# Recovery Strategy for the Oregon Spotted Frog (*Rana pretiosa*) in British Columbia

Prepared by the Canadian Oregon Spotted Frog Recovery Team

BRITISH COLUMBIA | Ministry of Environment

January 2012

Updated - August 2014

## 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. Recovery strategies are prepared in accordance with the priorities and management actions assigned under the British Columbia Conservation Framework. The Province prepares recovery strategies to ensure coordinated conservation actions and 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 recovery strategy?

A recovery strategy summarizes the best available science-based knowledge 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 what should be done to mitigate those threats.

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.

## 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>

To learn more about the British Columbia Conservation Framework, please visit the Ministry of Environment Conservation Framework webpage at:
< http://www.env.gov.bc.ca/conservationframework/>

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## Cover illustration/photograph

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## 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 January 2012 first edition of this document.
See **Updates** for specific changes to the document.

## Updates

Updated August 2014 - Changes to the original posting (January 2012) include correction of captions to Figure A1 and Figure A2 which were reversed in original publication, as well as correcting references to Tables in the document.

## Disclaimer

This recovery strategy has been prepared by the Canadian Oregon Spotted Frog 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 its 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 Oregon Spotted Frog populations 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 Oregon Spotted Frogs.

# RECOVERY TEAM MEMBERS

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## RESPONSIBLE JURISDICTIONS

The British Columbia Ministry of Environment is responsible for producing a recovery strategy for Oregon Spotted Frog under the *Accord for the Protection of Species at Risk in Canada*. Canadian Wildlife Service of Environment Canada participated in the preparation of this recovery strategy.

## ACKNOWLEDGEMENTS

The development of this document has been ongoing since 2003. Initial drafts of this document were prepared by Vanessa Craig (EcoLogic Research) and Russ Haycock (Hyla Environmental Services Ltd.). This version of the document is a result of the work of Kym Welstead, Kristina Robbins (B.C. Ministry of Forests, Lands and Natural Resource Operations), and Purnima Govindarajulu (B.C. Ministry of Environment) who extensively updated these drafts and authored several new sections with input from the Canadian Oregon Spotted Frog Recovery Team. Individuals identified in the *Recovery Team Members* section represent the configuration of the recovery team as of March 2011. In addition to these individuals, many former members, observer and alternates have contributed to this document and the recovery of this species. Former members, observers and alternates of the recovery team include: David Fraser, Mark Hayes, Mike Pearson, Monica Pearson, John Richardson, Denis Knopp, Sylvia Letay, Laura Friis, Jamie Dorgan, Janice Jarvis, Russ Haycock, Stephanie Blouin, Danielle Smith, Arimathea Pappas, Rick Hebner, June Harris, Dave Dunbar, Andrea Gielens, Rene McKibbin, Annette Potvin and Kevin Bowen. Members of the recovery team and Russ Haycock, Denis Knopp, Virgil Hawkes, and Monica Pearson shared unpublished data. The document was formatted to conform to standard templates (Ministry of Environment 2010a) by Leah Westereng (B.C. Ministry of Environment) and Paul Chytyk (YUNI Environmental Consulting). Other reviewers include Leah Westereng, Dan Shervill (Environment Canada) and David Cunnington (Environment Canada). The World Wildlife Fund Canada and the B.C. Ministry of Environment funded the development of this Recovery Strategy.
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# EXECUTIVE SUMMARY

The Oregon Spotted Frog (*Rana pretiosa*) is a Pacific Northwest endemic whose global historical distribution ranged from the southwestern corner of British Columbia south to the northeastern corner of California. It is Canada's most endangered amphibian, with an estimated population of only 316 adults at 4 occupied locations (one of which may be near extirpation) in 2010.

The Oregon Spotted Frog is endangered throughout its North American range. It is extirpated from at least 70% of its known historical locations and as much as 90% of its extrapolated historical range. There is an immediate need to facilitate its recovery to a level at which extinction is no longer an immediate threat.

Based on the Oregon Spotted Frog's limited distribution, small population sizes, and small habitat areas, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) first designated the Oregon Spotted Frog as "Endangered" in November 1999. The Oregon Spotted Frog is listed as Endangered in Canada on Schedule 1 of the *Species at Risk Act* (SARA). In British Columbia, the Oregon Spotted Frog is ranked S1 (critically imperiled) by the Conservation Data Centre and is on the provincial Red list. The B.C. Conservation Framework ranks the Oregon Spotted Frog as a priority 1 under Goal 1 (contribute to global efforts for species and ecosystem conservation) and Goal 3 (maintain the diversity of native species and ecosystems).

Habitat loss as a result of land developments, agricultural land conversion, resource extraction and hydrological alternations has occurred historically and is likely the predominant cause of the decline of the Oregon Spotted Frog throughout its North American range. With only four remaining Canadian breeding populations (one of which may be near extirpation) and less than 350 estimated breeding individuals, the risk of demographic and environmental stochastic events is high and could result in further local extirpations. Threats with a very high or high overall impact on the Oregon Spotted Frog (as scored by the World Conservation Union-Conservation Measures Partnership classification) include invasive and other problematic species and genes, human intrusions and disturbance, and pollution. Threats with an overall impact scoring of moderate include agriculture, energy production and mining, and natural system modifications. These threat factors lead to the following stresses: habitat loss, habitat degradation, direct and indirect mortality, and accidental mortality.

The population and distribution goal for the Oregon Spotted Frog is
*To restore, maintain and where feasible expand extant Oregon Spotted Frog populations, and establish six or more additional self-sustaining populations in BC.*

In the time it takes to accomplish this goal, existing individual populations must remain stable or increase over the next 10 years.

The recovery objectives for the Oregon Spotted Frog are:

1. to prevent further habitat degradation/loss and population declines of Oregon Spotted Frog by protecting[1], managing, and restoring habitat at all four occupied locations; at additional occupied sites if found (see Objective 4), and at additional locations or sites established through population introduction/reintroduction (see Objective 3)
2. to sustain or improve survivorship rates of all life stages of the Oregon Spotted Frog where needed through threat mitigation, habitat restoration, and population augmentation;
3. to establish/re-establish self-sustaining populations at a minimum of six additional historical, suitable, or restorable sites;
4. to prevent inadvertent loss of currently unidentified populations by conducting a comprehensive inventory of potentially suitable habitat;
5. to determine the effectiveness of habitat protection/enhancement and population augmentation/reintroduction measures by monitoring population status; and
6. to adaptively improve conservation and recovery efforts by addressing knowledge gaps in the life-history, population ecology, threats, and habitat requirements of the species.

It is recommended that occupied habitat be protected using the current knowledge of the biological and habitat needs of the species. Protection of occupied sites alone will likely not be sufficient to prevent extirpation. Additional recovery habitat areas will also be needed to support the recovery of this species. Given that the Oregon Spotted Frog habitat is predominantly surrounded by private lands, stewardship efforts (involving the voluntary cooperation of landowners) will be important to their conservation and recovery.

## RECOVERY FEASIBILITY SUMMARY

The recovery of the Oregon Spotted Frog in B.C. is considered biologically and technically feasible based on the criteria outlined by the Government of Canada (2009):

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, monitoring of the 4 known populations indicates that reproductive individuals are present in at least 3 of the populations, and are capable of reproduction (the status of the population at Maintenance Detachment Aldergrove is currently in question).

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

   Yes, suitable habitat exists at currently occupied sites and additional suitable reintroduction sites have been identified. A series of broad-scale habitat suitability criteria have been developed and preliminary screening and monitoring of these habitats are

[1] Protection can be achieved through various mechanisms including: voluntary stewardship agreements, conservation covenants, sale by willing vendors on private lands, land use designations, and protected areas.

underway. Jointly the existing and reintroduction sites will provide sufficient suitable habitat.

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

   Yes, identified threats can be at least partially mitigated through habitat protection, management, restoration, and rehabilitation.

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

   Yes, captive breeding, captive rearing, and release will be used both to augment populations at known locations, and to establish populations at historic and new locations created through habitat restoration and rehabilitation.

The Canadian Oregon Spotted Frog Recovery Team has determined that recovery is biologically and technically feasible, providing that ongoing management intervention occurs. Intervention is required to ensure that habitat is protected and restored, and that threats are alleviated.

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# 1 COSEWIC SPECIES ASSESSMENT INFORMATION

In Canada, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has assessed Oregon Spotted Frog (*Rana pretiosa*) as Endangered nationally (COSEWIC 2011).

**Date of Assessment:** May 2011
**Common Name (population):** Oregon Spotted Frog
**Scientific Name:** *Rana pretiosa*
**COSEWIC Status:** Endangered
**Reason for designation:** This highly aquatic frog has a small Canadian distribution within the populated and highly modified Fraser River Basin in southwestern British Columbia. It currently occurs at four sites, isolated from one another, and has been extirpated from an additional three sites. One extant population is near extinction, and the remaining populations are small and vulnerable to disturbance and stochastic events. Habitat loss and fragmentation, hydrological alteration, disease, introduced predators, and poor water quality continue to threaten remnant populations.
**Canadian Occurrence:** British Columbia
**COSEWIC Status History:** Designated Endangered in an emergency assessment on 13 September 1999. Status re-examined and confirmed in May 2000 and in May 2011.

# 2 SPECIES STATUS INFORMATION

| **Oregon Spotted Frog**[a] | |
|---|---|
| **Legal Designation:** | |
| Identified Wildlife:[b] No | *B.C. Wildlife Act:*[c] Schedule A — SARA Schedule: 1 (2003) |
| **Conservation Status**[d] | |
| B.C. List: Red — B.C. Rank: S1 (2010) — National Rank: N1 (1998) — Global Rank: G2 (2010) | |
| Subnational Ranks:[e] S1 in WA and CA; S2 in OR | |
| **B.C. Conservation Framework (CF)**[f] | |
| Goal 1: Contribute to global efforts for species and ecosystem conservation. | Priority:[g] 1 (2009) |
| Goal 2: Prevent species and ecosystems from becoming at risk. | Priority: 6 (2009) |
| Goal 3: Maintain the diversity of native species and ecosystems. | Priority: 1 (2009) |
| CF Action Groups: | Compile Status Report; List under Wildlife Act; Send to COSEWIC; Planning; Habitat Protection; Habitat Restoration; Private Land Stewardship; Species and Population Management |

[a] Data source: B.C. Conservation Data Centre (2011) unless otherwise noted.
[b] Identified Wildlife under the *Forest and Range Practices Act*.
[c] This species is designated as wildlife under the B.C. *Wildlife Act* (Schedule A), which offers it protection from direct persecution and mortality (Province of British Columbia 1982).
[d] S = Subnational; N = National; G = Global; B = Breeding; X = presumed extirpated; H = possibly extirpated; 1 = critically imperiled; 2 = imperiled; 3 = special concern, vulnerable to extirpation or extinction; 4 = apparently secure; 5 = demonstrably widespread, abundant, and secure; NA = not applicable; NR = unranked; U = unrankable.
[e] Data source: NatureServe (2010).
[f] Data source: Ministry of Environment (2010b).
[g] Six-level scale: Priority 1 (highest priority) through to Priority 6 (lowest priority).

# 3 SPECIES INFORMATION

## 3.1 Species Description

Adult Oregon Spotted Frogs have black spots with light centres and fuzzy edges, scattered on a brown or reddish-brown head and back region that becomes increasingly red with age (COSEWIC 2000; Figure 1). Light brown to orange dorsolateral folds begin directly behind the eye and run over the tympanum along the back. Beyond the middle of the back, the folds become discontinuous and disappear as they approach the lower back. Juvenile Oregon Spotted Frogs are olive green or light brown.


**Figure 1.** Adult female Oregon Spotted Frog. Photo credit: D. Knopp.

Adult Oregon Spotted Frogs often have a fragmented orange or red-orange colour on the undersurfaces of the upper thigh and belly, and sometimes have dark spots mottling the belly (Hayes 1997; COSEWIC 2000). The mean snout-urostyle length (SUL) of adult frogs captured in Canada was 58.06 mm (N = 727; range = 38.48–80.21 mm; SD = 6.20) and the mean mass of adult frogs was 20.98 g (N = 733; range = 5.90–55.36 g; SD = 7.60).

Although Oregon Spotted Frogs are most likely confused with Red-legged Frogs (*Rana aurora*), they can be distinguished as follows:

- Red-legged Frogs have eyes that are angled outward; Oregon Spotted Frog eyes are oriented upwards;
- Red-legged Frogs have flecks/freckles rather than spots and much brighter legs than Oregon Spotted Frogs; and
- Oregon Spotted Frogs have completely webbed feet because they spend most of their time in or around water, whereas Red-legged Frogs have partially webbed feet reflecting their semi-terrestrial habits.

Both the Red-legged Frog and the Oregon Spotted Frog deposit eggs in March, although the Red-legged Frog typically deposits its eggs 2–3 weeks earlier than the Oregon Spotted Frog. Egg masses of the Oregon Spotted Frog are distinguished from egg masses of the Red-legged Frog by the oviposition pattern. The Oregon Spotted Frog generally deposits egg masses in clusters (rarely single), whereas the Red-legged Frog deposits single egg masses.

## 3.2 Populations and Distribution

The Oregon Spotted Frog is a Pacific Northwest endemic whose historical range is from the Pit River drainage in California, north to southwestern British Columbia (Figure 2). In the United States, historical and extant populations are documented in the Puget Trough, in the Willamette Valley, east in the south-central Cascades Mountains in Washington, in the central Cascade Mountains of Oregon, and into the Pit River drainage of northeastern California. In British Columbia, all historical and extant populations have been found in the Fraser River Lowlands (Stebbins 1985; McAllister and Leonard 1997). In total, the Oregon Spotted Frog has been documented at 103 localities across its North American range: 8 in British Columbia (4 extirpated, 4 extant; Figure 3), 19 in Washington (11 extirpated, 8 extant), 74 in Oregon (44 extirpated, 30 extant), and 3 in California (3 extirpated, 0 extant) (U.S. Fish and Wildlife Service 2009).

A population is delineated using the NatureServe occupancy criteria[1], separation distance, and the maximum distance moved over suitable habitat for Oregon Spotted Frogs (see Habitat and Biological needs section). Populations are considered independent if they are more than 1 km apart over unsuitable habitat or greater than 3 kms apart over suitable habitat. This operational definition of a population will be used to distinguish between separate populations' but may be redefined as more research becomes available. Locations are used to describe where a population is verses sites which are within a population.

[1] **Minimum Criteria for an Occurrence:** Occurrences are based on evidence of historical presence, or current and likely recurring presence, at a given location. Such evidence minimally includes collection or reliable observation and documentation of one or more individuals (including larvae or eggs) in or near appropriate habitat where the species is presumed to be established and breeding.
**Separation Barriers:** Busy major highway, especially at night, such that frogs rarely if ever cross successfully; urban development dominated by buildings and pavement; habitat in which site-specific data indicate the frogs virtually never occur.
**Separation Distance for Unsuitable Habitat:** 1km
**Separation Distance for Suitable Habitat:** 5km
Reference NatureServe (2011).

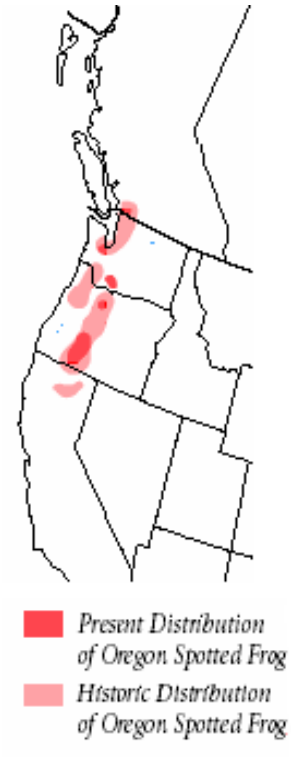


**Figure 2.** Present and historical distribution of the Oregon Spotted Frog in North America (adapted from Hayes *et al.* 1997).

When this species was first assessed in 1994, there were 61 documented populations of the Oregon Spotted Frog throughout its range. Of these 61 historically documented populations, only 23% or 14 populations remain: 1 in Washington and 13 in Oregon. In British Columbia and California, none of the historically documented populations remain (Haycock 1998, 1999, 2000; COSEWIC 2000). The Oregon Spotted Frog has disappeared from 70% (site count) to 90% (area-based estimate) of its extrapolated historical global range (Pearl and Hayes 2005; Pearl *et al.* 2005).

Currently, across its global range there are 38 extant populations in the U.S., including 8 in Washington (1 historic, 7 new), and 30 in Oregon (13 historic, 17 new) (Pearl and Hayes 2005; U.S. Fish and Wildlife Service 2009), and 4 extant populations in B.C., Canada.

**Extant populations in British Columbia**

In B.C., four extant populations of the Oregon Spotted Frog exist in the extreme southwestern corner of the province, an area generally referred to as the Fraser River Lowlands (Figure 3; Table 1). These populations are located in: the Department of National Defence property known as Maintenance Detachment Aldergrove in the Township of Langley; (on federal land; this population may be near extirpation); Mountain Slough and Maria Slough, both in Agassiz on private and First Nations land; and a recently discovered population (2008) found on private land in Morris Valley in Fraser Valley (locally referred to as Regional District Electoral Area "C"). The four populations of Oregon Spotted Frog in Canada represent approximately 2% of the global population of this species based on the 2009 egg mass census which found 153 egg mass

in B.C., approximately 3000 in Washington and 5300 in Oregon (U.S. Fish and Wildlife Service 2009 census data). See Appendix 1 for population estimates at extant locations in British Columbia. Note that the population at Maintenance Detachment Aldergrove is in danger of becoming extirpated; no egg masses have been discovered at the location since 2006.

**Extirpated populations in British Columbia**

The Oregon Spotted Frog has been extirpated from four known locations (populations) in British Columbia. Figure 3 maps these historic locations to the best of our knowledge based on site descriptions. As site records contained nonspecific location data in the Sumas Prairie and Nicomen Slough area, these locations are composed of several historic records/sites as their exact locations are unknown.

1. Campbell Valley Regional Park in Langley Township (Licht 1971b). This population was the subject of intensive study in the late 1960s (Licht 1969a, 1969b, 1971a, 1971b, 1972, 1974, 1975, 1986a, and 1986b). By the late 1990s, Oregon Spotted Frogs could not be found at any of these sites (Haycock 1999). It is thought that the removal of livestock grazing from the area negatively altered the habitat and allowed succession contributing the extirpation of Oregon Spotted Frog (Haycock 2006).
2. Sumas Prairie area. There are four nonspecific site records of Oregon Spotted Frog in the Sumas Prairie area including a remnant wetland of Sumas Lake near Sumas Prairie in Abbotsford, recorded before the 1940s. This area has undergone significant changes including the draining, damming and dyking of 33,000 acres that once was Sumas Lake in 1924 for agricultural use. Lakemount Marsh is one of the sole remnants of this historic wetland/lake area.
3. Nicomen Slough area. There are three non-specific sites described for the Nicomen Slough area including Nicomen Island in Matsqui, recorded before the 1940s.
4. West Creek wetlands. Glenn R. Ryder a well known local naturalist observed over 15 Oregon Spotted Frogs in West Creek Marsh / Wetland at Wood Duck Lake in Langley on March 2, 1993 at the southeast end in the shallow grassy areas. Approximately 10 were observed again on June 20, 1994 at a shallow backwater pool in the same area. This location has never been reconfirmed and is now occupied by bullfrogs.

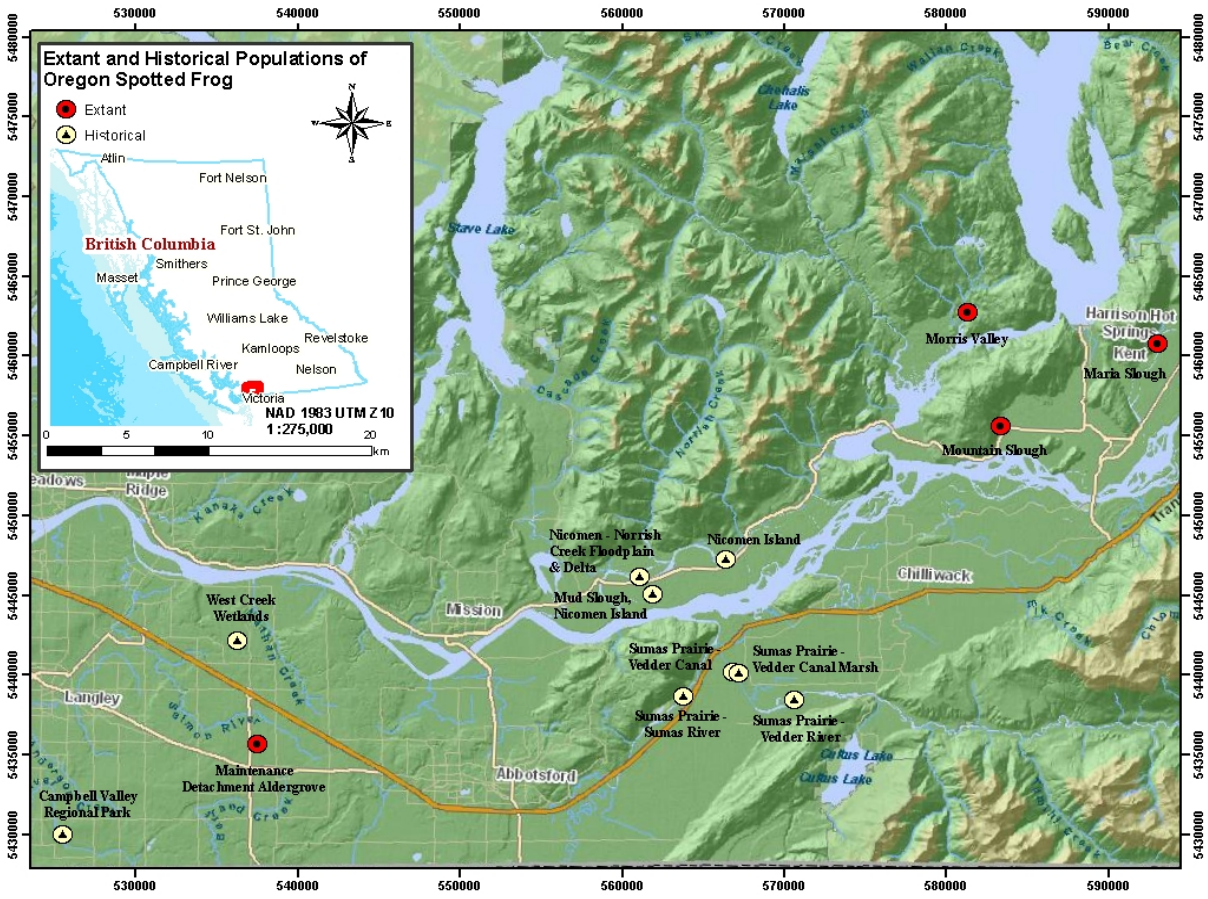


**Figure 3.** Map illustrating location of four extant populations and four historical populations of Oregon spotted frog. Map credit: Kristina Robbins.
Note that exact locations of the historic populations for Nicomen Island and Sumas Prairie are unknown and so are represented by several site records (locations approximate).

**Table 1**. Status and description of Oregon Spotted Frog populations in British Columbia. See Appendix 1 for population estimates at extant locations in British Columbia.

| Population | Status (habitat size) | Description | Land tenure |
|---|---|---|---|
| Maintenance Detachment Aldergrove | Extant[a] (18 ha) | Township of Langley | Federal - Department of National Defence |
| Mountain Slough | Extant (20 ha) | Agassiz | Private and Crown |
| Maria Slough | Extant (16 ha) | Agassiz | Private and First Nations |
| Morris Valley | Extant (13 ha) | Floodplain wetland, Fraser Valley Regional District Electoral Area "C". | Private (future plans to convert it to Crown land- Wildlife Management Area) |
| Sumas Prairie<br>• *Vedder Canal Marsh*<br>• *Vedder River*<br>• *Vedder Canal*<br>• *Sumas River* | Historical (unknown) | Remnant wetland of Sumas Lake near Sumas Prairie in Abbotsford, recorded before the 1940s (Licht 1971b). Extirpated by the late 1990s (Haycock 1999). | Private, Municipal, Federal and First Nations |
| Nicomen Island<br>• *Norrish Creek Floodplain + delta*<br>• *Nicomen Slough*<br>• *Mud Slough* | Historical (unknown) | Matsqui, recorded before the 1940s (Licht 1971b). Extirpated by the late 1990s (Haycock 1999). | First Nations, Private, and Provincial Crown |
| Campbell Valley Regional Park | Historical | In Langley Township (Licht 1971b). Extirpated by the late 1990s (Haycock 1999). | Municipal |
| West Creek Marsh/Wetland | Historical (30ha) | Glen Ryder | Greater Vancouver Regional District Parks (Langley) |

[a] This population is in danger of becoming extirpated; no egg masses have been discovered at the location since 2006

## Estimated change in population size in British Columbia

In comparison to numbers documented in Washington, populations in British Columbia are extremely small. Egg mass counts in 1997, and 2000 to 2010 at locations in British Columbia indicated that estimates of Canada's entire breeding population varied between a low of 116 breeding adults in 2007 to a high of 548 breeding adults in 2002. The population estimate at the known locations in Canada (including the recently discovered fourth location) was 316 breeding adults in 2010. Several populations in the United States are much larger. However the US populations have also experienced significant declines. For instance 7,018 egg mass were recorded at Conboy National Wildlife Refuge, Washington, in 1998 but in 2009 it was down to 1,435 egg masses. The Trout Lake, Washington population has also decreased from 959 eggs

mass in 2000 to 345 egg mass in 2009 (U.S. Fish and Wildlife Service Species Assessment form April 2010).

In British Columbia, overall population size has fluctuated over the last 10 years. When population trends are calculated based only on the 3 **original** known populations (Maria and Mountain Sloughs, and Aldergrove and excluding the Morris Valley population which was discovered in 2008), the overall population size has declined from 288 (1997) to 238 (2010) (17% reduction; see Appendix 1).

## 3.3 Needs of the Oregon Spotted Frog

### 3.3.1 Habitat and biological needs

Adult Oregon Spotted Frogs are warm-water marsh specialists that prefer floodplain wetlands, side channels, and sloughs associated with permanent water bodies and emergent vegetation (Hayes 1997; McAllister and Leonard 1997). They prefer habitat with a large amount of open water (low to moderate amounts of cover by emergent vegetation: 25–50%; Watson *et al.* 2003), and appear to avoid areas with a gravelly substrate. Limited data from 2001 suggested that Oregon Spotted Frog larvae (tadpoles) and juveniles used the shallow margins of wetlands in the immediate vicinity of oviposition sites (R. Haycock, unpubl. data, 2001). Juvenile Oregon Spotted Frogs were also frequently observed in shallow ephemeral pools beyond the margins of permanent water (R. Haycock, pers. obs., 2001). Habitat requirements can be divided into three life-seasons: breeding (oviposition) and early larval habitat, active summer habitat, and overwintering habitat.

**Breeding or oviposition microhabitats**
Oviposition and breeding microhabitats are located in seasonally inundated warm shallows (McAllister and Leonard 1997) associated with groundwater up-wellings, which provide relatively stable thermal and water quality conditions (Figure 4). These sites are used for courtship (when males call to females), mating, egg-laying, embryonic development, and hatching. Larvae wriggle from their egg jelly, spend their early days clustered within the remaining jelly egg mass substrate, and then disperse into the surrounding vegetation. Larvae are not free swimming, and they grow and develop in the vegetation and substrate where they hatch. As such, these microhabitats are critically important as a nursery for a portion of larval development, and as a staging area for larval dispersal as water levels change. In these habitats, water levels are typically lowest during egg-laying and rise with the annual rising of the Fraser River; in systems not connected to the Fraser, waters may recede during this period.

**Figure 4.** Typical oviposition habitat for Oregon Spotted Frog at Mountain Slough. Photo credit: K. Welstead.

Egg masses are typically laid in communal clusters, although some egg masses are laid singly (McAllister and Leonard 1997). Egg masses are deposited directly in the water on top of vegetation or on the substrate (Pearl and Hayes 2004; R. Haycock, pers. obs., 1997, 2000–2003). The number of masses per cluster varies widely. Licht (1969b) reported that clusters ranged from 5 to 26 masses, and McAllister and Leonard (1997) reported clusters ranged from 10 to 75 individual egg masses. The number of eggs per mass is also variable. In Canada, Licht (1974) reported an average of 643 eggs (range 249–935) per egg mass at a now-extirpated population in Campbell Valley Regional Park, and Haycock (COSEWIC 2000) reported an average of 670 eggs per mass at the Maintenance Detachment Aldergrove location. At the Dempsey Creek population in Washington, egg masses contained 598 eggs on average (McAllister and Leonard 1997). The clustering of egg masses laid on top of each other in shallow water can result in at least some of the egg masses being exposed to air.

Oregon Spotted Frogs select oviposition sites that meet specific requirements for water depth and temperature. In British Columbia, the water depth at oviposition sites at the Maintenance Detachment Aldergrove, Mountain Slough, and Maria Slough locations was 3–10 cm (COSEWIC 2000). Older data from Licht (1969a) from an historic population at Campbell Valley Regional Park indicated eggs were laid in water 5–12.5 cm deep. Across its range, Oregon Spotted Frog oviposition sites have been discovered in water averaging between 5.9 and 25.6 cm deep (Pearl and Hayes 2004). These shallow margins of wetlands, ponds, and rivers become quite warm (Licht 1971a; Figure 5). Water temperatures at the Maintenance Detachment Aldergrove, Maria Slough, and Mountain Slough locations ranged from 4 to 14$^{o}$C with an average daytime temperature of 9$^{o}$C (R. Haycock, unpubl. data, 2000). Similar ranges were seen at the Maintenance Detachment Aldergrove location in 2005 where water temperature at oviposition sites ranged from 3 to 18$^{o}$C in early to late March, and at Maria Slough in 2007 where temperature ranged from 5.6 to 21.4$^{o}$C at one location and 7.5 to 15.6$^{o}$C at another in early to mid-April (C. Bishop, unpubl. data, 2005, 2007). Licht (1971a) reported even warmer temperatures, with an average water temperature of 17.6$^{o}$C around egg masses at a now-extirpated population in Campbell Valley Regional Park. McAllister and White (2001) reported a

similar pattern in Washington, with daytime water temperatures at 6 sites averaging 16°C during oviposition.

**Figure 5.** Oviposition site. The egg cluster in the foreground is coloured green by algae. A groundwater-fed spring inputs warmer fresh water adjacent to the cluster. Photo credit: K. Welstead.

The water bodies in which breeding and oviposition occur are connected to permanent water, and are often dry in summer. However, at Maria Slough, Mountain Slough, and Morris Valley, water levels are often lowest during the breeding season and rise throughout the summer. This is due to the habitats' connection to the Fraser River hydrograph, which is lowest in winter (as most of the watershed's precipitation is sequestered in snow and ice) and typically highest in June (as the snow and ice melt in the Interior of British Columbia and drain into the Fraser River).

The permanent water connected to these oviposition locations can be fast-flowing or relatively stagnant. The location is almost always vegetated with indigenous aquatic vegetation such as rushes, sedges, grasses, pondweeds, and buttercups. Some of the plant genera found at these sites include *Scirpus*, *Juncus, Carex, Poa*, *Polygonum*, *Potamogeton*, and *Ranunculus*. Other plants present at these locations include the exotic grass of the genus *Phalaris*.

The timing of reproduction and egg-laying appears to vary with latitude and elevation (McAllister and Leonard 1997). In British Columbia, the known breeding sites are all at low elevation. Adults typically occupy the breeding sites from late February to late March, but in cold years breeding and oviposition is delayed (Licht 1969a). Typically, several males first arrive at the oviposition site sometime around late February each year, and call to females for as long as 1–3 weeks; the breeding season typically lasts less than 4 weeks (McAllister and Leonard 1997). Mating is first initiated at or close to the breeding site. Eggs are laid and embryos develop from late February to early April, and larvae develop and disperse from late March to late May (Licht

1969a; R. Haycock, pers. obs., 2001–2003). In the United States, egg-laying occurred between late February and late March at low elevation sites, but typically did not begin at higher-elevation locations until the latter half of March (McAllister and Leonard 1997).

The onset of the breeding season is determined by temperature and day-length for other ranid frogs (Duellman and Trueb 1986), and this pattern is likely true for Oregon Spotted Frog as well. Licht (1969a) suggested that air temperatures of 5$^{o}$C were required for Oregon Spotted Frogs to emerge from their hibernation sites (Licht 1969a). Cushman and Pearl (2007) reported that frogs at two sites in Oregon began breeding when water temperatures approached 10$^{o}$C, although at other locations, temperatures exceeded 10$^{o}$C.

Frogs show strong site fidelity to oviposition sites. Licht (1969a) reported that Oregon Spotted Frog oviposition sites used in 1969 were within 30 cm of those used in 1968. In Oregon, > 75% of egg masses from two populations were discovered within 5 m of egg-laying locations from previous years (Pearl and Bury, unpubl. data, cited in Pearl and Hayes 2004).

**Active season habitat**

Active season habitat, which is generally used in the summer months, includes warm, shallow wetlands dominated by floating emergent vegetation (Licht 1971a; Hayes 1997). The results of trapping (capture and release) and telemetry studies at the Maintenance Detachment Aldergrove, Mountain Slough, and Maria Slough locations in late spring and summer indicated that adult Oregon Spotted Frogs inhabited only the highly vegetated portions of wetlands (R. Haycock, unpubl. data, 2001–2002), where vegetation was dominated by floating emergent *Potamogeton* spp. interspersed with submergent *Polygonum* spp. Watson *et al.* (2003) also reported that Oregon Spotted Frogs at Dempsey Creek, Washington, inhabited only very densely vegetated portions of the wetland in the dry season; the dominant vegetation there was hardhack (*Spiraea douglasii*).

Research indicates that active season sites are typically in deeper water than breeding sites. In British Columbia, frogs were in water 42–112 cm deep in the active season, compared to breeding habitat 3–10 cm deep (R. Haycock, unpubl. data, 2001–2002). Watson *et al.* (2003) reported that summer frog locations were in deeper water (average 23.6 ± 1.0 cm) than water depths at random locations (average depth 16.5 ± 1.0 cm), or oviposition sites (average depth 16.9 ± 0.6 cm).

**Overwintering sites**

Overwintering habitats provide a place where adults and newly metamorphosed juveniles (all larvae mature before winter) hibernate and shelter from cold winter temperatures, and may be occupied between October and late February. These habitats are different than those used during the breeding and active seasons (Chelgren *et al*. 2006). Important characteristics of overwintering sites are that they do not freeze, and that they have more stable levels of dissolved oxygen than other areas (Pearl and Hayes 2004). Important habitats include springs, seeps, or low-flow channels (Pearl and Hayes 2004), and frogs may bury themselves in silty soil or in vegetation (McAllister and Leonard 1997). Watson *et al.* (2003) reported that frogs buried themselves at the base of vegetation clumps, under ice < 5 cm thick.

Radiotelemetry data of frogs at the Maintenance Detachment Aldergrove, Maria Slough, and Mountain Slough locations suggested that overwintering habitat might be associated with beaver-altered habitat (R. Haycock, unpubl. data, 2001–2002), and Hayes *et al.* (2001) reported that Oregon Spotted Frogs used beaver structures during winter. Frogs have also been reported using ditch habitat in late fall or over winter (Watson *et al.* 2003; Pearl and Hayes 2004). Watson *et al.* (2003) reported that water depth at overwintering locations was on average 17.4 ± 0.8 cm deep. Pearl and Hayes (2004) provided data from other studies in Washington that reported mean water depth at winter locations: Risenhoover *et al.* (2001) reported frogs at locations ranging from 0 to 120 cm water depth (average 22 cm), Hallock and Pearson (2001) reported frogs in water 1 to 88 cm deep (26.2 cm average), and Hayes *et al.* (2001) reported frogs in water from 6 to 111 cm deep (averages of 62, 49, 34, and 29 cm deep).

Aquatic connections between overwintering and breeding habitat during migratory periods in late spring and fall are at minimum important, and may be essential (Watson *et al.* 2003; Pearl and Hayes 2004). Known movements of Oregon Spotted Frog are almost exclusively along water. Watson *et al.* (2003) found 99% of all telemetred frog locations (of 654) were in at least 1 cm of water. Additional evidence cited in Watson *et al.* (2003) in support of aquatic movements was that they found no road-killed Oregon Spotted Frogs during their study (a road blocked access to a major breeding pond, but there was access to the pond through a culvert under the road), but did record Red-legged Frog and Pacific Chorus Frog (*Pseudacris regilla*) mortalities. Although Watson *et al.* (2003) did report 1 overland movement of a frog, this "overland" movement was through marshy swampy habitat, not dry upland habitat (M. Hayes, pers. comm., 2008).

### 3.3.2 Ecological role

The Oregon Spotted Frog may serve as an indicator of the occurrence and health of shallow, warm wetland habitats. Although other factors may contribute, the rarity of the Oregon Spotted Frog probably coincides with the rarity of its habitat throughout its range. Accordingly, the decline of the Oregon Spotted Frog is a likely indicator that shallow, warm aquatic habitats are equally endangered. Within these habitats, Oregon Spotted Frogs may serve as a top predator of aquatic invertebrates (e.g., Pearl *et al.* 2005) at the same time that they are a food source for reptiles, mammals, and birds.

### 3.3.3 Limiting factors

**Predators and elevated mortality rates**
As a member of the lower levels of the food web, the Oregon Spotted Frog has many natural potential predators. This placement in the food web makes it likely that Oregon Spotted Frog population recovery may be influenced by a number of direct and indirect predator-induced and trophic cascade effects that are not easily predictable. In addition, some of the predators listed below are introduced predators (noted with an asterisk) and Oregon Spotted Frogs may not have innate evolved anti-predator defenses. Other predators listed below are human commensals whose population numbers increase in human disturbed areas and hence may increase predation

pressure on Oregon Spotted Frog populations beyond natural sustainable levels. These non-native and human augmented predation pressures are addressed in the threats section.

Known and potential predators of various life stages of the Oregon Spotted Frog include, adult and larval Dytiscid beetles (*Dytiscus* spp.), Backswimmer (*Notonecta* spp.), Leech (*Batracobdella picta*), Odonate Nymph (Odonata), Water Scorpion (Nepidae), Bullfrog (*Lithobates catesbeianus*),* Green Frog (*Lithobates clamitans*),* Garter Snake (*Thamnophis* spp.), River Otter (*Lontra canadensis*), American Mink (*Neovison vison*), Great Blue Heron (*Ardea herodias*), Green Heron (*Butorides virescens*), Belted Kingfisher (*Megaceryle alcyon*), American Bittern (*Botaurus lentiginosus*), Northwestern Salamander adults and larvae (*Ambystoma gracile*), Rough-skinned Newt (*Taricha granulosa*), Giant Water Bug (*Lethocerus americanus*), Raccoon (*Procyon lotor*), Cutthroat Trout (*Oncorhynchus clarkii*), Red-tailed Hawk (*Buteo jamaicencis*), Northern Harrier (*Circus cyaneus*), Hooded Merganser (*Lophodytes cucullatus*), Great Horned Owl (*Bubo virginianus*), Red Fox (*Vulpes vulpes*), and Striped Skunk (*Mephitis mephitis*) (Licht 1974; Pearl and Hayes 2004, 2005; Hayes *et al.* 2005; Watson *et al.* 2000, 2003).

Mortality rates of Oregon Spotted Frogs in the tadpole stage are high, and most likely due to predation (Licht 1974; Hayes 1994b). Licht (1974) reported that tadpole mortality rates were > 93% when he studied the now-extirpated population in Campbell Valley Regional Park. In addition, juvenile Oregon Spotted Frogs may be more susceptible to Bullfrog predation than northern Red-legged Frogs (Pearl *et al.* unpubl. data, reported in Pearl and Hayes 2004).

Adult males may have higher mortality rates than females; Licht (1974) reported that sex-specific mortality rates were significantly different ( i.e., 1-year survival rates of 45% for males and 67% for females). He attributed the higher male mortality rates to their greater exposure to predators during the breeding season, and their smaller size. Chelgren *et al.* (2006) also reported higher mortality rates of males during the breeding season. Male Oregon Spotted Frogs are present at breeding sites, where they are more exposed to predators, for 2–4 weeks while females are present at the sites for only a short time (Licht 1974; R. Haycock, pers. obs., 2001–2003). The smaller size of adult male Oregon Spotted Frogs, which are 46–60 mm compared to 62–80 mm for females (Licht 1974), increases their susceptibly to predation, particularly from garter snakes, which may be a very important predator of these frogs (Licht 1974). This potential difference in survivorship of male Oregon Spotted Frogs may explain the absence of large males at the Maintenance Detachment Aldergrove location (R. Haycock, unpubl. data, 2001–2003).

**Risky oviposition site selection**

The Oregon Spotted Frog's selection of oviposition sites makes it particularly susceptible to intermittently diminished recruitment that may result in an overall decline in population size. Egg masses are deposited in the shallow margin of wetlands and are partially exposed to the air, making the eggs susceptible to freezing, and desiccation from exposure to air and direct sunlight, especially under windy conditions (Licht 1974; McAllister and Leonard 1997; Watson *et al.* 2000). In addition, oviposition sites are ephemeral and embryos are susceptible to desiccation if water levels recede and strand the egg masses (Licht 1974; McAllister and Leonard 1997; R. Haycock, pers. obs., 1997; Watson *et al.* 2000).

**Habitat size**

Based on data from occupied sites throughout its North American range, the minimum area required to maintain an Oregon Spotted Frog population is 4 ha (Pearl and Hayes 2004). Larger wetlands may be more likely to encompass the range of habitat types necessary to support a self-sustaining population that is better able to withstand high predation rates (M. Hayes, pers. comm., 2008). Although Oregon Spotted Frogs have been reported from sites < 4 ha in the United States, Pearl and Hayes (2004) suggested that these are remnant populations in areas that were previously connected to larger areas of habitat. All of the currently occupied locations in Canada are > 4 ha, but additional sufficient suitable habitat is scarce. Restoration of adjacent habitat next to occupied sites may provide opportunities for the local populations to expand and increase their population sizes. However, these opportunities are limited due to conflicting land use activities.

**Genetic isolation**

The greater the isolation between sites, the lower the probability of genetic rescue from dispersing individuals (Sjögren 1991). Thus, small populations may be at risk of inbreeding depression and stochastic extinction (Sjögren 1991). It is possible that all of the current known populations of Oregon Spotted Frog in Canada are genetically isolated. The mechanism of the landscape-level dispersal of the species is not fully understood. There is some speculation that the 100- to 200-year floods of the Fraser River may have historically played a role in allowing Oregon Spotted Frogs to move through the lower Fraser Valley (K. Welstead, pers comm., 2008; Figure 6). The current dyking and flood control systems in the area may inhibit long-distance dispersal.

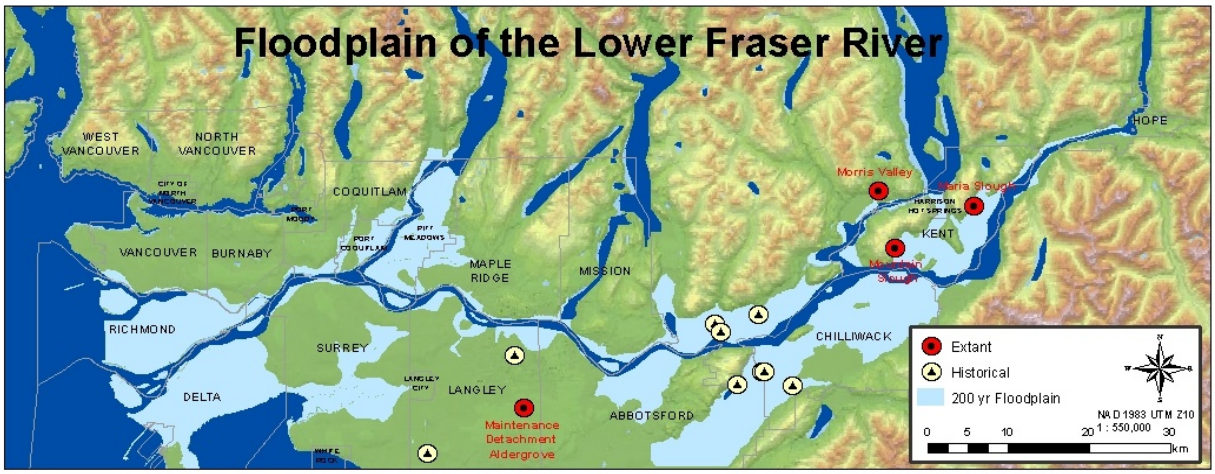


**Figure 6.** Map illustrating the floodplain area of the lower Fraser River (light blue area). The floodplain overlaps with the historic and current extant range of the species. Map credit: Kristina Robbins

Oregon Spotted Frogs regularly move several hundred metres between breeding and winter habitats. Watson *et al.* (2003) reported movements of Oregon Spotted Frog from 32 to 111 m/day for 2–18 days, which suggests that they are capable of longer-distance dispersal. A telemetry study of Oregon Spotted Frogs reported that telemetred individuals did not usually move more than 400 m from their original capture location (Hallock and Pearson 2001); however, movements of > 1 km have been recorded within wetland complexes and along linear

riparian systems (Watson *et al.* 2003; Pearl and Hayes 2004). Two juvenile frogs were recorded moving 1245 m and 1375 m, respectively, downstream from their initial capture location, and an adult female was captured 2799 m (estimated stream distance) from her original capture location (Cushman and Pearl 2007).

For Oregon Spotted Frog, aquatic connections between overwintering and breeding habitat are essential (Watson *et al.* 2003; Pearl and Hayes 2004). Known movements of Oregon Spotted Frog are almost exclusively along water. In Watson *et al.*'s (2003) study, 99% of all telemetred frog locations (of 654) were in at least 1 cm of water. Based on telemetry data, Pearl and Hayes (2004) suggested that all wetlands within 2–3 km of occupied locations be considered to have increased potential as habitat for Oregon Spotted Frogs. This 2–3 km range would represent the maximum expected movement for Oregon Spotted Frogs. Therefore, all known populations of the Oregon Spotted Frog in Canada are likely isolated from one another; the distance between the Morris Valley, Mountain Slough, and Maria Slough locations is about 8 km and each of these locaitons is 50–60km from Maintenance Detachment Aldergrove. In addition, suitable wetland habitat between any two locations is highly fragmented and movement between populations is unlikely to occur.

**Small population size and few sites**
With only four remaining Canadian breeding populations and less than 350 estimated breeding individuals, the risk of demographic and environmental stochastic events is high and could result in further local extirpations. Given this, it is crucial that recovery efforts simultaneously include both a small-population approach which addresses the effect of smallness on the persistence of a population, as well as a declining-population approach which aims to diagnose the decline (the reason the populations are small) and to resolve threats to the population (Caughley 1994).

Unfortunately, the Oregon Spotted Frog's limited distribution in BC restricts the number and availability of suitable recovery sites. Increasing the number of occupied locations (populations) would help to mitigate stochastic events. However the fragmentation of wetlands in the highly developed Lower Fraser River Lowlands will likely never allow for natural process such as meta-population dynamics and colonization of new locations.

# 4 THREATS

Threats are defined as the proximate (human) activities or processes that have caused, are causing, or may cause the destruction, degradation, and/or impairment of biodiversity and natural processes. Threats presented here do not include biological features of the species or population such as inbreeding depression, small population size, and genetic isolation, which are considered limiting factors. Some of the limiting factors may be intrinsic but some (e.g. small populations) are a direct result from historic or ongoing threats listed in this section and must be resolved concurrently in order to recovery the species. Natural phenomena such as Geologic Events, and Severe Weather (not related to climate change) are included in this definition, though should be applied cautiously. These stochastic events should only be considered a threat when other human-caused factors have reduced the population to such an extent that this type of event would have a disproportionately large effect on the population compared to what they would have at historic population levels.

## 4.1 Threat Classification

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 and the B.C. Conservation Framework. For a detailed description of the threat classification system, see the CMP website (CMP 2010[1]). For information on how the scores are assigned or overall impact is calculated see Master *et al.* (2009) and table footnotes for details. Threats for the Oregon Spotted Frog were assessed for the entire province (Table 2)[2] based on the best judgment of the Canadian Oregon Spotted Frog Recovery Team in the absence of published information. Threats were considered at the four extant populations and at six potential sites for Oregon Spotted Frog introduction/reintroduction in the next 10 years (see section 6.4.3, Table 4).

**Table 2**. Threat classification table for Oregon Spotted Frog.

| Threat number | Threat description | Impact[a] | Scope[b] | Severity[b] | Timing[d] | Stress[e] |
|---|---|---|---|---|---|---|
| 1 | Residential & commercial development | Low | Restricted | Moderate | High | |
| 1.1 | Housing & urban areas | Low | Restricted | Moderate | High | Habitat loss |
| 1.2 | Commercial & industrial areas | Low | Small | Slight | High | Habitat loss |
| 1.3 | Tourism & recreation areas | Low | Small | Slight | High | Habitat loss |
| 2 | Agriculture & aquaculture | Medium | Large | Moderate | High | |
| 2.1 | Annual & perennial non-timber crops | Low | Large | Slight | High | Habitat loss |
| 2.3 | Livestock farming & ranching | Medium | Large | Moderate | High | Habitat degradation; Accidental mortality |
| 3 | Energy production & mining | Medium | Restricted | Serious | High | |
| 3.2 | Mining & quarrying | Medium | Restricted | Serious | High | Habitat degradation; Accidental mortality |
| 4 | Transportation & service corridors | Low | Large | Slight | High | |
| 4.1 | Roads & railroads | Low | Large | Slight | High | Habitat degradation; Direct mortality |
| 4.2 | Utility & service lines | Unknown | Restricted | Unknown | High | Habitat loss |
| 5 | Biological resource use | Low | Small | Slight | High | |
| 5.3 | Logging & wood harvesting | Low | Small | Slight | High | Habitat loss |
| 6 | Human intrusions & disturbance | High | Large | Serious | High | |
| 6.1 | Recreational activities | Medium | Restricted | Slight | High | Habitat degradation; Accidental mortality |
| 6.2 | War, civil unrest, & military | Low | Small | Slight | High | Habitat degradation; Accidental mortality |

[1]< http://www.conservationmeasures.org/initiatives/threats-actions-taxonomies/threats-taxonomy/ >
[2] Note that Appendix 2 summarizes specific threats and limiting factors for the four sites occupied by the Oregon Spotted Frog in a different format.

| Threat number | Threat description | Impact[a] | Scope[b] | Severity[b] | Timing[d] | Stress[e] |
|---|---|---|---|---|---|---|
| | exercises[f] | | | | | |
| 6.3 | Work & other activities | High | Large | Serious | High | Habitat degradation; Accidental mortality |
| 7 | Natural system modifications | Medium | Restricted | Serious | High | |
| 7.1 | Fire & fire suppression | Low | Small | Serious | Insignificant/ negligible | Habitat degradation; Direct mortality |
| 7.2 | Dams & water management/use | Medium | Restricted | Serious | High | Habitat loss |
| 7.3 | Other ecosystem modifications | Medium | Restricted | Moderate | High | Habitat degradation; Direct mortality |
| 8 | Invasive & other problematic species & genes | Very High-High | Pervasive | Extreme-Serious | High | |
| 8.1 | Invasive non-native/alien species | Very High-High | Pervasive | Extreme-serious | High | Habitat degradation; Direct mortality |
| 8.2 | Problematic native species | Low | Restricted | Slight | High | Habitat degradation; Direct mortality |
| 9 | Pollution | High | Large | Serious | High | |
| 9.1 | Household sewage & urban waste water | Low | Restricted | Moderate | High | Direct and indirect mortality |
| 9.2 | Industrial & military effluents | Low | Restricted | Slight | High | Direct and indirect mortality |
| 9.3 | Agricultural & forestry effluents | High | Large | Serious | High | Direct and indirect mortality |
| 9.5 | Air-borne pollutants | Unknown | Small | Unknown | High | Direct and indirect mortality |
| 9.6 | Excess energy[g] | Low | Small | Slight | High | Direct and indirect mortality |
| 10 | Geological events | Low | Small | Moderate | High | |
| 10.3 | Avalanches/landslides | Low | Small | Moderate | High | Habitat degradation; Accidental mortality |
| 11 | Climate change & severe weather | Low | Small | Serious | Moderate | |
| 11.2 | Droughts | Low | Small | Serious | Moderate | Habitat degradation; Direct mortality |

[a] **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 stress is based on Severity and Scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. The median rate of population reduction or area decline 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%).

[b] **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%)

[c] **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 timeframe. Usually measured as the degree of reduction of the species' population. (Extreme = 71–100%; Serious = 31–70%; Moderate = 11–30%; Slight = 1–10%)

[d] **Timing** – High = continuing; Moderate = only in the future (could happen in the short term [less than 10 years or 3 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.

[e] **Stress** – The condition or aspect (key ecological, demographic, or individual attribute) of the conservation target that is impaired or reduced by a threat (e.g., directly or indirectly results from human activities).

[f] Military exercises at Aldergrove.

[g] Defined as inputs of heat, sound, or light that disturb wildlife or ecosystems. For Oregon Spotted Frog, this includes potential impacts from electromagnetic fields from transmission wires.

## 4.2 Description of the Threats

The overall province-wide Threat Impact for this species is Very High[1]. The greatest threat is invasive non-native species (Table 2). At all occupied locations, the potential for specific threats to cause a local extirpation is high due to small population numbers and isolation of populations caused by habitat fragmentation. Details are discussed below under the Threat Level 1 headings.

### 4.2.1 Very high, high and medium impact threats

**IUCN-CMP Threat 6. Human intrusions and disturbance**

At the four extant locations, recreational activities do not pose a threat. However, at two of the potential reintroduction sites, Grace Lake and Sasquatch Provincial Park, there are low impact recreational activities such as canoeing and fishing. Military exercises may be conducted at Maintenance Detachment Aldergrove, but such activities are rare, highly controlled, and not conducted in the frog wetland. Consequently, they have minimal impacts on Oregon Spotted Frogs or their habitat.

Work activities such as culvert maintenance and watercourse clearing can have a significant impact on Oregon Spotted Frog populations at Maria Slough, Mountain Slough (and McCallum ditch), and at the potential reintroduction sites at Prison Wetlands and the Agriculture Canada Lands. Culvert blockages and clearing can result in habitat changes and water level draw down. This has been recorded at Maria Slough where culverts were blocked in the spring and cleared out during breeding season resulting in eggs stranded out of water. This can be avoided through timing of culvert maintenance. Municipal in-stream maintenance works including ditch clearing and deepening, which can reduce the availability and suitability of habitat, cause direct mortality, and enable Bullfrog occupation and breeding.

**IUCN-CMP Threat 8. Invasive and other problematic species and genes**

In recent years there has been growing evidence that many amphibian declines witnessed on three continents have been the result of chytridiomycosis and iridoviral infections (Daszak *et al.* 1999). It is suspected that the global spread of these diseases is the result of amphibian imports and exports (Hanselmann *et al.* 2004). Chytridiomycosis has been reported from wild Oregon Spotted Frogs in Washington and Oregon, but the full potential impact on populations is not yet understood (Pearl *et al.* 2007). The causal agent of chytridiomycosis, *Batrachochytrium dendrobatidis,* has been detected in introduced and native amphibians, including Oregon Spotted Frog, from Maintenance Detachment Aldergrove and Maria Slough (P. Govindarajulu, pers. comm.; unpubl. data, 2006–2009).

[1] The overall threat impact was calculated following Master et al. (2009) using the number of Level 1 Threats assigned to this species where Timing = High. This includes 1 Very High, 2 High, 3 Medium, and 4 Low (Table 3).The overall threat considers the cumulative impacts of multiple threats.

There have been a few instances of mass mortality of captive frogs in the head-starting program (rearing of eggs and subsequent releasing of frogs to improve the chances of survival) in B.C. that may have been caused by either water quality issues or iridovirus outbreaks (S. Raverty, pers. comm., 2006). Iridovirus outbreaks in the most notable cases (i.e., *Rana temporaria* in the U.K. and *Ambystoma tigrinum* in Saskatchewan and Arizona) appear to be related to high densities of populations living in artificial or human-made habitats (Daszak *et al.* 1999). The success of husbandry efforts depends on a better understanding of the iridovirus and any other disease-causing organisms that may negatively affect wild and captive-reared populations.

Kiesecker and Blaustein (1997) found an increased occurrence of the Oomycete fungus *Saprolegnia* in Cascades frog (*Rana cascadae*) egg masses in a study population in Oregon. They reported that eggs laid in clusters had a higher mortality rate than those laid singly, and thus species with communal egg-laying habits, such as the Oregon Spotted Frog, may be at higher risk of *Saprolegnia* infection. Although B.C. populations have not been tested specifically for *Saprolegnia,* it can be assumed to be present in all extant locations and potential sites given the widespread distribution of this pathogen.

Although malformed Oregon Spotted Frogs have not been found at the 4 occupied sites in the Fraser Valley, nor have malformations been linked to massive die-offs of this species (Daszak *et al.* 1999), the potential exists for malformations to be of concern to the recovery effort. Four cases of malformed Oregon Spotted Frogs have been reported to the North American Reporting

Bullfrogs and Green Frogs are exotic species in Western Canada. The Bullfrog is present at Maintenance Detachment Aldergrove. Conversely, the Green Frog is present at Maria Slough and Mountain Slough, but absent at Maintenance Detachment Aldergrove. No Bullfrogs or Green Frogs have been observed at the Morris Valley site. Bullfrogs are opportunistic and indiscriminate predators of reptiles, birds, mammals, and amphibians, including Oregon Spotted Frogs (Licht 1974; Watson *et al.* 2003; Pearl and Hayes 2004). The Bullfrog is larger (snout–vent length, approximately 200 mm; Duellman and Trueb 1986) than even adult Oregon Spotted Frogs in Canada (maximum snout–vent length, 80 mm, average, 56 mm; N = 320) suggesting that all size classes of Oregon Spotted Frogs, including adults, could be preyed upon by Bullfrogs. Bullfrogs were recorded consuming hatchling Oregon Spotted Frogs at the Maintenance Detachment Aldergrove site (R. Haycock and R.A. Woods, unpubl. data, 2001). Adult Green Frogs (reach a snout–vent length of 100 mm; Duellman and Trueb 1986) may also eat young Oregon Spotted Frogs, but adult Oregon Spotted Frogs may reach a size that is too large to be prey for the species. Whether Green Frogs are significant competitors of Oregon Spotted Frogs is currently unknown. It is also possible that the high population densities of Green Frogs attract and maintain higher than normal population densities of native predators, which in turn increase predation pressures on Oregon Spotted Frogs.

Reed canary grass (*Phalaris arundinacea*) was introduced to North America from Europe as a cover crop and for use as silage. This clonal perennial propagates by underground rhizomes and seed. It is typically found in dense stands in shallow water (< 15 cm), but has been observed as floating mats in water as deep as 2.7 m (Lefor 1987); it occurs in water up to 2 m deep at the Maria Slough site (R. Haycock, pers. obs., 2000). Reed canary grass is a particular threat to native wetland species because of its rapid and aggressive growth, hardiness, and the difficulty of

selective control. Reed canary grass is present at the Maintenance Detachment Aldergrove, Mountain Slough, and Maria Slough sites, but is not present in the area of sedge meadow that the Morris Valley population occupies (D. Knopp, pers. comm., 2008).

Although the impact of reed canary grass on the suitability of habitat for Oregon Spotted Frog is not fully understood, it appears that once the grass invades a shallow floodplain marsh, it eliminates or reduces the amount of oviposition habitat available to the Oregon Spotted Frog (COSEWIC 2000). Trapping and telemetry data collected at Maintenance Detachment Aldergrove suggest that Oregon Spotted Frogs do not typically occupy homogenous stands of reed canary grass (R. Haycock, unpubl. data, 2001–2002), although they may seek refuge in less dense stands of reed canary grass when these stands are inundated with water. These clumps provide the equivalent structural habitat to clumps of sedge (*Carex* spp.) and common rush (*Juncus effusus*), which Oregon Spotted Frogs are known to inhabit (Watson *et al.* 2000; R. Haycock, unpubl. data, 2001–2002). It is possible that the presence of the exotic, invasive reed canary grass may increase the rate of natural succession and succession-related habitat loss. Moderate cattle grazing may increase habitat suitability for Oregon Spotted Frog in reed canary grass areas by breaking up vegetation mats and creating open habitat (Watson *et al.* 2000, 2003).

American Beaver (*Castor canadensis*) activity can influence the hydrology of the site. Both positive and negative effects of American Beavers have been observed at sites in British Columbia (COSEWIC 2000). American Beavers are present at all extant Oregon Spotted Frog habitats in British Columbia. At Maria Slough, American Beavers may have a positive effect on Oregon Spotted Frogs by encouraging water retention and providing overwintering habitat. At Maintenance Detachment Aldergrove, American Beaver activity has led to higher water volume retention and also resulted in the thinning of the canopy of forested wetlands, creating habitat conditions that the Oregon Spotted Frog prefers. In Mountain Slough, where water levels fluctuate during breeding season, American Beaver dams may stabilize water levels at certain oviposition sites. At Morris Valley, channels used by Oregon Spotted Frogs and fish during low water (paradoxically during the winter and spring when the wetland is not flooded) are likely created by American Beavers.

American Beaver activity has also degraded habitat quality in some areas; approximately 300 m of shallow wetland edge at Maintenance Detachment Aldergrove, where egg masses were laid in the past, was eliminated by the creation of beaver impoundments between 1995 and 1999 (Haycock 2000). Typically, if dam-building activities eliminate oviposition habitat at an occupied site, there is the possibility that they also create additional oviposition habitat elsewhere because water backs up into new areas behind the impoundment. However, at Maintenance Detachment Aldergrove, the topography behind newly created beaver dams is too steep to be useful as oviposition habitat. Other areas that are appropriately graded are too densely vegetated and unsuitable for oviposition.

**IUCN-CMP Threat 9. Pollution**

Water quality may be an issue for at least three of the currently occupied sites of Oregon Spotted Frog. At Maintenance Detachment Aldergrove, fertilizers are not used which is in keeping with the species management plan for this property (Haycock 2000); however, the wetlands occupied

by the Oregon Spotted Frog at Morris Valley, Mountain Slough, and Maria Slough are in largely agricultural areas (Figure 7). For the 4 B.C. populations of Oregon Spotted Frog, chemicals most likely enter the water from runoff from adjacent land use activities. Agricultural runoff includes fertilizers (including manure) and runoff or percolation into the ground water from manure piles (Rouse *et al.* 1999), and spraying of agricultural chemicals such as pesticides or insecticides (including Btk, or *Bacillus thuringiensis* bacterium) or fungicides (used by blueberry producers), including wind-borne chemicals. Water-borne sewage and non-point runoff from housing and urban areas that include nutrients, toxic chemicals, and/or sediments are becoming an increasing threat. Introduction of chemicals into waterways by chemical spraying during forestry activities, maintenance of power line corridors, or disruption of normal movements of nutrients by forestry activities (Lynch and Corbett 1990; Mayer *et al.* 2007) is also a potential source of contaminations. Pesticides in the waterway can make frogs more susceptible to parasitic infections and malformations, by negatively affecting their immune system (Kiesecker 2002) as well as increased susceptibility to disease (toads; Taylor *et al.* 1999)..

There is a garbage dump upstream of the Maria Slough site and garbage has been illegally dumped at sites at Mountain Slough and other sites that are close to human residential developments. The impact of garbage (possible leaching pollutants) and solid waste on Oregon Spotted Frogs is currently not known. The impacts of air-borne pollutants are unknown at the sites.

**Nitrogen.** Like other amphibian species (e.g., Hecnar 1995; Rouse *et al.* 1999), Oregon Spotted Frog is very sensitive to nitrogen in the environment in the form of nitrates, nitrites, or ammonium found in agricultural fertilizers (Marco *et al.* 1999; Rouse *et al.* 1999). Marco *et al.* (1999) suggested that this sensitivity might have resulted in the near extirpation of Oregon Spotted Frogs from lowland areas in Washington, which have intensive agriculture use. Poor water quality also exists within the Canadian range of the Oregon Spotted Frog. De Solla *et al.* (2002) suggested that poor water quality, particularly due to high biological oxygen demand and high levels of nitrogenous compounds such as ammonia and potentially organophosphate pesticides, caused low hatching rates for 2 species of amphibians (*Rana aurora* and *Ambystoma gracile*) at sites within the Sumas Prairie watershed in the Fraser Valley (an area of historical Oregon Spotted Frog occupancy). McKibbin *et al.* (2008) found very low concentrations of nitrate and total nitrogen in March and April during the Oregon Spotted Frog oviposition period in 2 sites, Maria Slough and Maintenance Detachment Aldergrove. Although the nitrogen levels in the spring were lower by orders of magnitude than those considered toxic to Oregon Spotted Frog, the levels are likely to be much higher later in the season when fertilizers are applied to the fields. Coliform bacteria levels were high in some sites and seasons and indicate high levels of livestock waste runoff into Maria Slough. At present, there has been insufficient research regarding impacts of high coliform levels on Oregon Spotted Frog.

**Phosphorous** may also impact wetlands. Phosphorous can enter the waterway from fertilizers (including manure/solid waste) applied to agricultural fields or lawns, as well as from septic fields or leaking sewer pipes. Phosphorous and nitrate inputs to wetlands have been linked to parasitic infections in amphibians, which can lead to malformations (Johnson and Chase 2004; Johnson *et al.* 2007). Because phosphorous typically attaches to sediment, buffer areas sufficient to limit sediment deposition in the wetland should also be sufficient to limit phosphorous input.

Although a buffer can become saturated with phosphorous, at which point phosphorous will leach into the waterway, the buffer will prevent large pulses (Wenger 1999).

**Pesticides** are a potential contaminant throughout the range of the Oregon Spotted Frog. Pesticides can reach fairly high concentrations in wetlands in agricultural landscapes without buffers. Wind-borne agricultural and forestry chemicals (such as insecticides or herbicides or fungicides) have been linked to population declines of amphibians (Davidson *et al.* 2002). In addition, exposure to chemicals such as carbaryl (insecticide) and atrazine (herbicide) can negatively affect development of some species of anurans, and can also affect food resources for some species of anurans (Hayes *et al.* 2002; Boone and James 2003). The herbicide glyphosate (Vision® or Roundup® formulation) appears to be toxic at environmental levels to many species of amphibians; however, the level of toxicity might be due to the surfactant in the formulation rather than the active ingredient (Govindarajulu 2008). Anecdotal evidence suggests that even taxon-specific biological pesticides such as *Bacillus thuringiensis kurstaki* - Btk and *Bacillus thuringiensis israelensis* - Bti can cause mortality of aquatic amphibians, probably due to additives to the pesticide such as surfactants and other non-active ingredients (P. Govindarajulu, pers. comm.; unpubl. data 1999, 2003; C. Bishop, pers. comm., unpubl. data 2008). The scope of this threat is difficult to estimate and the impact is currently unknown.

**Figure 7.** Drainage into Mountain Slough between two oviposition sites. Photo credit: K. Welstead

**Sediment** deposition into streams and wetlands may potentially impact Oregon Spotted Frog breeding habitat by changing the channel/wetland shape and depth. Potential sources of sediment include runoff from adjacent agricultural fields, channel scouring, cattle tramping of stream/wetland banks, road runoff, and runoff from adjacent forestry practices (Lynch and Corbett 1990; Rashin *et al.* 2006). Retention of a protective area around the wetland and watercourses can both trap sediment and help prevent it from entering the water.

Acid-leaching rock and iron influx from quarry activities may impact Oregon Spotted Frogs at the Mountain Slough site. Iron is a common component of mine drainage, which can have a

detrimental effect on aquatic ecosystems. It can be present in several forms combining with a variety of other ions. Impacts of precipitated iron are influenced by water pH and are generally less severe in alkaline conditions. Ferric iron, when discharged to surface water, hydrolyzes to produce hydrated iron oxide and more acidity. The acid lowers the pH of the water, making it corrosive and unable to support many forms of aquatic life (Earle and Callaghan 1998). Dalzell and MacFarlane (1999) found that the presence of iron at concentrations above 0.1 mg/L will damage the gills of the fish as small particles of iron with dimensions of a few microns can become trapped in the gill lamella potentially leading to secondary bacterial and fungal infections. Ferric hydroxides decrease oxygen availability by coating gills and eggs, and cover the stream bottom and alter the substrate, reducing prey availability (i.e., benthic invertebrates) (Hoehn and Sizemore 1977).

**Excess energy.** Installation of a 500 kV transmission line directly above known oviposition sites may cause maturation delays and reduced embryonic survival (Severini *et al.* 2003; Grimaldi *et al*. 2004). A 500 kV transmission line passing through the Morris Valley habitat is currently off-set from the oviposition sites. A twinning of this line is currently being proposed, which will involve installing a line over the known oviposition sites. The impacts of electromagnetic fields from transmission wires on amphibian are poorly studied, although a few studies indicate a potential risk to the development of Oregon Spotted Frogs and therefore could be an emerging threat. Metcalf and Borgens (1994) also found that voltages 25–75 mV/mm caused significant developmental changes in gastrula and neuruola stage salamanders when they were exposed to the electric field. The current right-of-way at Morris Valley has roughly the same magnetic field conditions as that in the Metcalf and Borgens (1994) experiment; however, frogs at Morris Valley will be exposed to the field throughout their life cycle. Because the lines at Morris Valley will be doubled, and the oviposition locations of the Oregon Spotted Frogs will be directly underneath the new line, it is possible that maturation delays will occur at that site if the project goes ahead. The electric field below 500 kV lines by some estimates is predicted to be 10 kV/m on the right-of-way and 2 kV/m at the edge.

### 4.2.2 Medium impact threats

**IUCN-CMP Threat 2. Agriculture and aquaculture**

Agricultural development in the Fraser River lowlands in the late 1800s and early 1900s required the construction of dykes designed to stabilize fluctuating hydrological regimes of floodplain habitats. Such activities have eliminated, or significantly limited, annual winter–spring wetland renewal in floodplain areas, which has allowed natural succession (in the absence of flood events) to proceed unchecked in these areas. This has resulted in a loss of Oregon Spotted Frog habitat (COSEWIC 2000).

Agricultural land use changes, such as the conversion of field habitat to blueberry and cranberry production, can lead to impacts through drain tile installation and riparian area encroachment/erosion. Sediment deposition into streams and wetlands from runoff from adjacent agricultural fields may potentially impact Oregon Spotted Frog breeding habitat by changing the channel/wetland shape and depth (Lynch and Corbett 1990).

Agriculture is an ongoing threat at Mountain Slough and to some extent at Maria Slough and Morris Valley, and could be an issue at potential reintroduction sites at Agriculture Canada lands, and the Mountain Slough habitat expansion sites.

Livestock use of riparian areas and access to watercourses or wetlands can affect bank stability and result in increased sedimentation as well as nutrient loading, which degrades habitat quality for Oregon Spotted Frogs. Livestock, primarily horses and cows, can also cause direct mortality by trampling of egg masses. Livestock can also act as vectors for the introduction of weed seeds that may alter riparian vegetation characteristics, and may be a potential source of parasite and pathogen introduction or enhancement (Johnson *et al.* 1999). However, moderate cattle grazing has been suggested to control invasive reed canary grass and preserve open habitat (Watson *et al.* 2000, 2003) but the threat of trampling should be weighed against the potential benefits.

**IUCN-CMP Threat 3. Energy production and mining**

Mining/quarry activities pose a potential risk because blasting can alter ground water directionality, and may risk eliminating the water source in oviposition sites in some instances. Mining on the steep hillside upstream of the Mountain Slough site has the potential of triggering landslides and the sudden release of sediment into the wetland. Depending on the timing of this event, it could have serious consequences to the population at this site. There are tentative plans for gravel quarrying near the Maria Slough site; if these plans were to be realized, there is potential for hydrological modification that would have severe impact on the Maria Slough population (M. Pearson, pers. comm., 2009). This threat is acknowledged here even if the extent of this threat is currently unclear.

**IUCN-CMP Threat 7. Natural system modifications**

Burning has been used for vegetation management at the Morris Valley site, potentially causing direct mortality to adult frogs and egg masses/tadpoles as well as destruction of juvenile habitat. Fire will no longer be used to control vegetation and increase forage for horses now that the Oregon Spotted Frog population has been identified at the site. Thus the Canadian Oregon Spotted Frog Recovery Team considers this a historic threat. It is unknown if previous fire management actually helped maintain the vegetation characteristics that favoured Oregon Spotted Frogs. This will need to be addressed as a knowledge gap and vegetation monitoring should be implemented at the site.

Historic water diversions have occurred at Aldergrove for road construction and at Maria and Mountain Sloughs for the development of agriculture. The impact of these historical diversions probably resulted in loss of habitat but may have also provided some benefits. For example, at Maria Slough several culvert structures create pinch points that separate the slough into cells that favour the development of Oregon Spotted Frog habitat (S. Letay, pers. comm.). Concurrently, these same water control structures likely prevent outmigration of individuals into unused but suitable habitat areas downstream (M. Pearson, pers. comm., 2009).

Oviposition sites in shallow wetlands are susceptible to hydrological alteration. This can have a devastating effect on Oregon Spotted Frog eggs and their habitat if there are sudden draw downs.

Additionally, the alteration of natural hydrological cycles due to the construction of water control structures can result in the advancement of early seral vegetation into wetland shallows that no longer flood, and may negatively affect Oregon Spotted Frog habitat. The most significant effect of natural succession appears to be an overall reduction of suitable oviposition habitat (Chelgren *et al.* 2006). Because of the growth of taller, denser vegetation at the periphery of wetlands, sites appear to receive less solar radiation, resulting in lower water temperatures (R. Haycock, pers. obs., 2001–2002). Movement studies suggest that Oregon Spotted Frogs do not use this altered habitat (R. Haycock, unpubl. data, 2001–2002).

Flood prevention and overflow management may impact breeding habitat. The Hammersley pump station at the Mountain Slough site is currently under review for upgrading. It is important that significant drawdown does not occur especially during the breeding season. Diversion of water from a site resulting in partial loss of water volume has the same effect as drought conditions during oviposition and embryonic development. Current hydrologic conditions at Mountain Slough show significant water level fluctuations during the breeding season, resulting in egg mass movement and potentially heavy mortality in affected breeding areas (M. Pearson, pers. comm., 2010).

Loss of riparian habitat that prevents erosion, sedimentation, and slow/absorbed runoff can also greatly impact the habitat. In-stream or riparian works may result in sedimentation (e.g., channel alteration, ditch maintenance, and fisheries work) directly impacting water quality and modifying channel structure. Watercourse modifications can lead to large runoff events with a resulting sudden influx of pollutants from the surrounding area.

Wetland restoration work, and in particular work designed to promote other species (such as fish) can have serious impacts on Oregon Spotted Frog habitat by increasing habitat suitability for competitors and predators. For example, the wetland restoration at Maintenance Detachment Aldergrove is thought to have increased the population of Bullfrogs at the site. Fish focused compensation works in occupied areas may inadvertently impact sites and may alter habitat suitability. This includes riparian plantings, which may shade the water, altering water temperature; changes in flow rate, which may reduce suitability and alter oxygen levels; increases in large woody debris cover, which may increase the habitat suitability for Red-legged Frogs (a sympatric species and potential competitor) and increase fish predation. Early seral vegetation planted to enhance fisheries values is not compatible with the needs of Oregon Spotted Frogs. These trees may grow to shade the site and/or decrease the availability of wetted edge habitat due to water uptake (such as the planting of willows [*Salix* spp.] or red-osier dogwood [*Cornus stolonifera*]) resulting in a loss of habitat for Oregon Spotted Frog. There has been fisheries restoration work at Mountain Slough and Maria Slough. Closer collaboration between various habitat restoration projects can greatly mitigate this threat.

### 4.2.3 Low impact threats

**IUCN-CMP Threat 1. Residential and commercial development**

Habitat loss as a result of human activities has occurred historically and is likely the predominant, chronic, and widespread cause of the decline of the Oregon Spotted Frog throughout its North American range (Hayes 1994a; Hayes 1997; McAllister and Leonard 1997;

COSEWIC 2000). Currently the sources of habitat loss and degradation due to rural and urban development are site specific.

Removal or alteration of natural riparian vegetation around watercourses or wetlands for development can compromise ecosystem function. Residential and commercial encroachment may destroy or disturb natural vegetation, alter water flow and seasonal flooding, or result in the loss of entire wetland complexes. Although the historic impact of this threat is high, it is currently an ongoing threat at only a few sites: housing and residential developments at Mountain and Maria Sloughs; commercial developments at Mountain Slough; and the recreation activities at a potential reintroduction site at Sasquatch Provincial Park and Grace Lake. Currently, the impact of development on Oregon Spotted Frogs is isolated to specific areas and thus is ranked as low in BC, according to the IUCN threat classification system process (Table 2) through the severity can be high if recommended best management practices (B.C. Ministry of Water, Lands and Air Protection 2004) are not followed.

**IUCN-CMP Threat 4. Transportation and service corridors**

Historically, the impact of road building may have been high as many wetlands are bisected by roads and railway corridors and the building of these roads changed the hydrology of wetlands. However at the Maria Slough site, the building of an embankment, rather than a bridge, by the Canadian National Railway upstream of Maria Slough cut off extensive seasonal flows into the slough from the Fraser River. As a result, the north end, or upstream side, of Maria Slough receives all of its water from groundwater and rainwater, instead of the historic flows from the Fraser River. Without the building of the railway embankment, the current oviposition site at Maria Slough would more than likely not exist, as it originally was a mobile channel of the Fraser that was regularly flooded and deposited with gravel (M. Pearson, pers. comm., 2010). Vegetation management along these transportation and service corridors could change wetland characteristics and also be a source of pollution. Sediment deposition into streams and wetlands from road runoff may impact Oregon Spotted Frog breeding habitat by changing water quality and wetland characteristics (Lynch and Corbett 1990).

Populations at Maintenance Detachment Aldergrove, Maria Slough, and Mountain Slough are close to roads but the severity of impact of these roads on Oregon Spotted Frogs is a knowledge gap. Oregon Spotted Frogs are highly associated with wetlands and riparian areas and roadkills may not be a threat to this species. However, roads may be preventing the expansion of extant populations into nearby favourable habitats.

Hydro power transmission lines run across the Morris Valley site and the potential reintroduction site at the Agriculture Canada lands. Maintenance of these utility corridors could pose a threat to Oregon Spotted Frogs from pollution (such as paints, solvents, sedimentation, and other pollutants from vehicles assessing the site) as well as increasing opportunities for the spread and introduction of invasives, but the severity of the impact is currently not known.

**IUCN-CMP Threat 5. Biological resource use**

Upslope forestry activities can increase sedimentation and nutrient loading. Sediment deposition into streams and wetlands from runoff from adjacent forestry practices may impact Oregon Spotted Frog breeding (Lynch and Corbett 1990). Logging could have a potential effect on Oregon Spotted Frog habitat, especially at Mountain Slough where the hillsides are logged before the start of mining and quarrying activities.

**IUCN-CMP Threat 10. Geological events**

Water quality at occupied sites may also be negatively impacted by runoff from natural cliff erosion. Natural water chemistry may also influence Oregon Spotted Frog; McKibbin *et al.* (2008) reported a correlation between embryonic survivorship and water chemistry, specifically low chloride with attendant low conductivity. There is also the potential for catastrophic slope failure and landslides at the Mountain Slough site that may release high levels of sediment into the water and increase risk of smothering. The probability of landslides is great during high rain events in the winter and spring which coincides with the overwintering and breeding seasons, which are also the most vulnerable times in the Oregon Spotted Frog lifecycle. Another geological event that may affect site characteristics at Maria Slough and Mountain Slough is stream avulsion, where the stream channel is laterally displaced. These rare events are unpredictable but could have significant impacts on the Oregon Spotted Frog population and habitat characteristics. While these threats are acknowledged for completeness here, little can be done to prepare for, or mitigate these threats.

**IUCN-CMP Threat 11. Climate change and severe weather**

Haycock (1999) speculated that climate change might be a threat to Oregon Spotted Frog populations because of reduced spring water levels. Kiesecker *et al.* (2001) provided evidence that climate change has resulted in reduced spring water levels at amphibian breeding sites in Oregon, as a result of low winter precipitation. Pounds (2001) reported that higher air temperatures and reduced water levels caused by climate change resulted in amphibian declines in Costa Rica. Changes in water levels as a result of climate change and/or drought have the potential to severely impact recruitment. As increased temperatures are known to affect the survival and development of eggs and tadpoles (Licht 1971a), it is probable that climate warming will affect this species.

Studies suggest that juvenile recruitment may be linked to spring rainfall; Watson *et al.* (2000) reported that larval survival and recruitment were low when low rainfall in March and April resulted in the elimination of outflow water from breeding ponds. In addition, both Licht (1974) and Watson *et al.* (2000) reported that potentially high losses of embryos due to receding waters were prevented only by researcher intervention.

The risk of drought at Maria Slough appears to be high. Maria Slough is fed by precipitation, groundwater discharge from the Bear Mountain and Mount Hicks watershed to the northwest, and hydraulic recharge from the Fraser River (Luttmerding and Sprout 1967). The water level at Maria Slough depends on the water volume of the Fraser River. As evidenced in 2001, drought conditions (Haycock 2001) reduced hydraulic recharge from all three sources and resulted in low

water levels in Maria Slough. The risk of drought at Mountain Slough also appears to be high, but must be confirmed by further observation. Mountain Slough is spring fed, although the origin of the spring water is poorly documented. Springs are visible in the main slough and originate either from Fraser River hydraulic recharge, or groundwater discharge from the escarpment above the slough, or a combination of sources. The risk of drought at Maintenance Detachment Aldergrove may be high because it is situated at the top end of the watershed and has a very limited catchment basin (S. Letay, pers. comm.). Although water levels at Maintenance Detachment Aldergrove fluctuate, the hydrology at this site currently appears to be stable (ECL Envirowest 2000; Haycock 2000). The risk of drought at Morris Valley is unknown. Note that at all sites, the presence of drought conditions may result in water being diverted for human use, thereby exacerbating the effects of drought at these sites.

The Oregon Spotted Frog extant sites along the Fraser River (Maria and Mountain Sloughs, and Morris Valley) will all be prone to flooding events should they become more frequent with climate change. Floods, especially during the breeding season, can have a significant effect on the population, and even the free-swimming tadpole stages may be vulnerable to extreme flow velocities.

# 5 RECOVERY GOAL AND OBJECTIVES

## 5.1 Population and Distribution Goal

The population and distribution goal (within 10 years) is

*To restore, maintain and where feasible expand extant Oregon Spotted Frog populations, and establish six or more additional self-sustaining populations in BC.*

## 5.2 Rationale for the Population and Distribution Goal

There are only four Oregon Spotted Frog populations known in B.C. with less than 350 individuals. One of the populations (Maintenance Detachment Aldergrove) is possibly on the brink of extirpation. An additional four populations are known to be extirpated. Each of the extant populations is isolated from the other populations, and the probability of gene flow between populations, or recolonization is extremely low. Suitable habitat within the range of the Oregon Spotted Frog has been lost and degraded over time, largely as a result of land modification for agricultural or urban development. Unless additional populations are created through re/introduction to new and/or restored sites, the probability of species extirpation from B.C. is considered high. The immediate goal is to prevent extirpation.

Habitat use pressures within the Oregon Spotted Frog range and the presence of introduced species constrains the number of available new or reintroduction sites. Although 13 potential sites are presented in Table 4, further investigation will likely reveal that several of these sites are not suitable (e.g., may be too degraded to be effective for recovery). With this in mind, the goal was set to establish 6 or more populations over the next 10 years. This would result in the number of occupied locations increasing from 4 to a minimum of 10 locations. A minimum

number of breeding adults at each location is needed to sustain viable populations. Until more specific information is available, the population objective is 200 breeding adults per location. It is recognized however, that the carrying capacity may limit what is achievable and as a result targets will vary by location. In addition, it should be noted that the distribution objective may slightly expand the species' range beyond the historic sites, due to introductions into suitable habitat in the Fraser Valley that is not known to have been occupied in the past.

In the time it takes to establish new or reintroduced populations, existing individual populations must remain stable or increase. This will hopefully be achieved through threat mitigation and population augmentation. If successful, extirpation of the Oregon Spotted Frog will be prevented. It may be possible for the COSEWIC designation to be upgraded from Endangered to Threatened, but further improvement in conservation status is not expected given the limited amount and fragmented nature of suitable habitat remaining for this species.

## 5.3 Recovery Objectives

The suggested timeframe to meet the long-term recovery goal is 10 years. However, the recovery objectives 1, 2, 4, 5, and essential components of 6 should be achieved within the next five years. The recovery objectives should be reevaluated every 5 years and updated as new information becomes available.

The recovery objectives for the Oregon Spotted Frog are:

1. to prevent further habitat degradation/loss and population declines of Oregon Spotted Frog by protecting[1], managing, and restoring habitat at all four occupied locations; at additional occupied sites if found (see Objective 4), and at additional locations or sites established through population introduction/reintroduction (see Objective 3)
2. to sustain or improve survivorship rates of all life stages of the Oregon Spotted Frog where needed through threat mitigation, habitat restoration, and population augmentation;
3. to establish/re-establish self-sustaining populations at a minimum of six additional historical, suitable, or restorable locations;
4. to prevent inadvertent loss of currently unidentified populations by conducting a comprehensive inventory of potentially suitable habitat;
5. to determine the effectiveness of habitat protection/enhancement and population augmentation/reintroduction measures by monitoring population status; and
6. to adaptively improve conservation and recovery efforts by addressing knowledge gaps in the life-history, population ecology, threats, and habitat requirements of the species.

# 6 APPROACHES TO MEET OBJECTIVES

The actions recommended in the recovery strategy address threats or limiting factors to the recovery of the Oregon Spotted Frogs in British Columbia or address the knowledge gaps that

[1] Protection can be achieved through various mechanisms including: voluntary stewardship agreements, conservation covenants, sale by willing vendors on private lands, land use designations, and protected areas.

currently hamper effective planning, implementation, or effectiveness monitoring of recovery actions.

The Canadian Oregon Spotted Frog Recovery Team has five recovery implementation groups (RIG) which address key threats and roughly correspond with our broad strategies. The RIGs are: Habitat protection, management and restoration; Husbandry; Invasive species and Disease; Recovery planning, Science acquisition information management and inventory/monitoring; and Outreach/Stewardship.

## 6.1 Actions Already Completed or Underway

Recovery actions for the Oregon Spotted Frog in British Columbia have been underway for several years. Below is a brief description of these action items listed by Conservation Framework action groups. Additionally, specific action items completed at each occupied location are listed separately at the end of this section.

**Compile Status Report (complete)**

- COSEWIC report completed (COSEWIC 2000). An update to the status report was completed in 2010 and will be submitted to COSEWIC.
- Survey for Oregon Spotted Frog at historically occupied sites – 2000.
1. Surveys for Oregon Spotted Frog in potential habitat in the Lower Fraser Valley – 1996, 1997, annual ongoing surveys since 2008.

**Planning (in progress)**

- B.C. Recovery Strategy completed (this document, 2011).
- Invasive Species Recovery Implementation Group (RIG) established and will assess and implement as required Bullfrog and Green Frog control, reed canary grass management, and disease monitoring and management (chytridiomycosis and iridovirus).
- Husbandry RIG established for captive rearing and head-starting of Oregon Spotted Frog in captivity. Currently the RIG is assessing the feasibility and planning in conjunction with the habitat RIG, population augmentation, reintroduction at historic sites, and introduction at additional sites to ensure population persistence.
- Habitat RIG established and is currently assessing habitat and threats at extant and potential reintroduction/introduction sites. This RIG is responsible for ongoing threat mitigation at occupied, historical, and reintroduction sites; and habitat restoration at potential re/introduction sites (see Table 4).

**Species and Population Management (in progress)**

- Habitat and ecological community assessments (including invasive species and disease profiles) in potential reintroduction sites – ongoing since 2009.
- Captive assurance populations which help to retain genetic diversity initiated at the Vancouver Aquarium and Toronto Zoo with ongoing maintenance.
- Captive rearing of wild collected eggs (mainly Maria Slough but also Mountain Slough) to metamorphosis at the Greater Vancouver Zoo and Mountain View Conservation Center.

- Monitor embryos for signs of predation, parasitic infection, fungal infection and other maladies at occupied sites (ongoing).
- Captive breeding of captively reared adults initiated at the Vancouver Aquarium and Toronto Zoo – ongoing since 2010.
- Release of metamorphic Oregon Spotted Frogs back into Maria Slough (year and number): 2002 (354); 2003 (381); 2004 (836); 2007 (846); and 2008 (1012).
- Release of metamorphic Oregon Spotted Frogs back into Maintenance Detachment Aldergrove (year and number): 2005 (317) and 2006 (423).
- Successful overwintering of metamorph Oregon Spotted Frog in mesocosms maintained outdoors, which enabled a spring release of juveniles in 2009.
- Second edition of captive husbandry manual in preparation (2009–2011). The first edition updated with data from density, temperature, and feeding experiments conducted at the captive rearing institutions (2005–2009).
- Captive husbandry and reintroduction plan in development (2009–2011).
- A review of other anuran population augmentation and reintroduction programs used elsewhere (2010).
- Survival habitat mapping has been draft at all occupied locations (2010) and modeling complete for several potential recovery sites.

**Habitat Protection, Habitat Restoration, and Private Land Stewardship (in progress)**

Several specific activities have been completed, are underway, and/or ongoing at each occupied location and are as follows:

Maintenance Detachment Aldergrove

- Egg mass enumeration – 1997, 2000, 2002 (ongoing).
- Management plan for the Oregon Spotted Frog – 2000.
- Habitat construction (1300-$m^2$ pilot project) – 2001.
- Radiotelemetry – 2001 and 2002.
- Bullfrog gut analysis – 2002.
- Growth study – 2003 and 2004, Skeletochronology – 2003.
- Mark–capture–recapture study – 2001–2003.
- Habitat evaluation and identification of important habitat – 2002.
- Habitat design for habitat rehabilitation – 2002.
- Phase 1 site preparation for habitat rehabilitation – 2003 and habitat construction (18,000 $m^2$) – 2004.
- Beaver management plan.
- Assessed the impacts of introduced Bullfrogs as predators and disease reservoirs – 2006 and removal of Bullfrogs – 2006–2008 (ongoing).
- Removal of reed canary grass (ongoing).
- Monitor water levels and ambient temperature (ongoing).

Maria Slough

- Egg mass enumeration – 1997, 2000, 2002–2011 (ongoing).

- Habitat construction (1500 $m^2$) and habitat rehabilitation (1000 $m^2$) – 2000. Habitat construction (5000 $m^2$) – 2009.
- Post–egg-laying and summer season radiotelemetry –2003 and 2004. Post-release radio telemetry of captive-reared frogs – 2009.
- Translocation of 30,000 embryos to habitat construction site – 2002–2004.
- Invasive reed canary grass species management – 2003.

Mountain Slough

- Egg mass enumeration – 1997, 2000–2002, 2004–2011 (ongoing).
- Radiotelemetry – 2005.
- Habitat construction (1800 $m^2$) – 2005.
- Habitat rehabilitation – site rehabilitation including garbage removal, native riparian vegetation restoration, and landowner stewardship contact program to encourage stewardship activities – 2008–2011.

Morris Valley

- Egg mass enumeration – 2008–2011 (ongoing).
- Mark-recapture study (ongoing).

## 6.2 Knowledge Gaps

Further analysis and empirical investigation are required to clarify several threats and limiting factors:

- Current species distribution: Although many wetlands within the range of the species have been surveyed, others have not. Habitat suitability models and prioritized inventories are required to protect important habitat, to develop specific recovery actions (such as to promote connectivity between populations, to rehabilitate habitat, to identify potential locations for population introductions), and to assess recovery progress.
- Minimum habitat size: What is the minimum habitat size required by Oregon Spotted Frogs that is able to include all three seasonal microhabitats? Does the more northern location of the Canadian populations influence the minimum habitat required?
- Habitat use: Refining our knowledge of the seasonal microhabitats used by Oregon Spotted Frogs at the 4 known occupied locations in Canada? This knowledge will help to assess future reintroduction and restoration initiatives, including restoration efforts for multiple co-occurring wetland species-at-risk.
- Ability to move between habitat patches: The maximum distance that Oregon Spotted Frogs move between habitats is 3 km (Pearl and Hayes 2004) along an aquatic corridor. What are barriers to movement of Oregon Spotted Frogs? What are ways to mitigate potential barriers? The Oregon Spotted Frog requires an aquatic corridor to move between habitat patches. What is the habitat composition between known B.C. populations of Oregon Spotted Frog?
- Captive breeding/introduction: Recently we have started a successful captive breeding program which involves captive adults mating and fertilizing eggs in captivity. This program will be developed and a protocol on captive breeding will be developed as more

research is completed, gaps included but are not limited to issues of tracking provenance, potential disease, age, treatments etc.

- Captive rearing/husbandry: Captive rearing involves rearing of all life stages of Oregon Spotted Frogs. The effectiveness of the captive rearing program in improving survivorship and augmenting populations needs to be evaluated.
- Predation and disease: The level of threat from Bullfrogs and Green Frogs and the necessity for mitigation of these non-native predators is poorly understood. The potential diseases that may affect wild and captive-reared populations in B.C. are poorly known.
- Encroaching vegetation/natural succession: The level of threat to suitable habitat presented by encroaching vegetation, including reed canary grass, is poorly understood. Also, what is the most practical and economically feasible way of controlling unwanted vegetation? Could grazing improve habitat for Oregon Spotted Frog in areas of reed canary grass by breaking up vegetation mats and creating openings (as per Watson *et al.* 2000, 2003) or should reed canary grass be actively managed using mowing, shade, and/or competition with native vegetation?
- Hydrological alteration: The effects of hydrological alteration by beavers or anthropogenic structures and the creation or elimination of Oregon Spotted Frog habitat is poorly understood. The elevated water levels following beaver dam construction or other man-made blockage may eliminate shallow breeding habitat but the retention of water may increase summer foraging habitats and dam structures may provide overwintering habitat. As all the extant Oregon Spotted Frog populations occur in habitats with potentially increasing beaver activity, the interaction between beavers and Oregon Spotted Frog habitat needs to be better understood.
- Impacts of electromagnetic radiation on embryo development: An electrical transmission line will be built in Morris Valley in the next few years, and the transmission line will run directly over the traditional mass oviposition site of the Oregon Spotted Frogs. This breeding site will need to be monitored to assess if electromagnetic radiation from the transmission line affects growth or survival of the Oregon Spotted Frog embryos. Baseline data on embryo survival are currently being collected.
- Climate change: The long-term impact of climate change on the Oregon Spotted Frog is not clear. Changes in rainfall and temperature associated with climate change will potentially have hydrological impacts on this species that depends on permanent shallow wetland habitat.

## 6.3 Recovery Planning Table

**Table 3**. Recovery planning table for Oregon Spotted Frog in British Columbia.

| Target Objective # | Approaches to meet objectives | Threat[a] or concern addressed | Priority[b] |
|---|---|---|---|
| **Habitat Protection** | | | |
| 1, 2, 3 | **Habitat Protection and Management:**<br>• Update and refine survival habitat mapping/polygons (includes occupied locations) annually. Finalize recovery habitat spatial definition/ mapping and provide results to relevant agencies and land users and initiate consultation.<br>• Protect, maintain, improve, expand and/or restore the area, extent and quality of seasonally occupied habitats (e.g. oviposition sites, overwintering sites, and active summer habitat) at occupied and potential recovery sites (see Table 4).<br>• Mitigate direct and indirect threats to Oregon Spotted Frogs and eggs. Address direct and indirect threats to survival and recovery habitat. Minimize or eliminate the threat factors that limit habitat suitability or connectivity. | 1, 2, 3, 4, 5, 6, 7; Knowledge gaps | Essential |
| 4 | **Inventory and monitoring:**<br>• Use surveys at extant locations and radio-telemetry data to develop habitat suitability models to prioritize surveys to find currently unknown populations.<br>• Conduct surveys to further determine range of Oregon Spotted Frog and its presence at potentially suitable habitats.<br>• Incorporate information on land use and landscape features to identify potential threats to habitat. | Knowledge gap<br>Knowledge gap | Essential<br>Essential |
| 1,2,5 | • Monitor habitat quality and respond to signs of degradation as appropriate. | All threats | Essential |
| 1, 4, 5, 6 | • Describe, monitor (for threats and changes), and report on the biophysical, chemical, and microclimate characteristics of seasonal habitats at currently occupied, historical, and newly established sites. | 1, 2, 3, 4, 5, 6, 7 Knowledge gap | Essential |
| **Land Stewardship** | | | |
| 1, 2, 5 | • Work with all levels of government, land managers, and private landowners to inform and encourage best practices and ensure compliance in relation to water quality, hydrology, and land use practices.<br>• Coordinate with the Ministry of Agriculture to implement supporting farming practices and environmental farm plans options to decrease agro-chemical and nutrient pollution into Oregon Spotted Frog aquatic habitats.<br>• Develop, promote and implement Best Management Practices (BMPs) for Oregon Spotted Frogs and watershed management and monitoring plans.<br>• Develop and implement site management plans for | 1, 3, 4, 5, 6, 7, 8<br>2, 9<br>1, 2, 3, 4, 5, 6, 7, 8, 9<br>All threats | Essential<br>Essential<br>Necessary<br>Essential |

| Target Objective # | Approaches to meet objectives | Threat[a] or concern addressed | Priority[b] |
|---|---|---|---|
| | occupied locations addressing site-specific threats and developing site-specific mitigation measures. | Knowledge gaps | |
| | • Work one-to-one with willing landowners/managers to mitigate threats (e.g., fencing of riparian areas to prevent disturbance by people, pets, and livestock; pollution reduction). Where there are willing landowners implement formal conservation covenants or stewardship agreements. | 2, 7, 8, 9 | Essential |
| | • Work with local governments and other agencies to ensure in stream works and ditch maintenance impacts are mitigated, e.g. ditch clearing, and maintenance of culverts, utility pipelines etc.. | 6, 7 | Essential |
| | **Information management and outreach:** | | |
| 1,3,4 | • Maintain a current database and a map delineating survival and recovery habitat that is easily available as a SHAPE file to all levels of government and other land managers to prevent inadvertent impacts to Oregon Spotted Frog habitat. | 1, 2, 3, 4, 5, 6, 7 | Essential |
| | • Build public and stakeholder support for recovery activities by increasing understanding and promoting responsible behaviour toward wetland conservation, and amphibians, among all levels of governments, natural history groups, volunteers, general public, and private landowners | | |
| **Habitat Restoration** | | | |
| | **Restore habitat and connectivity:** | | |
| 1, 2, 3 | • Identify and map priority areas for protection, management, and rehabilitation to promote habitat connectedness throughout range and to allow dispersal of the species. Where possible protect connecting habitat between occupied locations with the goal of restoring natural migration dynamics. Coordinate with regional districts, municipalities, and forest licensees to promote connectedness among riparian habitat through landscape-level planning. | 1, 2, 3, 4, 5, 6, 7 | Essential |
| | • Improve water quality through restoration, monitoring, and increased compliance to regulations. Monitor water quality and quantity (levels) in partnership with agencies to ensure a natural hydrologic state. | 2, 9 | Essential |
| 3 | • Where necessary restore and enhance habitat at priority sites for introductions/reintroductions. Where feasible, initiate habitat restoration including creation of appropriate breeding and other seasonal habitats, restoring hydrological conditions, establishing habitat connectivity among seasonal habitats. Coordinate with stewardship groups and DFO to incorporate habitat for Oregon Spotted Frog into rehabilitation projects. Develop guidelines for habitat rehabilitation and distribute to funding bodies and agencies (e.g., Canadian Department of Fisheries and Oceans, Habitat | All threats, Knowledge gaps, Limiting factor | Essential |

| Target Objective # | Approaches to meet objectives | Threat[a] or concern addressed | Priority[b] |
|---|---|---|---|
| | Conservation Trust Fund) for implementation to avoid conflict with fisheries compensation activities and other works. | | |
| 5, 6 | • Monitor and evaluate newly created and enhanced habitats. | | |
| 2, 3, 5, 6 | • Investigate a multi-species approach when considering enhancing existing habitats and creating new habitats. | All threats, Knowledge gaps | Necessary |
| | **Native habitat maintenance, invasive species and disease management:** | | |
| 1, 2, 3, 5, 6 | • Monitor natural succession and vegetation changes to assess the impact of this natural process on the availability of essential habitat for Oregon Spotted Frogs | 7, 8; Knowledge gaps | Necessary |
| | • Maintain habitat conditions for all life stages. Manage the availability, size and number of oviposition sites through control of encroaching vegetation. Monitor ambient water temperature and habitat conditions. | | |
| | • Control colonization and overgrowth of habitat by reed canary grass where it has compromised oviposition sites. Plant competing native species to mitigate colonization of reed canary grass. | 8 | Necessary |
| 2, 6 | • Assess the relative risk of invasive predators and evaluate predator control and mitigation strategies for managing introduced predator risk. | 8; Knowledge gaps | Necessary |
| | • Monitor and map bullfrog populations and initiate control measures where feasible. Reduce habitat suitability for bullfrogs and where feasible reduce population numbers. Outreach messaging to not move bullfrogs and other non-native species. | | |
| 2, 6 | • Assess and monitor parasite and disease threats. | | |
| **Species and Population Management** | | | |
| | **Protect all life stages and population augmentation:** | | |
| 1, 2, 3 | • Maintain assurance populations from the extant populations to archive genetic pool. | Limiting factors | Essential |
| 2 | • Augment declining populations to stabilize egg mass productivity and restore known/historic populations. | Limiting factors | Essential |
| 3 | • Develop a reintroduction plan that incorporates capacity of husbandry facilities to produce animals for reintroduction, a prioritized list of potential introduction/reintroduction sites, recommendations for effective strategies for establishing self-sustaining populations and cost/resource budget for implementing the plan. | Limiting factors; Knowledge gaps | Essential |
| 3 | • Improve and refine captive head-starting and captive breeding techniques, so that sufficient numbers of animals of various life-stages are available for reintroduction programs. | Limiting factors; Knowledge gaps | Essential |
| 3 | • Consolidate captive rearing and husbandry capacity by establishing agreements with zoos, aquaria, and other rearing institutions. | Limiting factors | Necessary |

| # Target Objective | Approaches to meet objectives | Threat[a] or concern addressed | Priority[b] |
|---|---|---|---|
| 3, 6 | • Conduct genetic analyses to estimate the effective population size, rates of dispersal, and mixing among populations, and levels of inbreeding. This knowledge is essential to determine the genetic composition necessary to establish the most viable Oregon Spotted Frog populations at new and historic sites. | Limiting factors; Knowledge gaps | Necessary |
| | **Introduction/ reintroduction:** | | |
| 3, 5, | • Ensure at least 6 additional viable populations are secured through Oregon Spotted Frog range in B.C. by (1) introducing Oregon Spotted Frogs to priority new suitable sites within the Fraser River Lowlands; and (2) reintroducing Oregon Spotted Frogs to priority historically occupied habitats. | Small populations; Limiting factors | Essential |
| | **Population Monitoring:** | Knowledge gap | Necessary |
| 1, 2, 5, 6 | • Establish population monitoring at all occupied locations to estimate baseline population parameters using capture-mark-recapture, radio-telemetry, and other suitable techniques. Quantify population demographics using sensitivity analyses, population viability, and assessment models. Use the output from these models and field based results to improve sustainability of extant populations and increase probability of establishment of introduced populations. | | |
| 6 | **Research** | Knowledge gaps | Essential |
| | • Evaluate the risk of electromagnetic fields under high tension wires on development and survival of Oregon Spotted Frog embryos. | | |
| | • Monitor the impacts of climate change on Oregon Spotted Frogs | | Necessary |
| **Planning** | | | |
| 5, 6 | • Monitor and report on extant population health and survivorship at all locations annually including monitoring and evaluating all introduced and reintroduced populations. | Knowledge gap | Essential |
| 5, 6 | • Continue to collaborate on habitat assessment and recovery planning and implementation with conservation biologists and recovery teams in Washington and Oregon. | Knowledge gaps | Necessary |
| | • Resource acquisition, secure funding and other resources needed to implement recovery actions. | | |

[a] Threat numbers according to the IUCN-CMP classification (see Table 2 for details).
[b] Essential (urgent and important, needs to start immediately) and Necessary (important but not urgent, action can start in 2–5 years)

## 6.4 Description of the Recovery Planning Table

Recovery implementation should include considerations at the landscape level and incorporate other species at risk values whenever possible. However, because of the unique habitat and biological needs of the Oregon Spotted Frog, it is recommended that a single-species approach

be taken to implement recovery actions in most cases. Where possible, all recovery activities should be conducted as experiments using an adaptive management model to determine their effect and efficacy in reaching the desired recovery objectives and to improve subsequent recovery actions.

### 6.4.1 List under *Wildlife Act*

It is recommended that this species be listed as Endangered under the British Columbia *Wildlife Act.* This would assist in the conservation of the species by heightening the significance and profile of this species.

### 6.4.2 Habitat Protection, Land Stewardship and Restoration

A number of protection and threat mitigation measures will be needed to protect the Oregon Spotted Frog. This may include legislative protection (e.g., Protected Areas, Wildlife Habitat Areas, landscape management plans) and non-legislative protective means (e.g., best management practices, stewardship agreements). Existing legislative tools include the *Wildlife Act* which offers this species protection from direct persecution and mortality and other tools that indirectly offer some protection (e.g., *Fisheries Act*, provincial *Water Act*, *Environmental Protection Act* and Riparian Areas Regulation). For additional information on protection refer to http://www.env.gov.bc.ca/wld/faq.htm#17.

For successful implementation of protection for the Oregon Spotted Frog, there will be a strong need to engage in stewardship on a variety of land tenures, and in particular on private land. Stewardship involves the voluntary cooperation of landowners and managers to protect species at risk and the ecosystems they rely on. This stewardship approach will cover many different kinds of activities, including: following guidelines or best management practices to support species at risk; voluntarily protecting important areas of habitat; conservation covenants on property titles; eco-gifting of property (in whole or in part) to protect certain ecosystems or species at risk; or sale of property for conservation.

Restoration of adjacent habitat next to occupied locations may provide opportunities for the local population to expand and increase its size. Although opportunities may be limited due to conflicting land use activities, this option should be investigated around the locations of all known, newly discovered populations and introduced populations.

### 6.4.3 Species and Population Management

There are four extant populations of Oregon Spotted Frogs in B.C. Of the 4 populations, Maintenance Detachment Aldergrove has the most protected habitat as it is on lands managed by the Department of National Defence, and yet the numbers of Oregon Spotted Frogs at this location have declined with no breeding activity observed since 2007. Given the fluctuating numbers in the other three populations and the inability of habitat protection alone to recover this species, additional recovery measures are required.

The low numbers of individuals at the four extant locations mean that these populations are vulnerable to even moderate increases in mortality rates from introduced predators, disease, and parasites that larger populations may be robust enough to sustain. The collaboration with academic researchers to gain a better understanding of population ecology, demography, genetics of small populations, and impacts of introduced predators, parasites, and disease is recommended.

The Canadian Oregon Spotted Frog Recovery Team recommends the government maintain assurance populations in captivity, and support captive rearing/breeding and re/introduction program to both increase the size of current populations (i.e., augmentation) and to establish populations at new and historic sites within B.C. (i.e., re/introduction).

The locations of potential introductions (to establish new populations), reintroductions (to re-establish populations at historic sites), and population expansions (sites adjacent to existing populations that will expand the extant of that population) have not been finalized; however, the recovery team is currently considering the sites listed in Table 4 for re/introduction though others may be added to the list. Re/introduction is not guaranteed at these sites and will proceed only after appropriate consultation with stakeholders, and finalization of studies to determine their suitability.

**Table 4**. Potential introduction, reintroduction or population expansion sites for Oregon Spotted Frog in B.C. Sites that have an * were used in the threat scoring.

| Site | Description | Land tenure |
|---|---|---|
| **Potential introduction sites – new populations** | | |
| Chaplin Road site * | Chaplin Road site was modified in 2009 and 2010 to increase available wetland habitat. | Provincial Crown land |
| Grace Lake | North East of the Morris Valley site | Provincial Crown land |
| Sasquatch Provincial Park* | Wetlands areas around Deer Lake, Moss lake and Hicks Lake. | Sasquatch Provincial Park |
| Cheam Lake* and Chehalis wetland | Adjacent to the Cheam Wetland – human-made lake with wetland areas West of Cheam Lake | FVRD Park<br>First Nations |
| Opsee | Chilliwack low elevation expansive wetlands overlapping with Pacific Water Shrew habitat. | Provincial Crown – lease to Department of National Defence |
| Agriculture and Agri-Food Canada Research Station / UBC Farm 2 * | Wetlands at the Agriculture Canada lands in Agassiz. The UBC Farm 2 lands occupy a south facing valley that drains into Maria Slough. | Agriculture Canada leased to the University of British Columbia (UBC) Agassiz Research |
| **Potential reintroduction sites – historic populations** | | |
| West Creek Marsh* | Historic site and a protected wetland area. There is a healthy bullfrog population at this site | FVRD Park |

| Site | Description | Land tenure |
|---|---|---|
| Nicomen Slough | Historic site | Private |
| Sumas Prairie – Sumas River and Lakemount Marsh | Potentially suitable habitat when combined with Lakemount Marsh. Possibly the Great Blue Heron Nature Reserve Lagoon and adjacent wetland areas on the Sumas River. | 24% privately owned, 72% provincial Crown land (BCLAND) |
| Campbell River | Historic site - may require rehabilitation | 72% privately owned, 28% municipally owned (GVRD Parks) |
| **Potential population expansion sites** | | |
| Corrections Services Canada Mountain Institution* | A potential wetland restoration site adjacent to Mountain Institution on Mountain Slough. The Mountain Institution is a medium-security federal facility located in Agassiz approximately 800 meters from known existing Mountain Slough Oregon Spotted Frog Population | Correctional Service of Canada |
| Aldergrove – adjacent sites to Maintenance Detachment Aldergrove (DND) | Continue wetland habitat and restorable areas within the occupied site as well as the site across the road by the mushroom farm that has a previous Oregon Spotted Frog occurrence record – Libor 2002 | 100% privately owned |

### 6.4.4 Planning

We recommend that site-specific management plans be developed and implemented for all currently occupied locations. Management plans should focus on protection of populations and habitat from land use activities, and threats specific to each location. Appropriate protection measures and management plans should be put in place for all introduced/reintroduced and newly discovered populations.

A summary of the spring egg mass counts and trapping surveys is prepared each year for all 4 extant populations. Amphibian populations are naturally prone to large fluctuations in size and at small population sizes are prone to local extirpations due to stochasticity. Annual monitoring of populations is essential for determining conservation status of each population.

Oregon Spotted Frogs are declining throughout their global range. Close collaboration with recovery efforts in Oregon and Washington increases technical and scientific capacity for addressing knowledge-gaps and assessing cost-effectiveness of recovery efforts.

# 7 INFORMATION ON HABITAT NEEDED TO MEET RECOVERY GOAL

Threats to Oregon Spotted Frog habitat have been identified and habitat is limiting for this species. To meet the population and distribution goal for Oregon Spotted Frog in B.C., it is necessary to know the specific habitat requirements of this species. In addition, it is necessary to geospatially describe the locations of the habitat on the landscape to mitigate habitat threats and to facilitate the actions for meeting the population and distribution goal.

## 7.1 Description of Survival/Recovery Habitat

In the following sections the habitat needed for survival and recovery of the species is defined (Section 7.1.1), biophysical attributes described (Section 7.1.2) and the procedure to describe both survival and recovery habitat is presented (see Section 7.1.3). Appendix 3 provides maps of survival habitat at four locations where Oregon Spotted Frog is known to occur. However, as these areas of survival habitat are expected to evolve as information on this species increases and additional sites are confirmed and defined, the Canadian Oregon Spotted Frog Recovery Team keeps a working document that is used to formulate/track advice on survival and recovery habitat (Canadian Oregon Spotted Frog Recovery Team unpubl. report). Thus, the procedure to describe survival habitat supersedes the geospatial delineation. Where additional Oregon Spotted Frog populations are discovered or new populations established or re-established, additional areas of survival habitat will be defined.

### 7.1.1 Habitat needed for survival and recovery

It is recommended that survival habitat be defined as the habitat that is necessary for the persistence of the species at occupied sites including any newly discovered locations in the future. Currently that includes the four known occupied locations: Maintenance Detachment Aldergrove, Mountain Slough, Marie Slough and Morris Valley. It is recognized that these four occupied locations alone are insufficient to meet the population and distribution goal for the species "...to maintain and where feasible expand extant Oregon Spotted Frog populations, and establish six or more additional self-sustaining populations in B.C.". Recovery habitat is also required and can be defined as habitat where the species is reintroduced or translocated (introduced), in adjacent areas where the species has expanded its range. The habitat necessary for recovery must also include the habitats found at historical and high-suitability sites needed to expand the extant populations and to meet the population targets of six more occupied locations (10 in total) within 10 years. Thus, survival habitat will apply at any occupied sites and additional identification will be completed for recovery habitat following the same procedure described below once candidate locations or historical sites are confirmed.

### 7.1.2 Biophysical attributes of survival and recovery habitat

Oregon Spotted Frogs have three distinct life-seasons within a year: the breeding/oviposition season, the active summer season, and the overwintering period. Habitat requirements during each of these life stages differ as described in Section 3.3.1 “Habitat and Biological Needs”.

### 7.1.3 Procedure to describe survival and recovery habitat

It is recommended that the description of survival/recovery habitat follow a precautionary approach designed to minimize the chance of loss of Oregon Spotted Frog populations, or degradation or loss of habitat, based on the current understanding of the biology of the species, and potential threats to populations and habitat.

The procedure to describe survival/recovery habitat at the four known Oregon Spotted Frog populations is based on known occurrences for all life stages and the habitat needed to sustain those life stages. Identification of survival/recovery habitat for Oregon Spotted Frog must be based on a scientifically defensible mechanism to delineate and rate habitat suitability during each of the three important life-seasons, and the required area to protect populations and habitat from potential threats. The procedure outlined below has taken into consideration the habitat features or attributes that must be maintained or managed for persistence of the species.

Recommended procedure to describe survival/recovery habitat around known Oregon Spotted Frog populations:

1. Identify locations of all occurrences. Use all occurrence records (including future records) for all life stages (egg, juveniles, adults, larvae/tadpoles) at (a) the 4 occupied locations, (b) any new sites, and (c) all re/introduction sites once occupied[1].

2. Define the area of survival/recovery habitat to include occupied (based on the above occurrence) and suitable aquatic and terrestrial habitat. This includes but is not limited to contiguous riparian habitat and associated watercourses (e.g. water bodies, wetlands, ponds, seasonally inundated areas, wetted areas, seeps, streams and ditches, etc) and essential habitat as identified in section 3.3.1 as well as through the habitat mapping/modelling for the breeding/oviposition season, the active summer season, and the overwintering period within a 3000 meter radius of the above occurrence points.

Pearl and Hayes (2004) and Hayes (pers. comm.) found that Oregon Spotted Frogs can move 3 kilometres. Cushman and Pearl 2007 captured an adult female 2799 m (estimated stream distance) from her original capture location which also suggests 3 km as a maximum distance of travel. Taking a precautionary approach and protecting large areas of habitat is important to increase the chance of preserving potential metapopulations (Semlitsch 2002) and to increase the

[1] Occupied means any current or historical occurrence, of any life stage (egg, juveniles, adults, larvae/tadpoles) of Oregon Spotted Frog whether introduced or naturally occurring.

likelihood of including the variety of habitats required by the Oregon Spotted Frog. This selection should exclude the Fraser River Main stream.

3. Capture suitable connected habitat, by including the entire watercourse that Oregon Spotted Frogs are known to use as part of the area of survival/recovery habitat. Suitable habitats and connecting watercourses/water bodies should be included if they are < 260 m in elevation, and within a 3 km radius of the occurrence records to the extent of the included watersheds. In addition, isolated patches of suitable habitat within 400 m of the habitat described above should also be included.

To increase the likelihood of maintaining suitable hydrological characteristics associated with Oregon Spotted Frog habitat, the entire wetland and associated watercourses should be included in the area. Watercourses, including streams and ditches, are included because they are important travel corridors for Oregon Spotted Frogs (Watson et al. 2003, Pearl and Hayes 2004). Oregon Spotted Frogs also have been reported to use ditches for breeding and over-wintering (Watson et al. 2003, Pearl and Hayes 2004). Including the entire wetland and associated watercourses will increase the probability of including habitat important to the species during all its life-seasons (including winter; there are little data on winter habitat use in B.C.) and across a variety of environmental conditions (e.g. extremely wet or dry years, or long-term changes potentially associated with climate change). Additionally, it will avoid inadvertent impacts to sites that may be occupied or colonized in the future but presently lack sufficient inventory.

The maximum elevation at which habitat was considered suitable for Oregon Spotted Frog was established as 260 m. Pearl and Hayes (2004) examined the relationship between elevation and latitude from known sites in B.C., Washington, Oregon and California (N=73), and suggested that at the northern limit of its range, as in B.C., the Oregon Spotted Frog is unlikely to be discovered above 200 m elevation. However, to increase the probability of including suitable habitat, the 200 m limit was increased by 30%.

The maximum distance that Oregon Spotted Frogs were considered able to move across unsuitable habitat (e.g., without an aquatic connection) to colonize isolated patches of suitable habitat was established as 400 m. Although most Oregon Spotted Frog movements occur along aquatic habitat, individuals occasionally move across nonaquatic habitat (e.g., Watson et al. 2003, M. Hayes, pers. comm., 2011). Hayes suggested that 400 m was likely the maximum distance that Oregon Spotted Frog could move across non-aquatic habitat (M. Hayes, pers. comm. 2011).

4. Include supporting habitat that is essential to ensure water quantity and quality. This may include groundwater flow and discharge areas that flow into the above identified sites, such as intermittent stream channels, springs or water seeps, and contiguous riparian habitat and connecting watercourses that may be > 250 meters and within 3 km of the occurrence records to the extent of the included watersheds.

Oviposition and breeding microhabitats are frequently associated with groundwater up-wellings, which provide relatively stable thermal and water quality conditions. Supporting habitat is an essential component of survival/recovery habitat for Oregon Spotted Frogs. This step requires a

closer assessment of the local hydrological conditions and an understanding of the essential hydrological conditions upslope or upstream that must be maintained in order for the occupied sites to persist.

5. For each of the above selected areas (occupied, connecting, supporting habitats), delineate a 45 m buffer area on either side of the bank above the high water mark[1] of the watercourse (or the top of bank for ditches). This is to be applied around all occupied habitats (procedure 1 and 2), all other suitable habitats in the watershed where it is feasible for the Oregon Spotted Frog to colonize (procedure 3), all types of groundwater flow that may influence the water quantity or quality of the above, where the groundwater flow is identified to its headwaters (procedure 4). For supporting habitat within intact forested areas (procedure 4), a smaller area of 30 meters either side of the bank can be implemented instead of 45 meter if the adjacent landscape remains forested. If the land is converted from forest to any other landuse the original 45 m buffer applies.

This area is essential to buffer the habitat from surrounding landuses. Impermeable surfaces such as roads do not contribute to the size of the area. Where roads or other impermeable features are present within the survival/recovery habitat area, the area is increased by the width of the feature. If currently forested areas are converted to more intensive land uses (e.g. agriculture, urban development, commercial uses such as gravel removal or others), the survival/recovery habitat area should be increased to provide a 45 m area around the wetland and associated stream, ditches, and seeps. To finalize the area of survival/recovery habitat, the wetlands should be surveyed on the ground to establish the high water mark. The area boundary would then be measured outward from the high water mark.

The aquatic nature of Oregon spotted frogs makes them vulnerable to chemicals entering wetland habitat (see threats section). Various research projects have reported that buffer retention can reduce the input of chemicals into waterways. Lowrance and Sheridan (2005) reported that on a 2.5% slope, a 75 m three-zone buffer (grass, managed forest and unmanaged forest) between an agricultural field and a stream reduced nitrate-N by 59%, ammonium-N by 48%, and Total N by 37%. Lowrance et al. (1997) reported that a 50 m managed 3-zone buffer (grass, managed pine forest, and hardwood forest) was effective in removing herbicide residue (atrazine and alachlor) by the time it reached a stream. Thompson et al. (2004) reported that 30-60 m buffers were effective in limiting glyphosate concentrations to low levels compared to levels in wetlands with no buffers.

A meta-analysis of peer-reviewed studies of the effectiveness of riparian buffers in removing nitrogen by Mayer et al. (2007) suggested that buffers >50 m wide were more effective at removal of nitrogen than buffers 0-25 m wide. Based on their analysis they reported that to remove 75% of nitrogen would require a 49 m buffer and to remove 90% would require a 149 m

[1] **"high water mark"** means the visible high water mark of a stream where the presence and action of the water are so common and usual, and so long continued in all ordinary years, as to mark on the soil of the bed of the stream a character distinct from that of its banks, in vegetation, as well as in the nature of the soil itself, and includes the active floodplain. http://www.env.gov.bc.ca/habitat/fish_protection_act/riparian/documents/regulation.pdf assessed October 2011.

buffer (categories had large SE). Removal of nitrogen was influenced by buffer width, water flow (removal from subsurface flow is more efficient than surface flow), and type of vegetation present. To adopt a precautionary approach, and to increase the probability that the habitat critical to the survival of the Oregon spotted frog is maintained and buffered from surrounding land practices, the recommend area of critical habitat in agricultural and urban landscapes is 45 m around wetlands and either side of watercourses adjacent to agricultural/residential habitat, and 30 m either side of supporting watercourses in forested habitat.

## 7.2 Specific Human Activities Likely to Damage Survival/Recovery Habitat

Activities described in Table 5 include those likely to damage survival habitat for Oregon Spotted Frog. But destructive activities are not limited to those listed. Damage would result if part of the survival habitat were degraded, either permanently or temporarily, such that it would not serve its function when used by the species. Damage may result from single or multiple activities at one point in time or from the cumulative effects of one or more activities over time. Most of the identified threats to Oregon Spotted Frog populations in Canada are habitat-related, thus specific threats discussed in Section 4.2 should be assessed at each site and used to determine if an activity is permitted. Where a situation does not clearly fit in with the activities identified in Table 5, but has a potential impact on Oregon Spotted Frog habitat, the proponent is advised to contact the responsible jurisdiction for guidance on the activity.

**Table 5.** Examples of human activities likely to damage survival/recovery habitat for Oregon Spotted Frog.

| Activity | Description |
|---|---|
| Hydrological modifications | Any alteration of watercourses that leads to changes in water quantity and/or in the flow rate and pattern. This includes but is not limited to changes in: water levels (excessive drawdown or sudden increases), ground water (diversion or loss), flow, water quantity (removal or increases), disturbance (e.g. ditch cleaning), or diversion of water (ditching or culverting or relocation). Retaining natural water levels is important for populations of Oregon Spotted Frog, particularly during: the period between oviposition and hatching of tadpoles; over-winter during the coldest period; and in areas that are required to support oviposition, over-wintering, foraging or dispersal. Change in hydrology may result in direct or indirect mortality, loss of recruitment and reduced survivorship. |
| Spray/application of fertilizers or chemicals (including manure or pesticides) to Oregon Spotted Frog habitat, or the area immediately adjacent to it | Oregon Spotted Frogs are sensitive to pollutants and are highly aquatic; thus, activities that cause contaminants to enter the wetland or watercourse could be damaging. Examples include runoff or spray of pesticides or fertilizers into or adjacent to Oregon Spotted Frog habitat, runoff of manure stored adjacent to habitat, or direct input of manure/urine by cattle or livestock. |
| Input of sediment to Oregon Spotted Frog habitat | Sedimentation can directly affect water quality and modify channel structure. The build-up of sediment in the watercourse/wetland or the watercourses that input water/materials to the watercourse/wetland can lead to large runoff events with a resulting sudden influx of pollutants from the surrounding area. Forestry activities, where they include harvesting close to watercourses draining into wetlands, can increase |

| | |
|---|---|
| | sedimentation. In addition, cattle access to watercourses or wetlands can affect bank stability and result in increased sedimentation. Lack of rooted vegetation along the banks of watercourses affects bank stability; this may result from activities such as cattle access, machinery, or herbicide application. |
| Removal or alteration of natural riparian vegetation around watercourses or wetlands | Removal or alteration of natural riparian vegetation around watercourses or wetlands can alter the functioning of the ecosystem. Examples of activities that can disturb natural vegetation include encroachment during or as a result of development or adjacent land use, and forestry activities. Alteration of the natural environment can also be caused by the introduction of exotic species, such as reed canarygrass, which can build up and modify the structure of the environment. |
| Introduction of exotic predators | Introduction of exotic predators and competitors, such as the Bullfrog or Green Frog, can also have a negative impact on the quality of habitat for Oregon Spotted Frog habitat and increased potential for disease introduction. |
| Mining | Mining exposes rock mineral leachate at a higher rate than normal, and the resulting run-off can pollute adjacent habitat. Mining may also alter subsurface water flow, and lead to landslides. |

# 8 PERFORMANCE MEASURES

Evaluation criteria will be developed as the recovery team refines the recovery objectives for the Oregon Spotted Frog. Based on current information, criteria used to evaluate progress towards meeting the recovery goal include:

**Objective 1**

- Occupied locations monitored yearly using spring egg mass counts and capture-mark-recapture of adults and juveniles (ongoing monitoring continuing to at least 2020)
- Stable or increase numbers at each extant population (based on egg mass counts - ongoing monitoring continuing to at least 2020)
- Number of occupied sites increased by 6 by 2021
- Threats mitigated and impacted areas restored at the four occupied locations by 2020
- Refined survival and recovery habitat polygons (ongoing) and no further habitat loss/degradation within those areas, evaluated in 2020
- Improved water quality at impacted sites through site repair and restoration and stable or improving water quality at all sites, evaluated annually continuing to at least 2020
- At least 5 landowners engaged in stewardship actions by 2015 with numbers of engaged citizens increasing through time continuing to at least 2020)

**Objective 2**

- Habitat assessment at each occupied location to assess major threats and barriers to population growth at that location by 2014
- Intervention protocol (to ensure no reproductive loss caused by controllable desiccation or through acute threats) developed and implemented by 2012 with no reproductive loss

(for example, the protocol will outline when, where and how stranded eggs will be relocated or brought in; continuing to 2020)
- At a least two priority sites, restoration techniques implemented (e.g., such as reed canary grass control to improve the quality of oviposition sites or habitat expansion) by 2013 (adaptive management will be ongoing to 2020)
- An assessment of captive rearing/population augmentation efforts to date completed by 2014 and draft protocol for a cost-effective captive rearing program completed by 2014

**Objective 3**
- The number of occupied locations increased from 4 to at minimum 10 locations (including the 4 extant) with a minimum number of breeding adults[1] at each location to sustain a viable population by 2020
- Total population size increased to approximately 2000 or more breeding individuals[2] by 2020
- Husbandry facilities capable of rearing up to 3000 animals at 2 or more institutions by 2020
- Assurance populations at 2 or more institutions by 2015

**Objective 4**
- All suitable wetlands within the range of the Oregon Spotted Frog surveyed (initial surveys to be completed by 2014)

**Objective 5**
- Monitoring of captive-reared and released frogs post-release to estimate survival (ongoing spring and fall surveys continuing to 2020)
- Monitoring of newly introduced frog populations for breeding (ongoing spring surveys continuing to 2020)
- Monitoring of augmented populations for signs of increased breeding activity (increasing trend in number of egg masses) (ongoing spring surveys continuing to 2020)
- Radio-telemetry and habitat assessment conducted at restored sites to assess if Oregon Spotted Frog microhabitat needs have been met by restoration efforts by 2014. An adaptive recovery implementation plan has been prepared using the information above by 2015.
- Oregon Spotted Frog populations monitored using spring egg surveys and capture-mark-recapture studies to assess effectiveness of whether threat mitigation measures (e.g., removal of introduced species and improvement in water quality) ongoing and continuing to at least 2020

[1] Targets for the numbers of breeding adults will vary by site. The recovery team anticipates establishing a minimum population size of 200 breeding adults at each site though carrying capacity may limit achievable number.

[2] Total population size is enumerated using an estimate of breeding individuals. Minimum population sizes will be re-evaluated once a demographic sensitivity analysis is complete, and sizes may vary according to the estimated carrying capacity of each site.

**Objective 6**

- Radio-telemetry studies conducted at occupied locations to better understand Oregon Spotted Frog microhabitat use and threats/risks at seasonal habitats initiated/completed by 2014 and continuing to 2015
- Capture-mark-recapture data gathered at currently extant and future reintroduced populations to construct population matrix models (potential graduate student projects continuing up to 2020)
- Focused research on threat/risk factors that might be constraining recovery of populations (e.g., such as genetic bottlenecking, disease epidemiology, invasive predation pressure, and habitat modification due to invasive species) initiated and ongoing projects as needed
- Research on threat mitigation and restoration techniques completed by 2016. This information used to update best management protocols or guidance documents for habitat measures (e.g., ditch cleaning, the establishment of riparian buffers, or habitat enhancement for co-occurring endangered species such as the Salish Sucker) by 2020 and ongoing as needed
- A well-designed monitoring program in place so that potential effects of climate change can be detected early enough to make mitigation and intervention possible (ongoing continuing to 2020)

# 9 EFFECTS ON OTHER SPECIES

It is unlikely that recovery activities will have any adverse effects on other species at risk. Habitat enhancement and restoration projects that benefit the Oregon Spotted Frog will likely positively benefit other threatened species and species of special concern, such as the Red-legged Frog, American Bittern, Great Blue Heron, Green Heron, the Salish Sucker (*Catostomus catostomus*), and the Pacific Water Shrew (*Sorex bendirii*).

In addition, efforts to enhance and restore wetland function and the habitats occupied by the Oregon Spotted Frog will likely have a positive effect on aquatic plant, invertebrate, and vertebrate populations that occupy or visit the affected wetlands.

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# Appendix 1. Population estimates at occupied sites in British Columbia

Table **A1.** Population estimates at four currently occupied locations in British Columbia, based on egg mass counts. Note that sampling intensity does vary across years.

| Population Year | Total number of egg masses | Number of communal oviposition sites | Estimated number of breeding adults |
|---|---|---|---|
| Maintenance Detachment Aldergrove [a] | | | |
| 1997 | 90 | 4 | 180 |
| 2000 | 29 | 6 | 58 |
| 2001 | 31 | 6 | 62 |
| 2002 | 34 | 7 | 68 |
| 2003[b] | 12 | 5 | 24 |
| 2004 | 10 | 4 | 20 |
| 2005 | 7 | 4 | 14 |
| 2006 | 8 | 6 | 16 |
| 2007 | 0 | 0 | 0 |
| 2008 | 0 | 0 | 0 |
| 2009 | 0 | 0 | 1 adult male observed |
| 2010 | **0** | **0** | 0 |
| Mountain Slough | | | |
| 1997 | 16 | 2 | 32 |
| 2000 | 43 | 4 | 86 |
| 2001[c] | 70 | 12 | 140 |
| 2002[c] | 96 | 7 | 192 |
| 2003 | 54 | 5 | 108 |
| 2004 | 62 | 6 | 124 |
| 2005 | 49 | 8 | 98 |
| 2006 | NA[d] | NA[d] | NA[d] |
| 2007 | 37 | NA[d] | 74 |
| 2008 | 50 | 5 | 100 |
| 2009 | 45 | 8 | 90 |
| 2010 | **52** | **13** | 104 |
| Maria Slough [e] | | | |
| 1997 | 38 | 3 | 76 |
| 2000 | 75 | 3 | 150 |
| 2001 | 71 | 10 | 142 |
| 2002 | 144 | 7 | 288 |
| 2003[f] | 127 | 6 | 254 |
| 2004 | 117 | 5 | 234 |
| 2005 | 125 | 4 | 250 |
| 2006 | 99 | NA[d] | 198 |
| 2007 | 21 | NA[d] | 42 |
| 2008 | 67 | 10 | 134 |
| 2009 | 45 | 10 | 90 |
| 2010 | **67** | **NA**[d] | 134 |
| Morris Valley | | | |
| 2008 | 77 | 15 | 154 |

| Population Year | Total number of egg masses | Number of communal oviposition sites | Estimated number of breeding adults |
|---|---|---|---|
| 2009 | 63 | 5 | 126 |
| 2010 | 39 | 7 | 78 |
| All Four Sites | | | |
| 1997 | 144 | 9 | 288 |
| 2000 | 147 | 13 | 294 |
| 2001 | 172 | 28 | 344 |
| 2002 | 274 | 21 | 548 |
| 2003 | 193 | 15 | 386 |
| 2004 | 189 | 15 | 378 |
| 2005 | 181 | 15 | 362 |
| 2006[g] | 107 | 6 | 214 |
| 2007[g] | 58 | NA[d] | 116 |
| 2008[h] | 194 | 30 | 388 |
| 2009[hi] | 153 | 23 | 306 |
| 2010[h] | 158 | 20[g] | 316 |
| Average | 164 | 17 | 328 |

[a] Release of metamorphic Oregon Spotted Frogs back into Maintenance Detachment Aldergrove (year and number): 2005 (317) and 2006 (423).
[b] Includes a count of one pair observed in amplexus. Egg mass not located.
[c] Incomplete survey due to lack of permission to access private properties.
[d] Data not available.
[e] Release of metamorphic Oregon Spotted Frogs back into Maria Slough (year and number): 2002 (354); 2003 (381); 2004 (836); 2007 (846); and 2008 (1012).
[f] Assume female frogs lay one annual clutch of eggs, and a 1:1 sex ratio.
[g] Data not available from at least 1 site, so numbers are minimums.
[h] Totals include data from the new (fourth) population (Morris Valley) discovered in 2008.
[i] One site with multiple single egg masses that had moved due to water fluctuations.

# Appendix 2. Site-specific threat assessment

**Table A2.** Threats to Oregon Spotted Frog populations in B.C. by occupied site (expanded from Hayes 1997).

| Threats/Limiting factor | Site [a] | Relative impacts [b] | Spatial/temporal nature [c] | Certainty [d] |
|---|---|---|---|---|
| 1. Habitat losses caused by human activities | MDA | C | W - C | C |
| | MTS | C | W - H | C |
| | MS | C | L - H | C |
| | MO | P | W - C | C |
| 2. Hydrological alteration | MDA | C | W - C | P |
| | MTS | P | W - H | C |
| | MS | P | W - H | C |
| | MO | C | W - H | C |
| 3. Habitat losses caused by natural succession | MDA | P | W - C | C |
| | MTS | C | W - C | C |
| | MS | C | W - C | C |
| | MO | C | W - C | P |
| 4. Insufficient habitat size | MDA | N (18 ha) | W - E | P |
| | MTS | N (20 ha) | W - E | P |
| | MS | N (16 ha) | W - E | P |
| | MO | N | W - E | P |
| 5. Exotic predators[e] | MDA | P (Bf) | W - C | C |
| | MTS | C (Gf) | W - C | P |
| | MS | C (Bf, Gf) | W - C | P |
| | MO | U | L | C |
| 6. Exotic, invasive vegetation[f] | MDA | P | W - C | C |
| | MTS | P | W - C | C |
| | MS | P | W - C | C |
| | MO | N | L | C |
| 7. Genetic isolation due to habitat fragmentation (distance in km to nearest occupied site) | MDA | C | W (50) | P |
| | MTS | C | W (7) | P |
| | MS | C | W (8) | P |
| | MO | C | W (7) | P |
| 8. Risk of drought and climate change | MDA | C | W - E | C |
| | MTS | C | W - E | P |
| | MS | C | W - E | P |
| | MO | C | W - E | P |
| 9. Water quality | MDA | U | W - E | S |
| | MTS | C | W - E | C |
| | MS | C | W - E | C |
| | MO | U | W - E | S |
| 10. Disease | MDA | U | W - E | C |
| | MTS | U | W - E | S |
| | MS | U | W - E | S |
| | MO | U | W - E | S |
| 11. Low population numbers/small populations | MDA | P | W - C | C |
| | MTS | C | W - H | C |
| | MS | C | L - H | C |
| | MO | P | W - C | C |

[a] Site: MDA = Maintenance Detachment Aldergrove; MTS = Mountain Slough; MS = Maria Slough; MO = Morris.
[b] Relative Impact: P = Predominant; C = Contributing; U = Unknown; N = None.
[c] Spatial/Temporal Nature: W = Widespread; L = Localized; C = Chronic; E = Episodic; H = Historical.
[d] Certainty: C = confirmed based on empirical data; P = Probable; S = Speculative.
[e] Exotic Predators: Bf = Bullfrog; Gf = Green Frog.
[f] Exotic, Invasive Vegetation: reed canary grass.

# Appendix 3. Maps of survival habitat for Oregon Spotted Frog in B.C.


**Figure A 1. Area of survival habitat (yellow shadow) for Oregon Spotted Frog around Morris Valley, B.C.**


**Figure A 2. Area of survival habitat (yellow shadow) for Oregon Spotted Frog around the wetland at Maria Slough, B.C.**

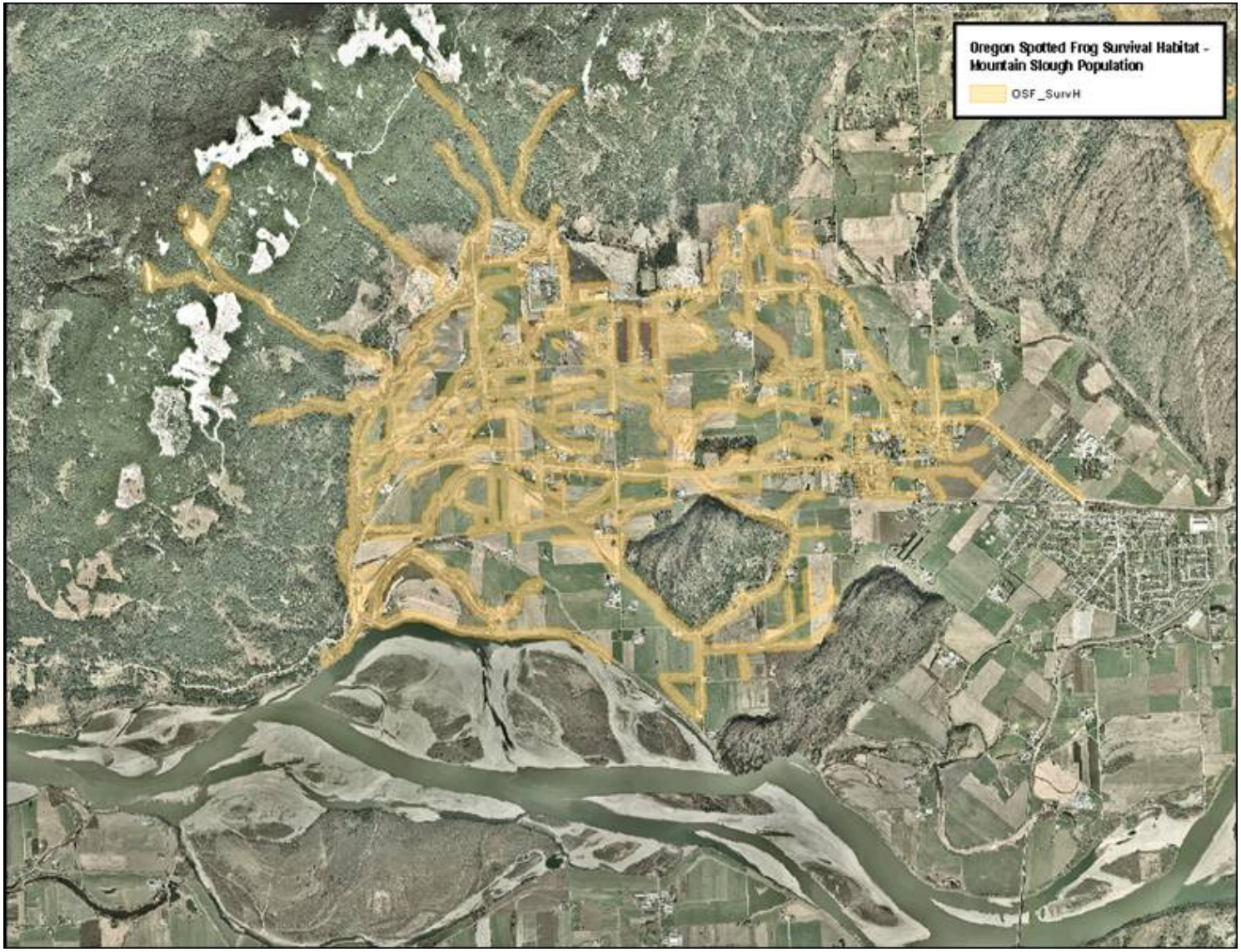


**Figure A 3. Area of survival habitat (yellow shadow) for Oregon Spotted Frog around Mountain Slough, B.C.**

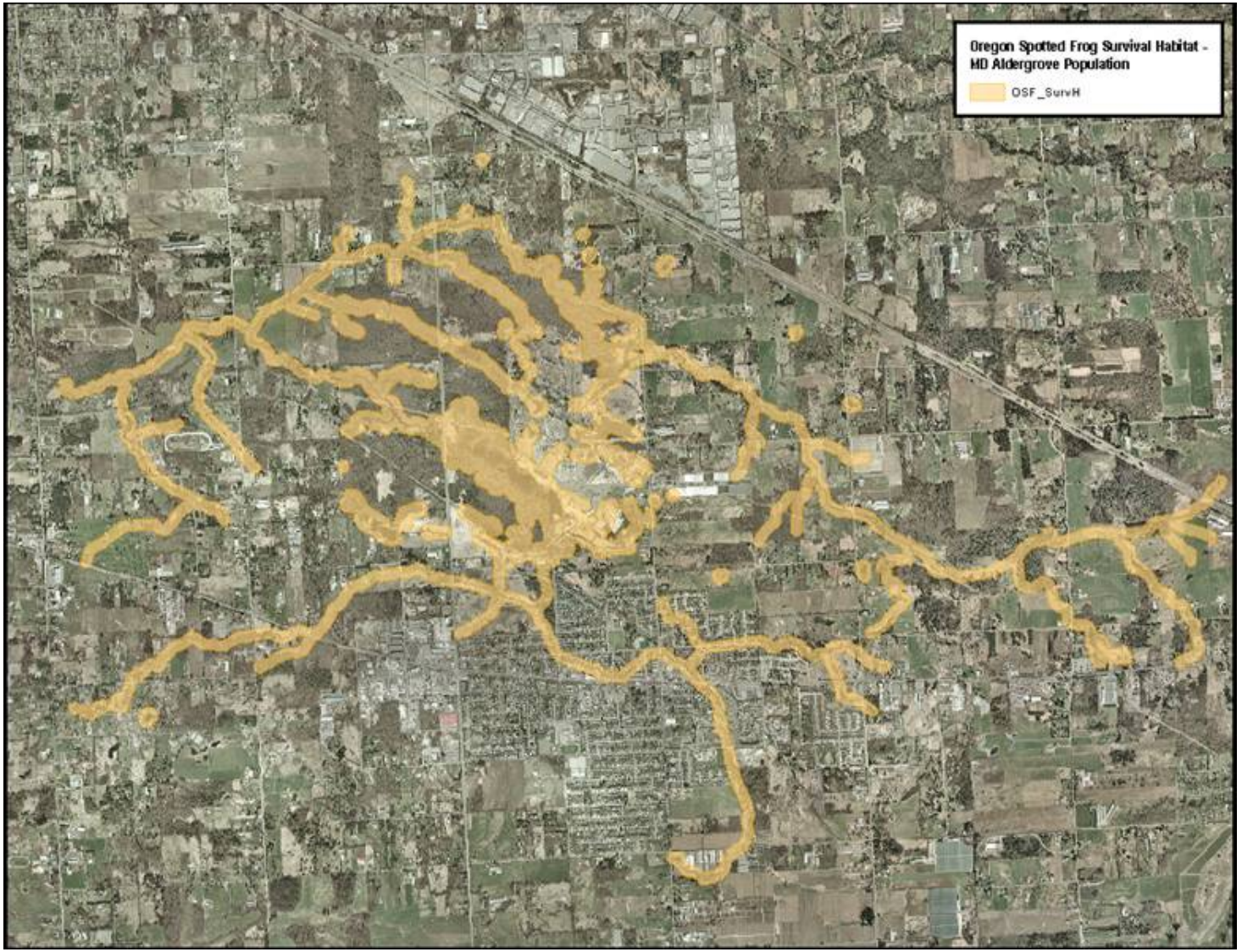


**Figure A 4. Area of survival habitat (yellow shadow) for Oregon Spotted Frog around the wetland at Maintenance Detachment Aldergrove, B.C.**