 m was estimated to encompass 95% of adults and subadult salamanders in the terrestrial habitat. Results of a population viability model suggested that a buffer zone of 400 m surrounded by incompatible land uses would result in >50% reduction in population size over 100 years, and that a buffer zone of at least 600 m would be required for the persistence of the local population. In the South Okanagan, all movements of nine radio-tagged adult Tiger Salamanders were less than 125 m from breeding sites in the summer of 1998 (Richardson *et al.* 2000a). An additional 12 radio-tracked salamanders moved <500 m from the breeding ponds in 1999 (Richardson 2000b; details of movements were not included). Data were collected during spring and summer only and excluded movements to and from overwintering sites, the locations of which were unknown.

iii. **Dispersal movements**: Movement distances of about 15 km/yr have been recorded for some frogs (*Bufo marinus*, *Rana lessonae*) and up to 4 km/yr for some salamanders (*Taricha torosa*), illustrating that amphibians can move long distances under some circumstances (reviewed in Marsh and Trenham 2001). Ambystomatid salamanders are thought to move shorter distances than other pond-breeding salamanders (Semlitsch 1998). Marsh and Trenham (2001) reviewed inter-pond movements of amphibians, including four species of *Ambystoma*. The greatest reported movement distances between ponds, up to 800 m, were for the Spotted Salamander (*A. maculatum*). Distances between pairs of ponds where dispersing California Tiger Salamanders (*A. californiense*) were caught ranged from 60 to 670 m; dispersal probabilities showed an inverse relationship with distance between ponds (Trenham *et al.* 2001).

iv. **Population structure across the landscape**: A genetic analysis offers a potentially more accurate way to measure inter-connectivity of populations than observations of movements, but unfortunately such data are not available for the Tiger Salamander. Genetic analysis of Woodfrog (*Rana sylvatica*) populations suggested that gene flow was nearly non-existent between breeding sites separated by more than 1126 m (Berven and Grudzien 1990). Genetic differentiation was substantial among local populations of the Edible Frog (*R. temporaria*), separated by an average of 2.3 km within an urban setting in Brighton, England (Hitchings and Beebee 1997). These distances are relatively short when compared with dispersal capabilities of the frogs (movement distances up to 15 km recorded for *R. temporaria* that is closely related to *R. lessonae*; reviewed in Marsh and Trenham 2001). Similarities in demographic parameters (mass and age distribution) were found among breeding sites of the California Tiger Salamander separated by <1 km and interpreted to reflect dispersal probabilities (Trenham *et al.* 2000). However, as the authors pointed out, habitat and environmental differences can contribute to this pattern, and the data should be interpreted with caution.