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

Recovery Strategy for the Oregon Forestsnail (*Allogona townsendiana*) in Canada

Oregon Forestsnail

2016

Government of Canada
Gouvernement du Canada
Canada

Recommended citation:

Environment Canada. 2016. Recovery Strategy for the Oregon Forestsnail (*Allogona townsendiana*) in Canada. *Species at Risk Act* Recovery Strategy Series. Environment Canada, Ottawa. 23 pp. + Annex.

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

Cover illustration: Jennifer Heron

Également disponible en français sous le titre
« Programme de rétablissement de l'escargot-forestier de Townsend (*Allogona townsendiana*) au Canada »

ISBN 978-0-660-04582-5
Catalogue no. En3-4/231-2016E-PDF

[1] http://www.registrelep-sararegistry.gc.ca

RECOVERY STRATEGY FOR THE OREGON FORESTSNAIL (*Allogona townsendiana*) IN CANADA

2016

Under the Accord for the Protection of Species at Risk (1996), the federal, provincial, and territorial governments agreed to work together on legislation, programs, and policies to protect wildlife species at risk throughout Canada.

In the spirit of cooperation of the Accord, the Government of British Columbia has given permission to the Government of Canada to adopt the "Recovery Plan for Oregon Forestsnail (*Allogona townsendiana*) in British Columbia" (Part 2) under Section 44 of the *Species at Risk Act.* Environment Canada has included an addition which completes the SARA requirements for this recovery strategy.

The federal Recovery Strategy for the Oregon Forestsnail (*Allogona townsendiana*) in Canada consists of two parts:

Part 1 – Federal Addition to the "Recovery Plan for Oregon Forestsnail (*Allogona townsendiana*) in British Columbia", prepared by Environment Canada.

Part 2 – "Recovery Plan for Oregon Forestsnail (*Allogona townsendiana*) in British Columbia", prepared by the Oregon Forestsnail Recovery Team for the British Columbia Ministry of Environment.

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PART 1 - Federal Addition to the "Recovery Plan for Oregon Forestsnail (*Allogona townsendiana*) in British Columbia", prepared by Environment Canada

PREFACE

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996)[2] agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of recovery strategies for listed Extirpated, Endangered, and Threatened species and are required to report on progress within five years.

The Minister of the Environment is the competent minister under SARA for the Oregon Forestsnail and has prepared the federal component of this recovery strategy (Part 1), as per section 37 of SARA. To the extent possible, it has been prepared in cooperation with British Columbia Ministry of Environment, the Department of National Defence, and the British Columbia Conservation Data Centre. SARA section 44 allows the Minister to adopt all or part of an existing plan for the species if it meets the requirements under SARA for content (sub-sections 41(1) or (2)). The attached provincial recovery plan (Part 2 of this document) for the species was provided as science advice to the jurisdictions responsible for managing the species in British Columbia. Environment Canada has prepared this federal addition to meet the requirements of SARA.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Environment Canada, or any other jurisdiction, alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of the Oregon Forestsnail and Canadian society as a whole.

This recovery strategy will be followed by one or more action plans that will provide information on recovery measures to be taken by Environment Canada and other jurisdictions and/or organizations involved in the conservation of the species. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

The recovery strategy sets the strategic direction to arrest or reverse the decline of the species, including identification of critical habitat to the extent possible. It provides all Canadians with information to help take action on species conservation. When the recovery strategy identifies critical habitat, there may be future regulatory implications, depending on where the critical habitat is identified. SARA requires that critical habitat identified within federal protected areas be described in the *Canada Gazette*, after which prohibitions against its destruction will apply. For critical habitat located on federal lands outside of federal protected areas, the Minister of the Environment must either make a statement on existing legal protection or make an order so that the prohibition against destruction of critical habitat applies. For critical habitat located on non-federal lands, if the Minister of the Environment forms the opinion that any portion of critical habitat is not protected by provisions in or measures under SARA or other Acts of Parliament, and

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

not effectively protected by the laws of the province or territory, SARA requires that the Minister recommend that the Governor in Council make an order to extend the prohibition against destruction of critical habitat to that portion. The discretion to protect critical habitat on non-federal lands that is not otherwise protected rests with the Governor in Council.

ADDITIONS AND MODIFICATIONS TO THE ADOPTED DOCUMENT

The following sections have been included to address specific requirements of SARA that are either not addressed in the "Recovery Plan for Oregon Forestsnail (*Allogona townsendiana*) in British Columbia" (see Part 2 of this document, referred to hereafter as the "provincial recovery plan"), or that need more detailed comment. In some cases, these sections may also include updated information or modifications to the provincial recovery plan for adoption by Environment Canada.

1. Species Status Information

This section augments section "Species Status Information" (section 2) in the provincial recovery plan.

Legal status: SARA Schedule 1 (Endangered) (2005)

Based on recent and historic records combined, the global range extent is estimated at 135,000 km^2. The extent of occurrence for B.C. is estimated to be 3313 km^2 (including the unsuitable Strait of Georgia between Vancouver Island and the lower Fraser Valley). Although the Canadian population in the Fraser Valley only covers a small proportion of the global range, species experts predict that 10-20% of the global population of Oregon Forestsnail could be in Canada (J. Heron, B.C. Ministry of Environment, pers. comm. (2012).

2. Population and Distribution Objectives

This section replaces "Population and Distribution Goal" (section 5.1) in the provincial recovery plan. Environment Canada has identified the following Population and Distribution Objective for Oregon Forestsnail:

> *The population and distribution objective is to maintain the current population throughout the species' natural range and distribution in British Columbia.*

Rationale:
The following statement augments "Rationale for the Population and Distribution Goal" (section 5.2) from the provincial recovery plan. The population and distribution objective includes currently occupied known and unknown natural occurrences of Oregon Forestsnail; it does not extend to sites established through snail salvage and translocation.

3. Approaches to Meet Objectives

3.1 Actions Already Completed or Underway

The following text replaces the final paragraph in "Actions Already Completed or Underway" (section 6.1) in the provincial recovery plan:

There are ongoing surveys and management for species at risk, including Oregon Forestsnail, at Area Support Unit (ASU) Chilliwack (Department of National Defence; A. Manweiler, pers. comm., 2011).

4. Critical Habitat

This section replaces "Information on Habitat Needed to Meet Recovery Goal" (section 7) in the provincial recovery plan.

Section 41(1)(c) of SARA requires that recovery strategies include an identification of the species' critical habitat, to the extent possible, as well as examples of activities that are likely to result in its destruction.

4.1 Identification of the Species' Critical Habitat

This section replaces "Description of Survival/Recovery Habitat" (section 7.1) in the provincial recovery plan.

Critical habitat can only be partially identified at this time. A schedule of studies (section 3.2) has been developed to provide the information necessary to complete the identification of critical habitat that will be sufficient to meet the population and distribution objective. The identification of critical habitat will be updated when the information becomes available, either in a revised recovery strategy or action plan(s).

Critical habitat for Oregon Forestsnail is identified based on known extant and historical occurrences surrounded by an area with a radius equivalent to the maximum known home range/displacement distance for the species, 32.2 m (Edworthy et al. 2012). Though Oregon Forestsnail can be found in edge habitats, the species requires habitat features provided by interior forests (or their functional equivalents) to complete their life cycle. As such, a 50 m Critical Function Zone is also added to maintain minimum constituent microhabitat properties where the snails are found (based on average edge effects distances in coastal forests (Kremsater and Bunnell 1999)). For areas where Terrestrial Ecosystem Mapping (TEM) is available (Blackwell and Associates 2003; Durand 2010; Madrone Environmental Services Ltd. 2008, 2006; Metro Vancouver, unpublished data;), the critical habitat also includes the TEM polygons intersecting the occurrence. The TEM polygon must meet or exceed the minimum area requirement described above, and contain at least one ecosystem type capable of providing the biophysical attributes of critical habitat.

The areas containing critical habitat for Oregon Forestsnail, totaling 1402 ha, are presented in Appendix 1 Figures 1-12. Within the mapped areas, locations that do not possess the biophysical attributes listed below are not critical habitat.

4.1.1 Biophysical attributes of critical habitat

In general, Oregon Forestsnail habitat is low elevation (<360 m above sea level) and has a site context that promotes persistent high moisture. This can include ravines, gullies and depressions with both permanent and ephemeral watercourses; the edges of streams, wetlands, seasonally flooded areas or wet lowlands; moist forest interfaces (including adjacent edge habitats); and moist, densely-vegetated meadows (Oregon Forestsnail Recovery Team 2012). Within these habitats, specific features must be present to support a number of critical functions, including overall maintenance of the moist microclimate, as well as provision of cover; aestivation, nesting, mating, and oviposition substrate; and forage. These critical features include:

- intact deciduous and/or mixed wood and/or dense shrub or herbaceous canopy, to maintain the moist microclimate;
- patches of Stinging Nettle (*Urtica dioica*), to support feeding, mating, oviposition, and healthy shell growth (Oregon Forestsnail Recovery Team 2012; B.C. Conservation Data Centre 2014; Edworthy et al. 2012; Steensma et al. 2009);
- dense understory vegetation, to provide cover and maintain moisture; and
- coarse woody debris and leaf litter, to provide cover and substrate for aestivation and nesting.

4.2 Schedule of Studies to Identify Critical Habitat

This section replaces the “Studies Needed to Describe Survival/Recovery Habitat” (section 7.2) in the provincial recovery plan.

The purpose of the schedule of studies is to outline the studies required to identify the critical habitat necessary to meet the population and distribution objectives for the species.

Table 1 outlines the research required to identify additional critical habitat needed to meet the population and distribution objective.

Table 1. Schedule of studies required to complete critical habitat identification for Oregon Forestsnail.

Description of activity	Outcome/rationale	Timeline
Conduct habitat assessments at known Oregon Forestsnail sites (e.g., coarse woody debris, moisture, soil attributes, plant species composition, etc.).	Data collected in known Oregon Forestsnail habitats will facilitate more accurate identification of key habitat features that predict Oregon Forestsnail presence, and support the development of a habitat suitability model to identify where additional populations/supporting habitat are located.	2016 - 2018
Conduct mark-recapture studies on Oregon Forestsnail.	A better understanding of snail home range, dispersal, source/sink habitat dynamics, etc. will facilitate more accurate estimates of the amount of habitat (in a patch) required for snail survival.	2016 - 2018
Develop habitat suitability model from data collected in habitat assessments (above).	An accurate habitat suitability model will support identification of critical habitat for the remainder of the Canadian population.	2016 - 2018
Survey candidate sites identified as Oregon Forestsnail habitat by the habitat suitability model.	Additional critical habitat identified.	2017 - 2018
Spatially define habitat polygons at all newly identified Oregon Forestsnail sites (identified through surveys and habitat suitability modelling) using established mapping techniques, plant community classification, coarse woody debris classification guidelines, information from mark–recapture studies, and other existing resources for describing habitat attributes.	This will complete the critical habitat identification.	2016 - 2018

4.3 Activities Likely to Result in the Destruction of Critical Habitat

This section replaces the “Specific Human Activities Likely to Damage Survival/Recovery Habitat” (section 7.3) in the provincial recovery plan.

Understanding what constitutes destruction of critical habitat is necessary for the protection and management of critical habitat. Destruction is determined on a case by case basis. Destruction would result if part of the critical habitat were degraded, either permanently or temporarily, such that it would not serve its function when needed by the

species. Destruction may result from a single or multiple activities at one point in time or from the cumulative effects of one or more activities over time.

Activities described in Table 2 include those likely to cause destruction of critical habitat for Oregon Forestsnail; destructive activities are not limited to those listed. Where a situation does not clearly fit in with the activities identified in Table 2, but has a potential impact on riparian habitat within identified critical habitat and/or water quality associated with waterways or wetlands that have a direct influence on identified critical habitat, the proponent should contact Environment Canada – Canadian Wildlife Service, Pacific and Yukon Region, for guidance on the activity.

Table 2. Examples of activities likely to result in destruction of critical habitat for Oregon Forestsnail.

Description of activity	Description of how activity would destroy critical habitat
Activities that change the hydrology of a site. *Examples: Urban and commercial land development; land clearing; trail building.*	Changes to hydrology can alter the plant composition and moisture levels at a site, resulting in loss of all of the critical functions (cover, nesting/aestivation/mating/oviposition substrate, and forage).
Excavating, contaminating, or compacting soil. *Examples: Recreational activities such as mountain biking and all-terrain vehicle use within occupied habitats, excavating, herbicide application; trail building.*	Significant alterations to the soil can result in loss of suitable substrate for nesting and aestivation. It can also compromise growing conditions for preferred host plants, resulting in loss of mating and oviposition substrate and forage. Compaction/excavation can also increase the potential for flooding or drying of the nest site.
Removal of the tree/shrub/high forb canopy. *Examples: Forest clearing, trail or road maintenance/construction.*	Removal of the canopy results in drying of the microclimate, altering the moisture regime required for maintenance of an Oregon Forestsnail population. It can also result in long term loss of coarse woody debris (aestivation and nesting substrate).
Removal of the understory. *Examples: vegetation management activities including herbicide and other chemical applications, mowing, pruning, and brush burning.*	Removal of the understory leads to desiccation and/or reduced humidity at the site, altering the moisture regime required for maintenance of an Oregon Forestsnail population. It also eliminates the critical cover function. Removal of preferred host plants (e.g., Stinging Nettle) results in loss of mating and oviposition substrate and forage.

Description of activity	Description of how activity would destroy critical habitat
Removal of coarse woody debris. *Examples: Hauling away or removing coarse woody debris; cutting downed wood into pieces; removing bark, or otherwise destroying coarse woody debris.*	Removal of coarse woody debris results in loss of suitable substrate for nesting and aestivation and has the potential to reduce microsite moisture.
Introduction of non-native plants into Oregon Forestsnail habitat. *Examples: planting invasive ornamental species; dumping unwanted compost or vegetation.*	Some invasive plants can alter the understory moisture regime, potentially eliminating the moist conditions required for maintenance of an Oregon Forestsnail population. If they replace preferred host plants (e.g., Stinging Nettle), they may also cause loss of mating and oviposition substrate and forage.

5. Statement on Action Plans

One or more action plans will be posted on the Species at Risk Public Registry by 2021.

6. Effects on the Environment and Other Species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*[3]. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below in this statement.

The following augments "Effects on Other Species" (section 9) in the provincial recovery plan:

Habitat requirements of Oregon Forestsnail overlap those of other SARA-listed species that occur in small streams adjacent to riparian/forest/edge Oregon Forestsnail habitat, or in the same moist forest habitat type as Oregon Forestsnail. These species include Pacific Water Shrew (*Sorex bendirii)*, Salish Sucker (*Catostomus catostomus* ssp), Nooksack Dace (*Rhinichthys cataractae* ssp.), Oregon Spotted Frog (*Rana pretiosa*), Coastal Giant Salamander (*Dicamptodon tenebrosus*), Coastal Tailed Frog (*Ascaphus truei*), Tall Bugbane (*Cimicifuga elata*), Streambank Lupine (*Lupinus rivularis*), and Phantom

[3] http://www.ceaa.gc.ca/default.asp?lang=En&n=B3186435-1

Orchid (*Cephalanthera austiniae*). As threats to these species are similar to the threats for Oregon Forestsnail (e.g., habitat loss, fragmentation, and degradation), recovery actions for all of these species are likely to be mutually beneficial.

7. References

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Durand, R. 2010. *City of Abbotsford Sumas Mountain Sensitive Ecosystems Inventory*. Prepared for the City of Abbotsford, Abbotsford, BC. 86 pp.

Edworthy, A., K. Steensma, H. Zandberg, and P. Lilley. 2012. Dispersal, home range size and habitat use of an endangered land snail, the Oregon Forestsnail (*Allogonal townsendiana*). Can. J. Zool. 90(7):875–884.

Kremsater, L. L. and F.L. Bunnell. 1999. Edges: Theory, evidence, and implications to management of western forests. Pp. 117-153 in J. A. Rochelle, L. A. Lehmann and J. Wisniewski (editors.) *Forest Fragmentation: Wildlife and Management Implications*. Brill, Leiden, Netherlands.

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Steensma, K.M.M., L.P. Lilley, and H.M. Zandberg. 2009. Life history and habitat requirements of the Oregon Forestsnail, *Allogona townsendiana* (Mollusca, Gastropoda, Pulmonata, Polygyridae), in a British Columbia population. Invert. Biol. 128:232–242.

Appendix 1. Maps of Critical Habitat for Oregon Forestsnail

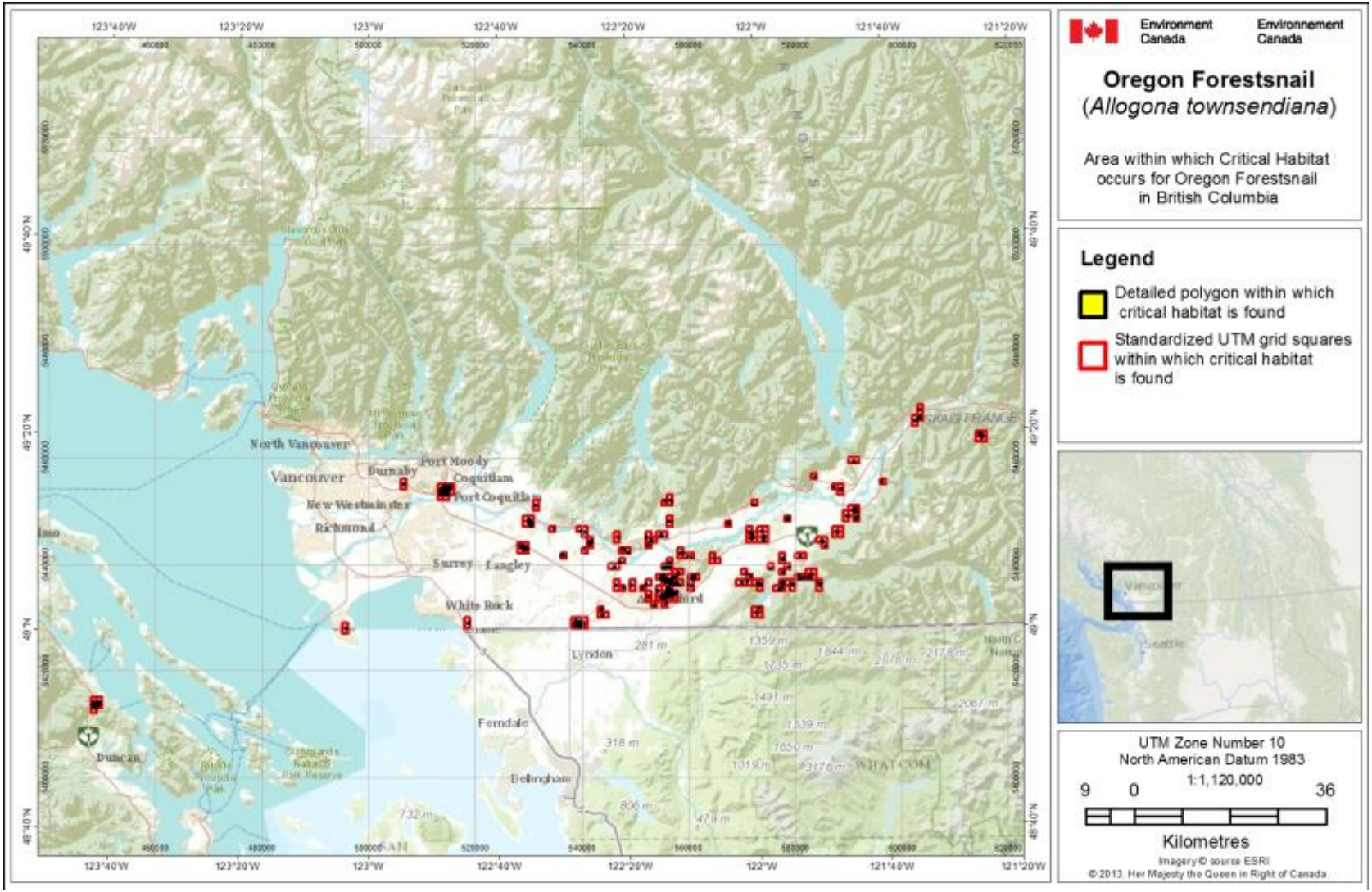

Figure 1. Area within which critical habitat for Oregon Forestsnail occurs in B.C. shown using 1 km standardized UTM grid squares (red outline).

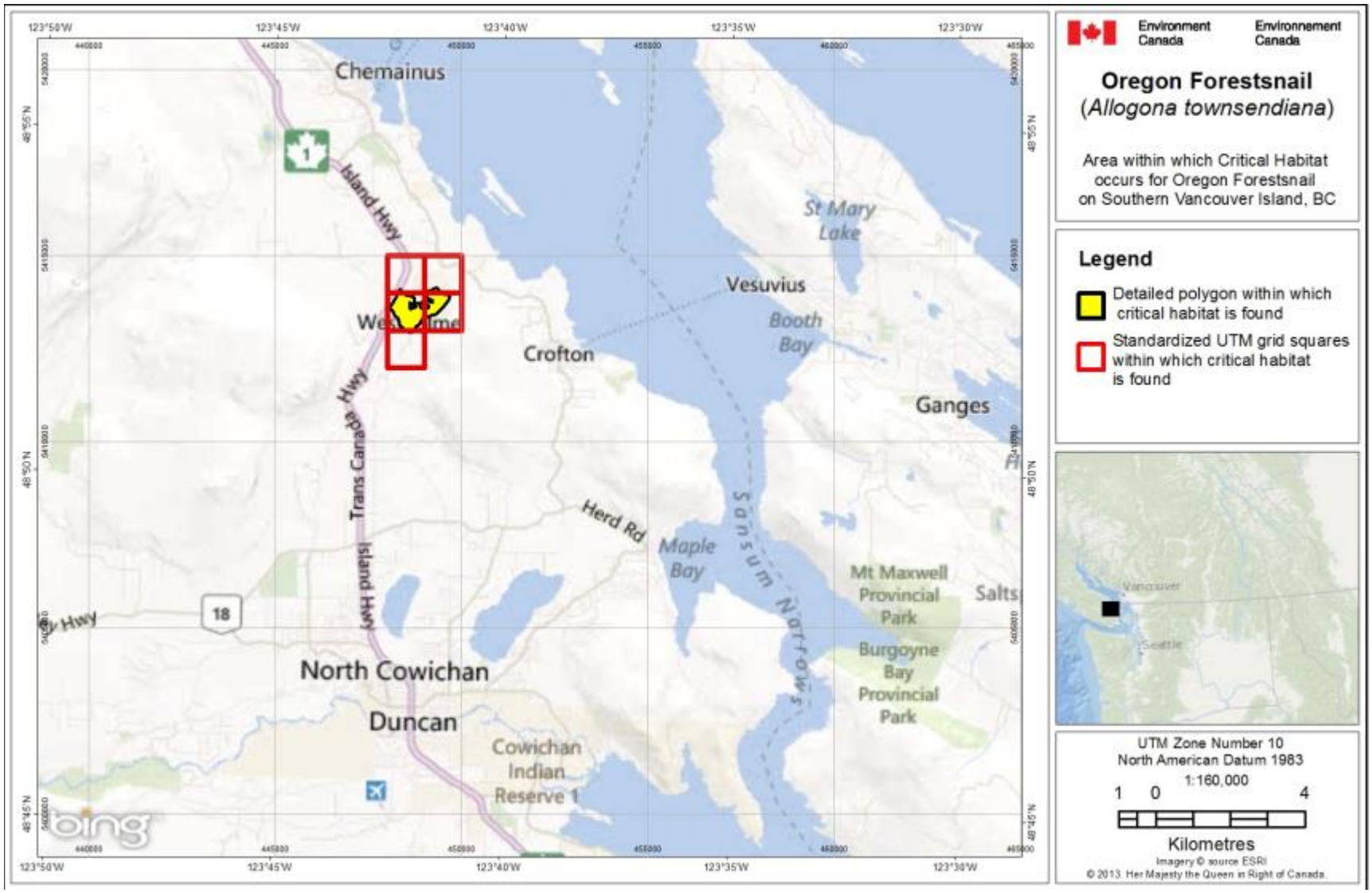

Figure 2. Area within which critical habitat for Oregon Forestsnail occurs on southern Vancouver Island, B.C.

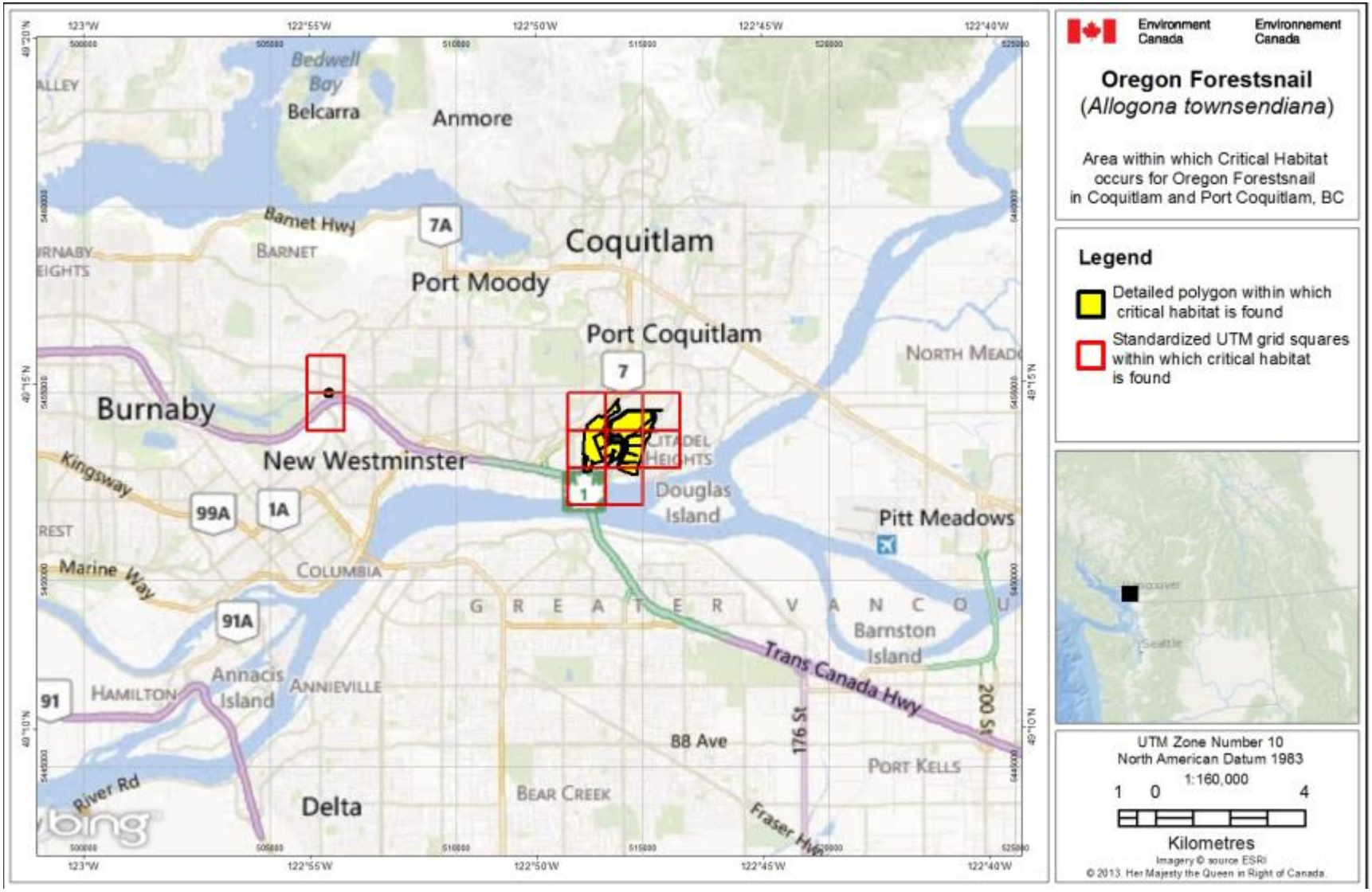

Figure 3. Area within which critical habitat for Oregon Forestsnail occurs in Coquitlam and Port Coquitlam, B.C.

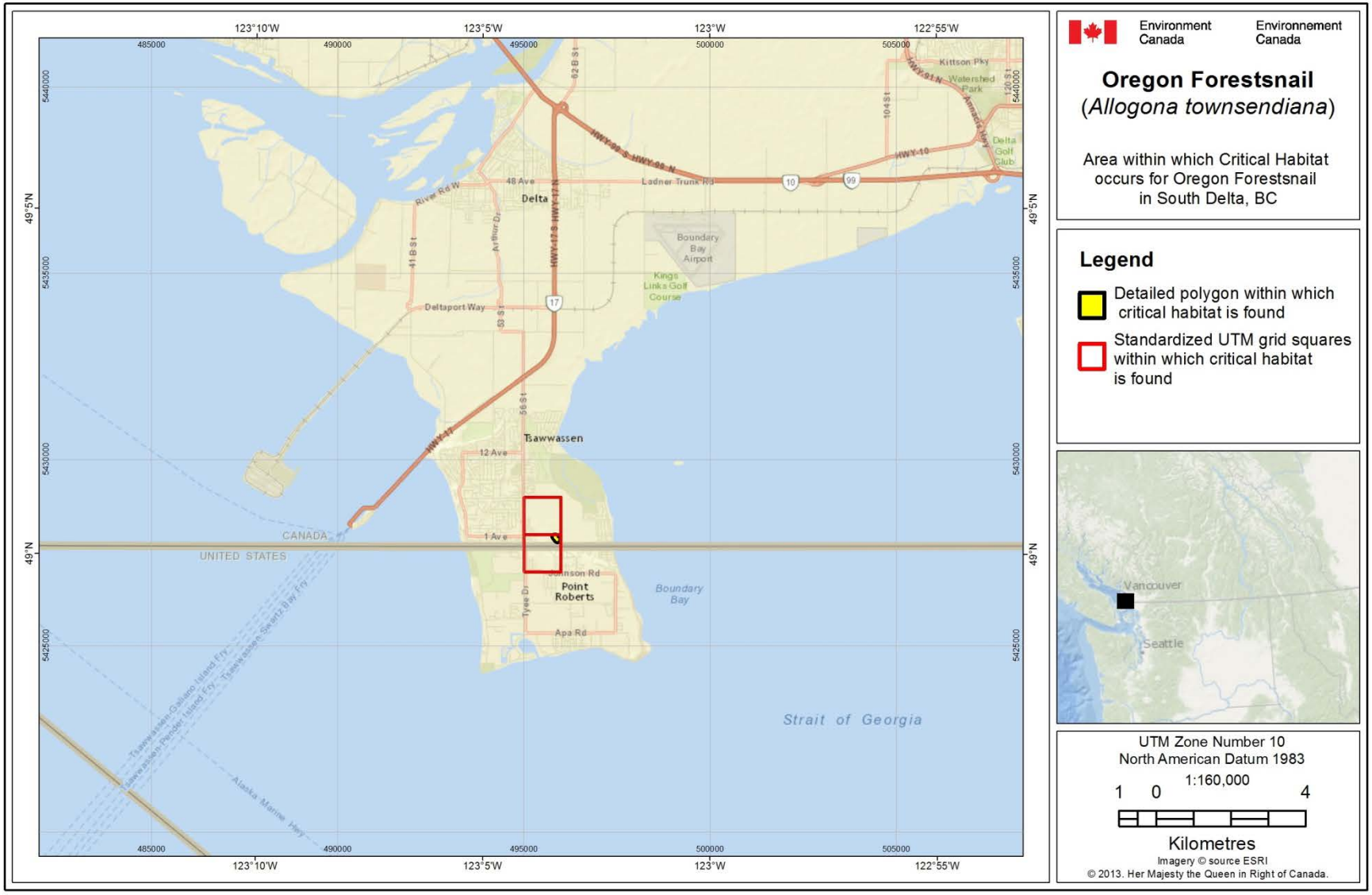

Figure 4. Area within which critical habitat for Oregon Forestsnail occurs in South Delta, B.C.

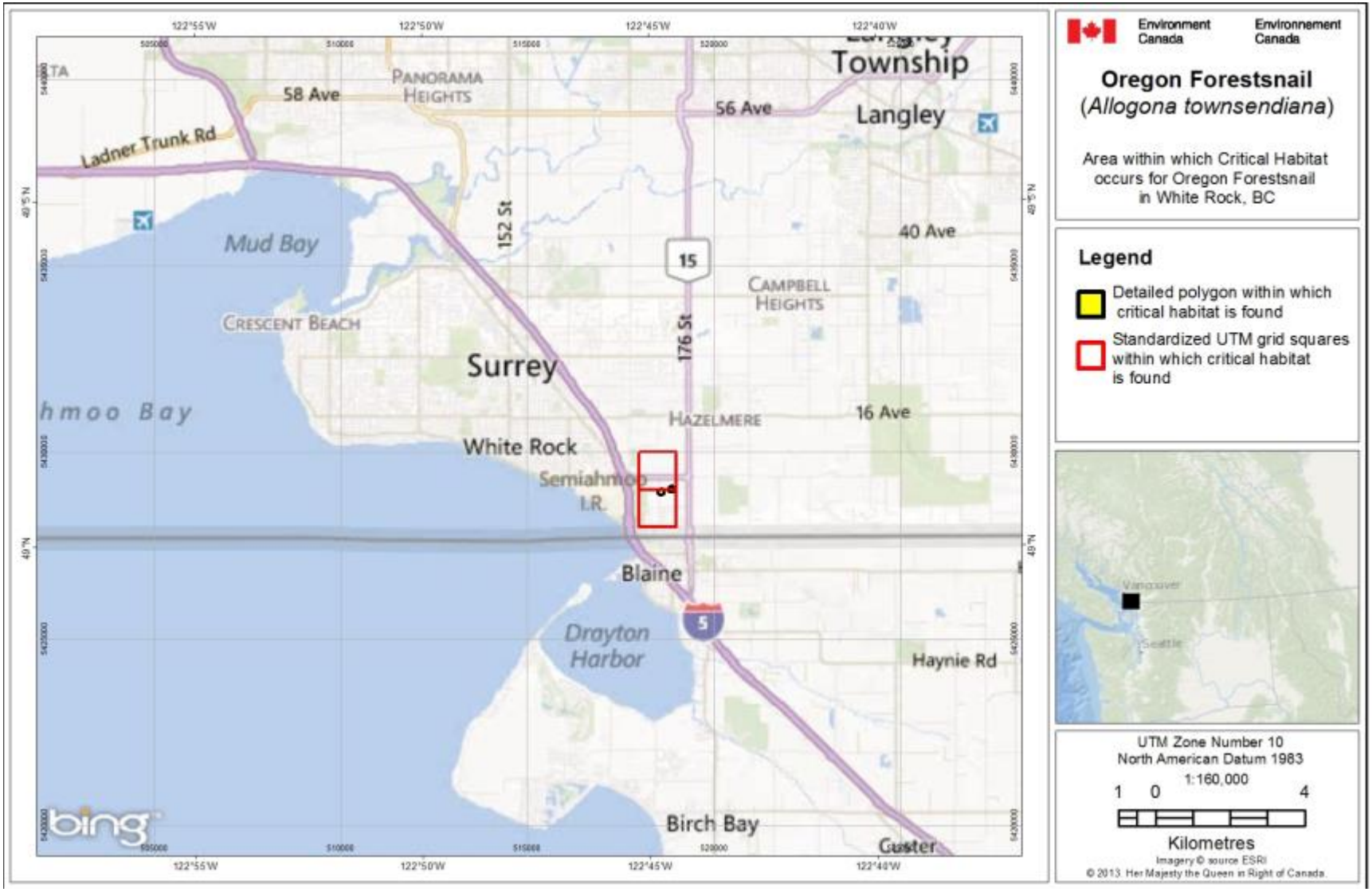

Figure 5. Area within which critical habitat for Oregon Forestsnail occurs in White Rock, B.C.

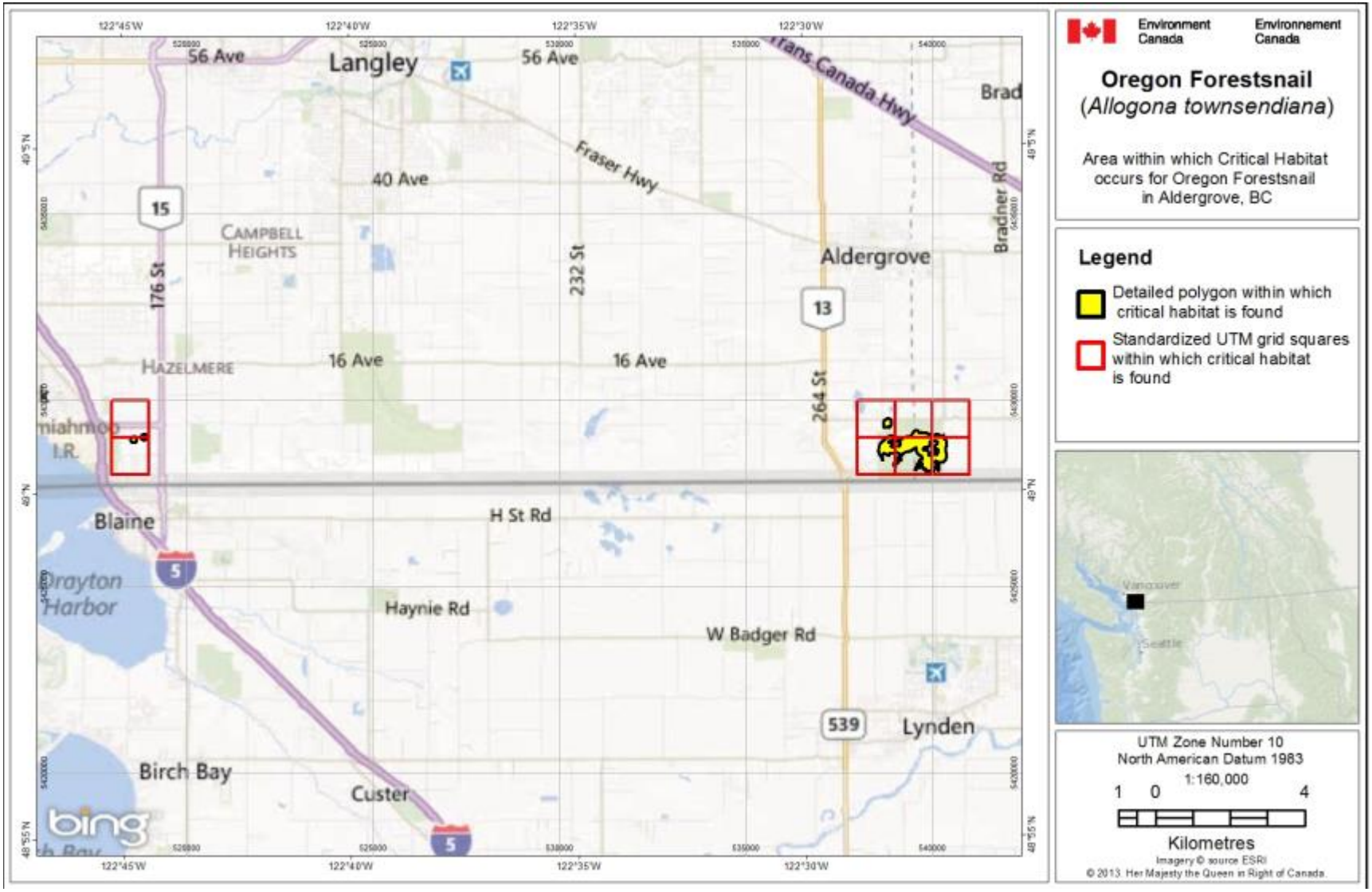

Figure 6. Area within which critical habitat for Oregon Forestsnail occurs in Aldergrove, B.C.

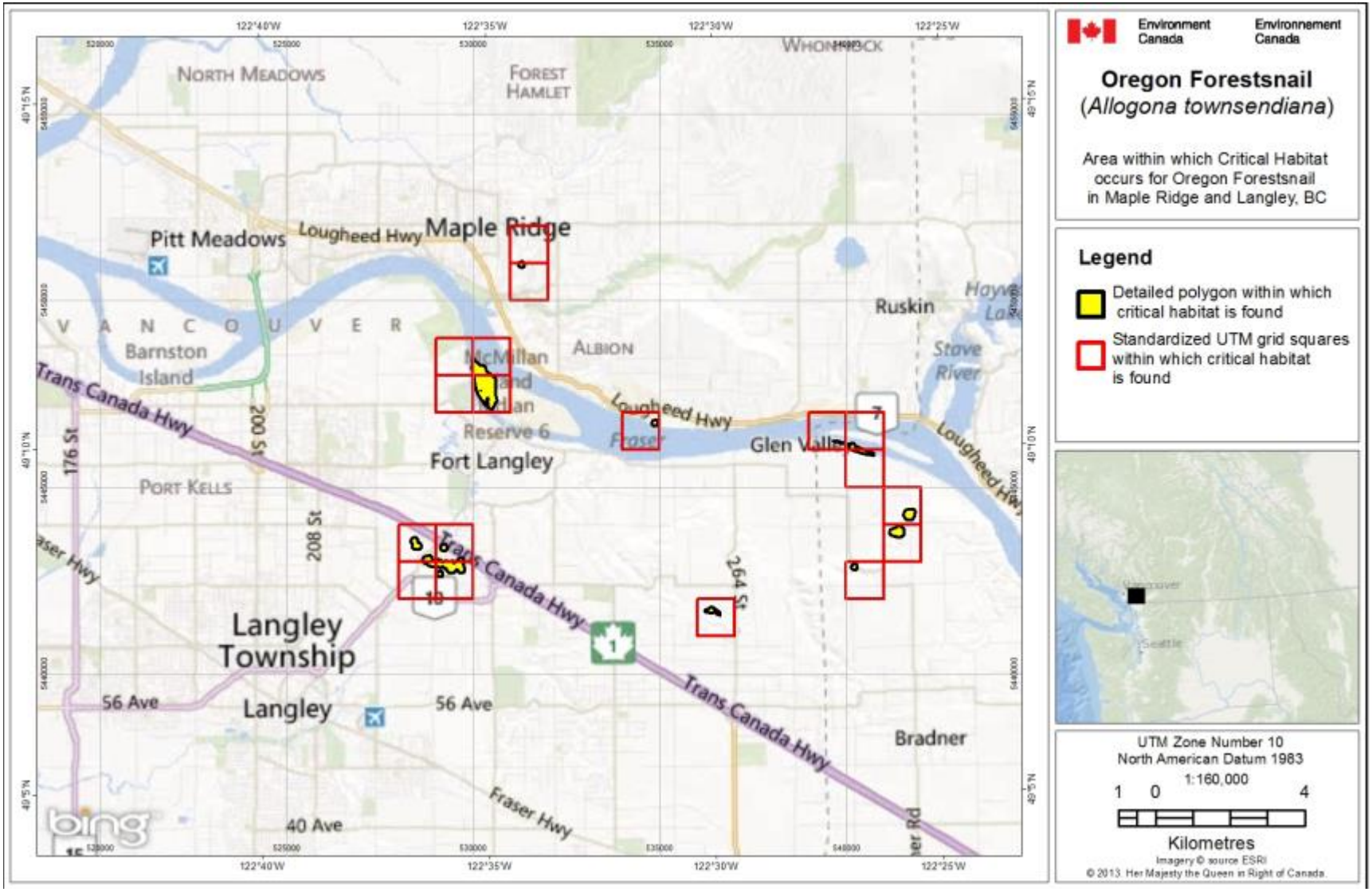

Figure 7. Area within which critical habitat for Oregon Forestsnail occurs in Maple Ridge and Langley, B.C.

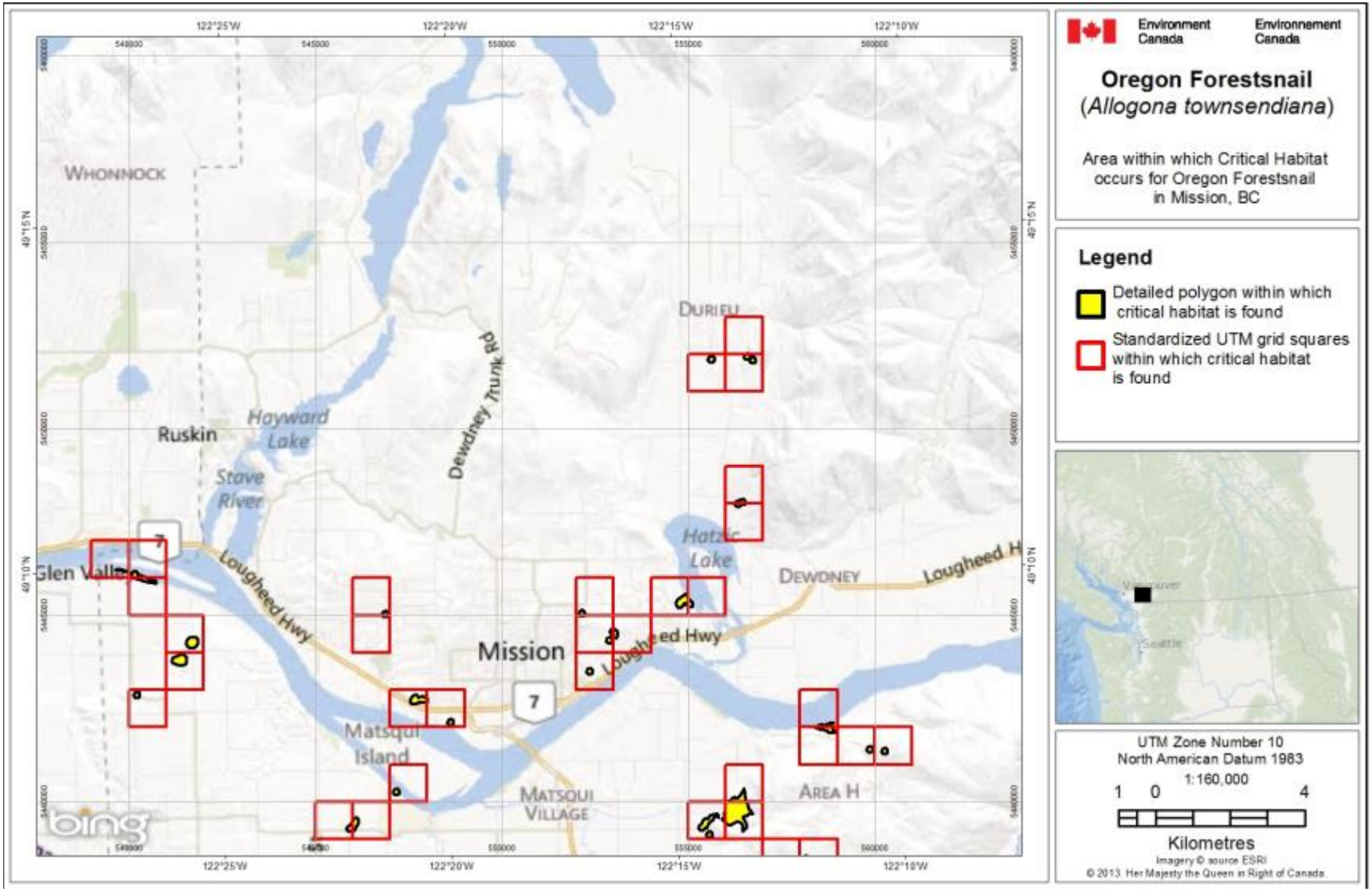

Figure 8. Area within which critical habitat for Oregon Forestsnail occurs in Mission, B.C.

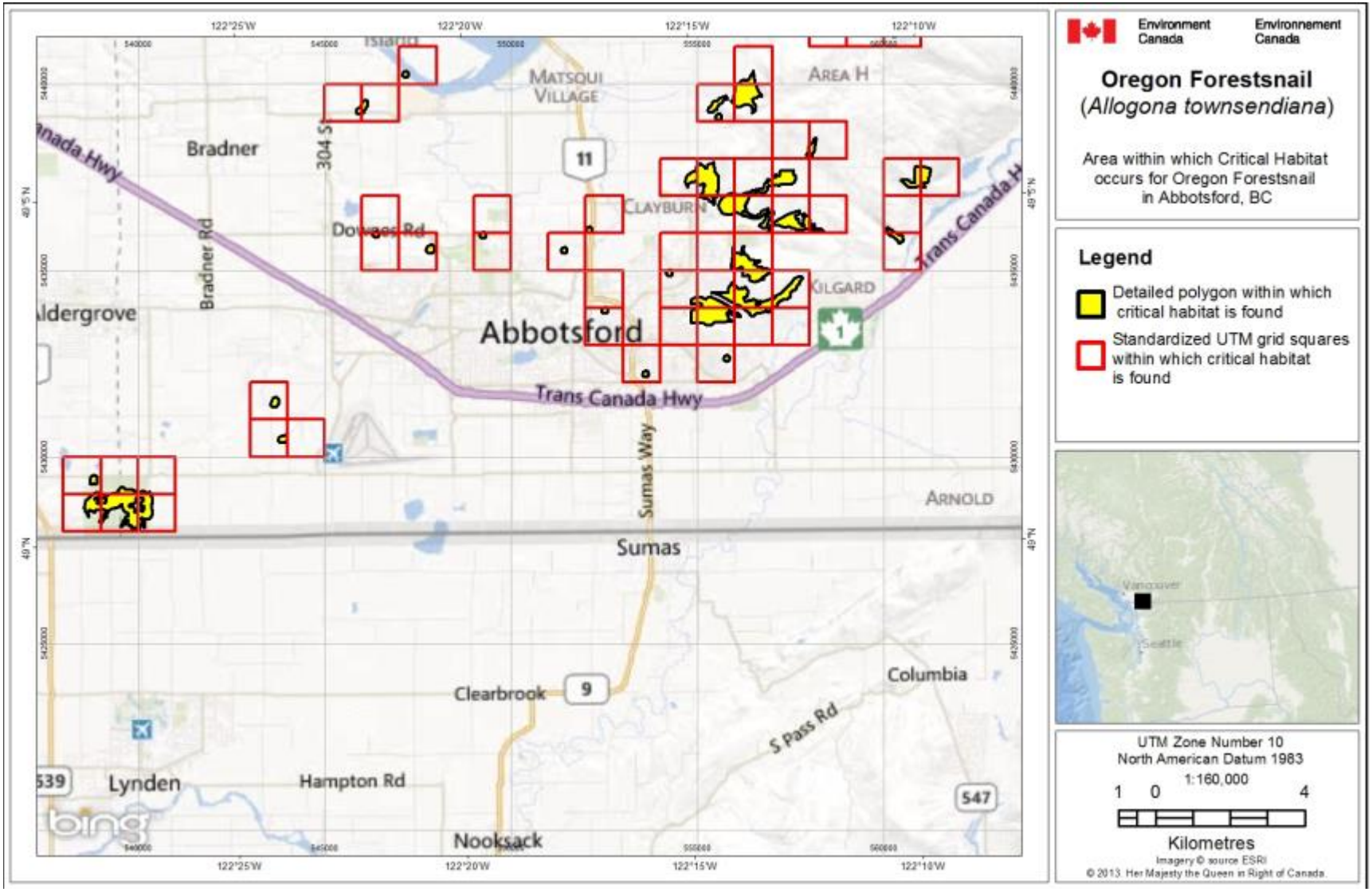

Figure 9. Area within which critical habitat for Oregon Forestsnail occurs in Abbotsford, B.C.

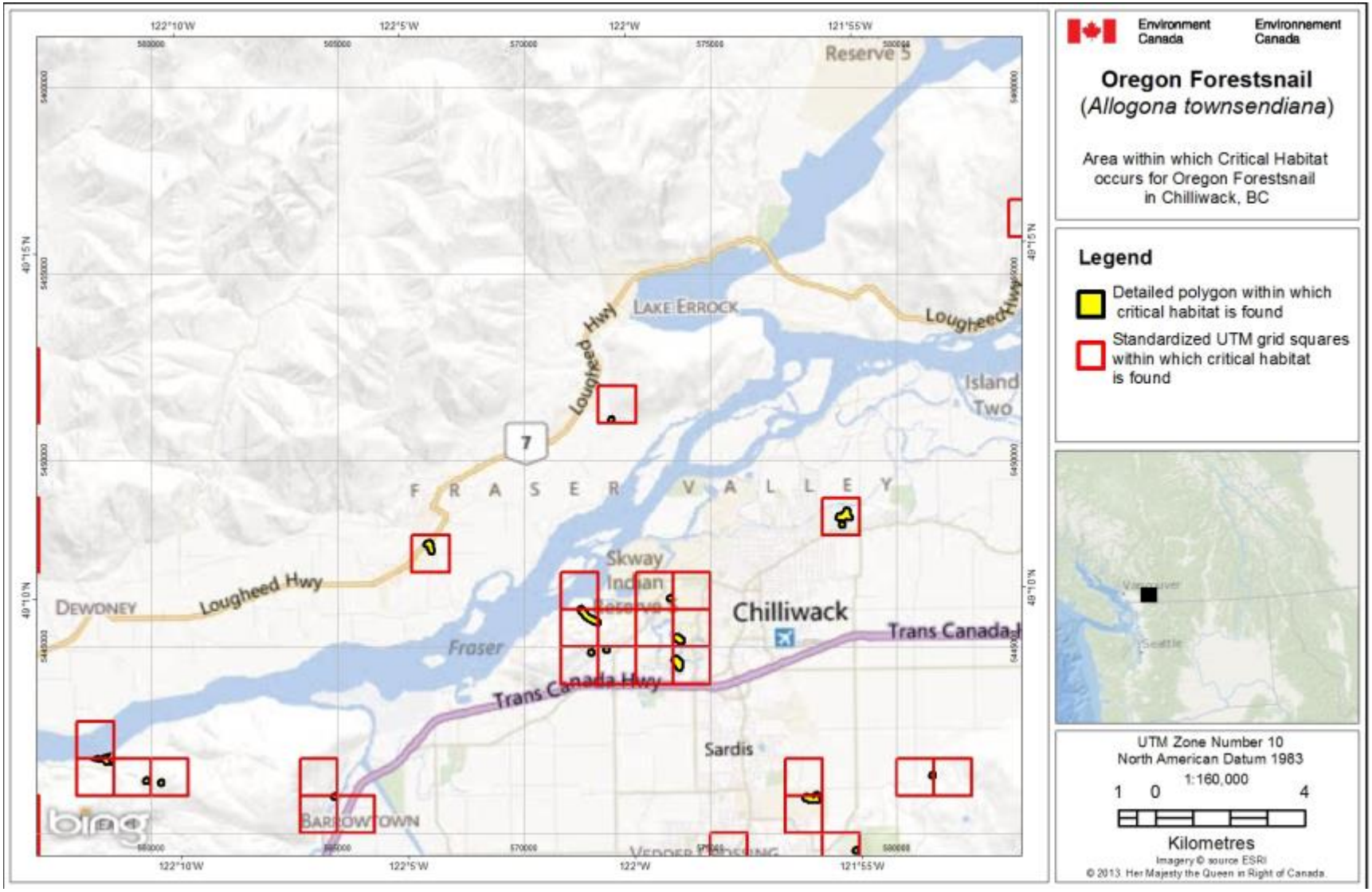

Figure 10. Area within which critical habitat for Oregon Forestsnail occurs in Chilliwack, B.C.

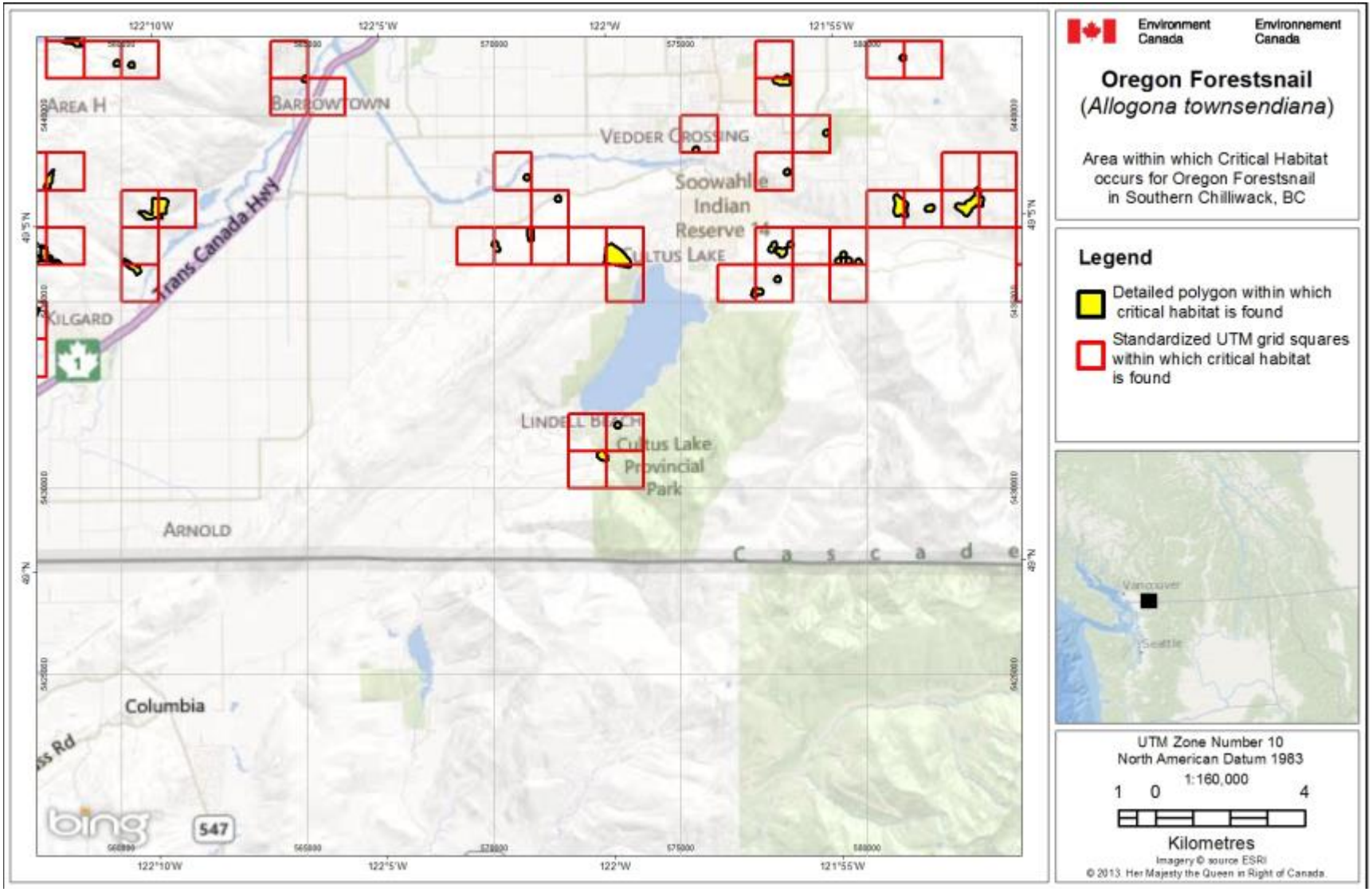

Figure 11. Area within which critical habitat for Oregon Forestsnail occurs in southern Chilliwack, B.C.

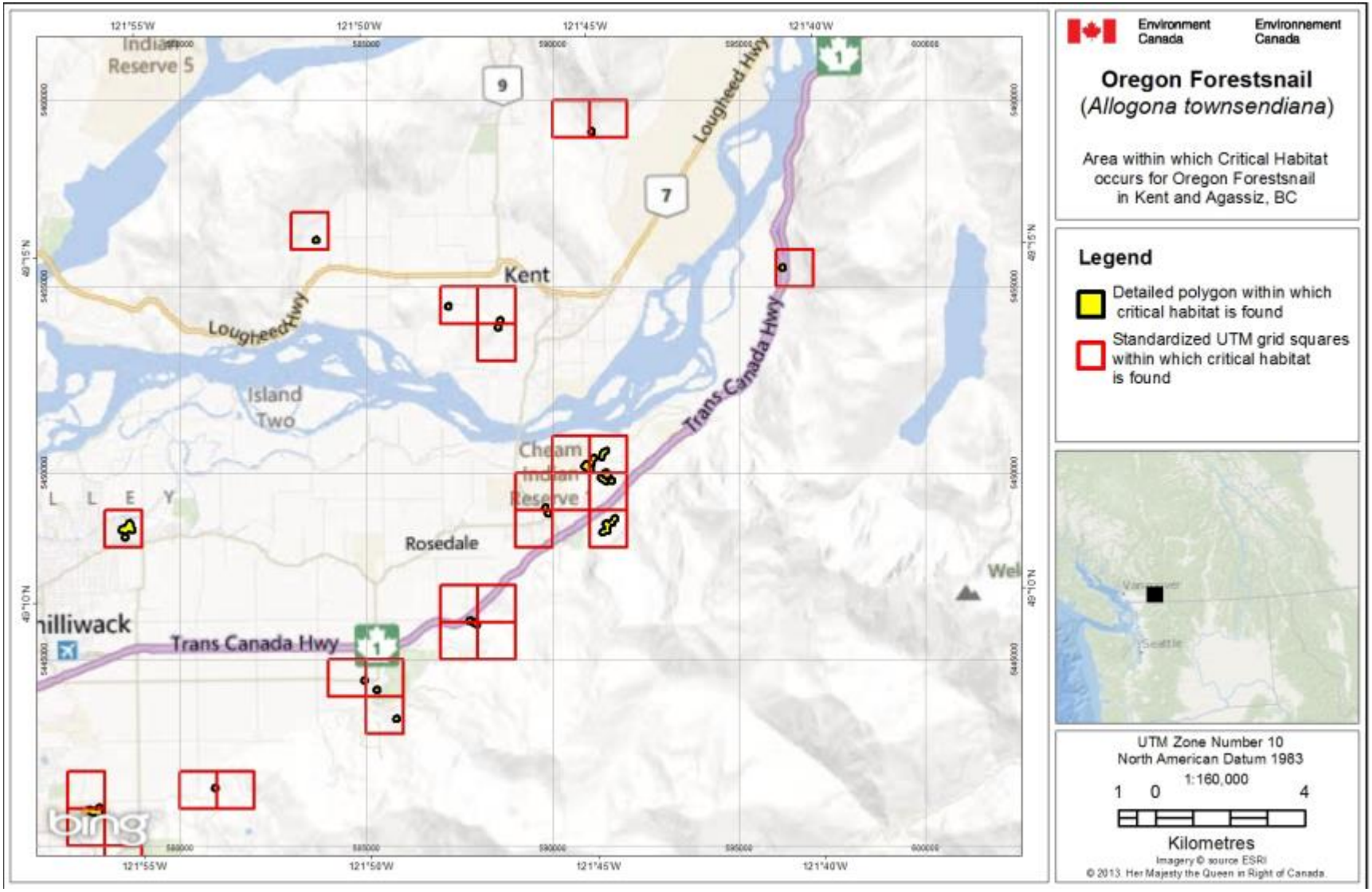

Figure 12. Area within which critical habitat for Oregon Forestsnail occurs in Kent and Agassiz, B.C**.**

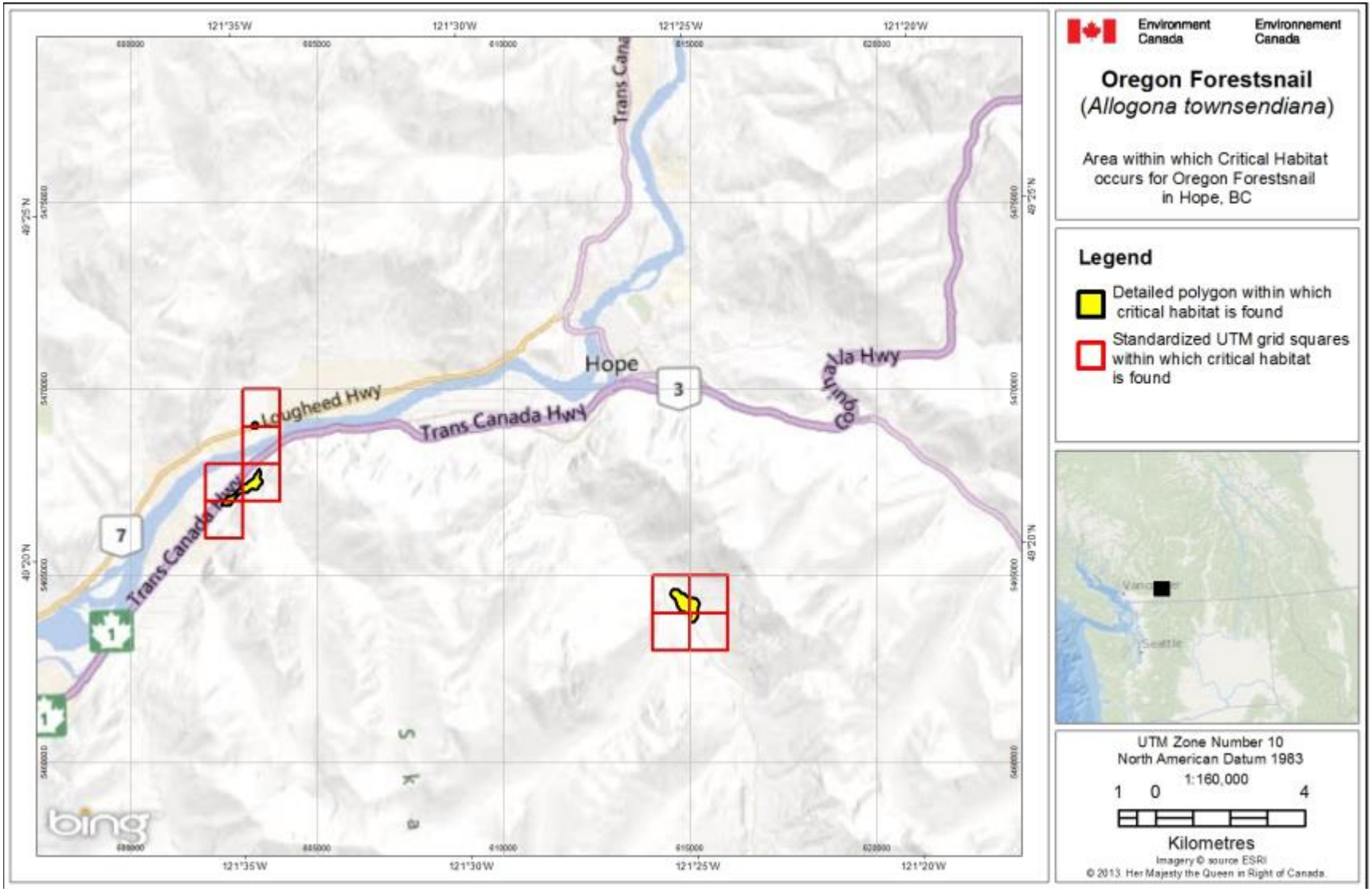

Figure 13. Area within which critical habitat for Oregon Forestsnail occurs in Hope, B.C.

PART 2 - "Recovery Plan for Oregon Forestsnail (*Allogona townsendiana*) in British Columbia", prepared by the Oregon Forestsnail Recovery Team for the British Columbia Ministry of Environment

Recovery Plan for Oregon Forestsnail (*Allogona townsendiana*) in British Columbia

Prepared by the Oregon Forestsnail Recovery Team

BRITISH COLUMBIA | Ministry of Environment

October 2012

About the British Columbia Recovery Plan Series

This series presents the recovery strategies or recovery plans that are prepared as advice to the Province of British Columbia on the general strategic approach required to recover species at risk. Recovery strategies or recovery plans 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 plan?

A recovery plan 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 explain what should be done to mitigate those threats. When sufficient information to guide implementation for the species can be included, the document is referred to as a recovery plan, and a separate action plan is not required.

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>

Recovery Plan for Oregon Forestsnail (*Allogona townsendiana*) in British Columbia

Prepared by the Oregon Forestsnail Recovery Team

October 2012

Recommended citation

Oregon Forestsnail Recovery Team. 2012. Recovery plan for Oregon Forestsnail (*Allogona townsendiana*) in British Columbia. Prepared for the B.C. Ministry of Environment, Victoria, BC. 50 pp.

Cover illustration/photograph

Heron, Jennifer

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

Library and Archives Canada Cataloguing in Publication

Oregon Forestsnail Recovery Team (Canada)
Recovery plan for Oregon forestsnail (Allogona townsendiana) in British Columbia [electronic resource] / prepared by the Oregon Forestsnail Recovery Team.

(British Columbia recovery strategy series)
Includes bibliographical references.
Electronic monograph in PDF format.
ISBN 978-0-7726-6607-9

1. Polygyridae--Conservation--British Columbia. 2. Rare invertebrates--British Columbia. I. British Columbia. Ministry of Environment II. Title. III. Series: British Columbia recovery strategy series

QL430.5 P6 O73 2012 333.95'5716 C2012-980180-1

Disclaimer

This recovery plan has been prepared by the Oregon Forestsnail 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 Forestsnail 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 plan. The B.C. Ministry of Environment encourages all British Columbians to participate in the recovery of Oregon Forestsnail.

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ACKNOWLEDGEMENTS

Jennifer Heron completed this final version of the recovery plan. Leah Westereng (Ministry of Environment [MoE]) provided extensive review and input into the plan. Scientific advice, review, and revisions have been the collaborative efforts of the Oregon Forestsnail Recovery Team. This recovery plan started a number of years ago and has been updated many times over the past years. Thank you to Kristiina Ovaska and Lennart Sopuck of Biolinx Environmental Research Ltd., Robert Forsyth (private malacologist), Tom Burke (private malacologist), and Terry Frest (private malacologist). The past and ongoing research by Trinity Western University, Karen Steensma, and involving Sooze Waldock, Heather Zandberg, Patrick Lilley, Martyna Kus, Martin Rekers, Deanna Leigh, Amanda Edworthy, Marie DenHaan, Jordan Thiessen, Stephanie Koole, and Melissa Oakes has contributed much to answering some of the knowledge gaps of Oregon Forestsnail. Thank you to Dwayne Lepitzki and Gerry Mackie (co-chairs, Mollusc Specialist Subcommittee, Committee on the Endangered Wildlife in Canada) and Dave Fraser (MoE) for input on the threats and Byron Woods (MoE) for mapping support. Thank you to all the biologists and private citizens who submit data on Oregon Forestsnail.

Additional reviews of the recovery plan were completed by Patrick Daigle (MoE [retired]), Jenny Feick (with MoE at the time), Brenda Costanzo (MoE), Ted Lea (MoE [retired]), Jeff Brown, (with MoE at the time), Laura Darling (MoE), Lucy Reiss (Environment Canada-Canadian Wildlife Service [EC-CWS]), Wendy Dunford (EC-CWS), Lucie Metras (EC-CWS), and Trish Hayes (EC-CWS).

EXECUTIVE SUMMARY

Oregon Forestsnail (*Allogona townsendiana*) was designated as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) because the species is restricted to a very small area of the southwestern British Columbia (B.C.) mainland and southern Vancouver Island. Populations are severely fragmented with continuing declines observed in extent of occurrence and quality of habitat due mainly to urban development. It is listed as Endangered in Canada on Schedule 1 of the *Species at Risk Act* (SARA). In B.C., Oregon Forestsnail is ranked S2 (Endangered) by the Conservation Data Centre and is on the provincial Red list. The B.C. Conservation Framework ranks Oregon Forestsnail as a priority 1 under goal 3 (maintain the diversity of native species and ecosystems). Recovery is considered to be biologically and technically feasible.

Oregon Forestsnail is a large, hermaphroditic land snail endemic to western North America. The shell of mature individuals is pale brown or straw yellow, round and flattened in form, and ranges from 28 to 35 mm in diameter. The Oregon Forestsnail in Canada is at the northern limits of its geographical range, and consequently may possess unique adaptations.

Oregon Forestsnail occupies mixedwood and deciduous forest habitat, typically dominated by bigleaf maple (*Acer macrophyllum*), black cottonwood (*Populus trichocarpa*), and scattered western redcedar (*Thuja plicata*). Many records are from riparian habitats and forest edges, where dense cover of low herbaceous native vegetation is typically present. The presence of Oregon Forestsnail is correlated with the presence of stinging nettle (*Urtica dioica*). All known Canadian Oregon Forestsnail populations are from habitats lower than 360 m above sea level.

Major threats include residential and commercial development; recreational activities; and invasive non-native/alien species.

The population and distribution goal is to maintain current (and new) populations and supporting habitat for Oregon Forestsnail throughout the species' natural range and distribution in British Columbia.

The recovery objectives for Oregon Forestsnail are:

1. To identify and prioritize important Oregon Forestsnail habitat throughout the species' range in B.C.
2. To secure protection[1] for Oregon Forestsnail habitats within the species' range.
3. To assess and reduce threats at all known sites in B.C.
4. To address knowledge gaps (e.g., population ecology, habitat associations, dispersal) that currently prevent quantitative population and distribution objectives from being established.

[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.

RECOVERY FEASIBILITY SUMMARY

The recovery of Oregon Forestsnail 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. The persistence of Oregon Forestsnail populations for at least 10 years at 12 or more sites, combined with the known presence of juveniles/eggs at some sites, indicates that individuals capable of reproduction are available.

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

   Yes. Oregon Forestsnail persists in small habitat patches, at least for the short term, and additional localities likely exist within both small (< 1 ha) and larger habitats. The larger-scale patches of suitable habitat for Oregon Forestsnail are located on Sumas Mountain, Chilliwack Mountain, and the areas on the south side of the Fraser River from Langley east to Bridal Veil Falls Provincial Park near Hope. Restoration may be necessary at sites where there has been extensive disturbance and development, and some landowners may want to restore habitats that have already been modified by urban or agricultural practices. For example, potential measures include providing cover for the snails around seepages and other moist habitats, increasing the density of stinging nettle, and restoring habitat connectivity along creeks and waterways.

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

   Yes. It is possible to mitigate some of the threat to its habitat from new urban and agricultural developments by protecting core habitats of moist mixedwood forests and leaving forested buffers around such areas. Threats from introduced species may be more difficult to address, although site-specific removal of introduced species is possible. Threats such as fire and flooding may also be minimized at some sites. Managing recreational activities to minimize soil compaction at some sites is also possible and may aid in protecting snail habitat.

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

   Yes. Techniques used to recover this species are similar to recovery planning techniques applied to species with similar threats and requirements. Examples of recovery techniques include habitat protection, removal of site-specific threats (such as introduced species), and working with land managers and landowners to develop site-specific best management practices guidelines.

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1 COSEWIC* SPECIES ASSESSMENT INFORMATION

Date of Assessment: November 2002
Common Name (population): Oregon Forestsnail
Scientific Name:* *Allogona townsendiana*
COSEWIC Status: Endangered
Reason for Designation: The species is restricted to a very small area of the extreme southwestern British Columbia mainland and southern Vancouver Island. Populations are severely fragmented with continuing declines observed in extent of occurrence, area of occupancy and area, extent and quality of habitat due mainly to urban development. Even though there may be other locations, the species is still very uncommon.
Canadian Occurrence: British Columbia
COSEWIC Status History: Designated Endangered in November 2002. Assessment based on a new status report. Currently undergoing ten year assessment and will be re-assessed by COSEWIC November 2012.

* Committee on the Status of Endangered Wildlife in Canada

2 SPECIES STATUS INFORMATION

Oregon Forestsnail[a]		
Legal Designation:		
Identified Wildlife:[b] No	B.C. *Wildlife Act*:[c] No	SARA Schedule: 1-Endangered (2005)
Conservation Status[d]		
B.C. List: Red	B.C. Rank: S1 (2011)	National Rank: N3N4 (2011) Global Rank: G3 (2011)
Other Subnational Ranks:[e] Washington: S3/S4; Oregon: SNR.		
B.C. Conservation Framework (CF)[f]		
Goal 1: Contribute to global efforts for species and ecosystem conservation.		Priority:[g] 4 (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; Monitor Trends; Planning; List under *Wildlife Act*; Send to COSEWIC; Habitat Protection; Habitat Restoration; Private Land Stewardship	

[a] Data source: B.C. Conservation Data Centre (2011) unless otherwise noted.
[b] Identified Wildlife under the *Forest and Range Practices Act*, which includes the categories of species at risk, ungulates, and regionally important wildlife (Province of British Columbia 2002).
[c] Listed as Endangered or Threatened under the *Wildlife Act* (Province of British Columbia 1982)/ Schedule E = Listed as Endangered under the B.C. *Wildlife Act* (Province of British Columbia 1982).
[d] S = subnational; N = national; G = global; 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. U.S. data from NatureServe (2011).
[e] Data source: NatureServe (2011).
[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

Oregon Forestsnail (*Allogona townsendiana*) (family Polygyridae) is a large hermaphroditic land snail (adult shell diameter 28–35 mm) endemic to western North America (Figure 1). Snail shell colour varies, ranging from amber to light reddish brown to straw yellow, with white lines running across each segment of the spiral. The shell shape is round and slightly flattened. Adult shells typically have from 5.25 to 6 whorls with fine, wavy spiral striae and irregular, light-coloured, wrinkle-like axial riblets and an overall irregular dimpled sculpture (Pilsbry 1940). As the snail ages the outer periostracal layer (outer surface of shell) flakes, becomes bleached and the fine spiral striae are no longer evident. Fine hair-like structures are not present on Oregon Forestsnail. The main distinguishing feature of Oregon Forestsnail adults is a distinct whitish apertural "lip" or rim at the shell opening, which is thickened, and strongly flared, outward. There is no denticle within the aperture.

Figure 1. Oregon Forestsnail adult showing topside (left), underside (centre), and underside of the shell showing the white apertural lip (right), June 11, 2010, Colony Farms – Metro Vancouver Regional Park. Photographs by J. Heron.

Oregon Forestsnail eggs are round, globose, opaque and grayish-white, slightly flattened, and with a grainy texture (COSEWIC 2002; Forsyth 2004; Steensma *et al.* 2009). Eggs are laid singly or in clusters with an average clutch size of 34 eggs in captivity (Steensma *et al.* 2009). Average egg diameter of captivity laid eggs was 3.1 mm.

Adult and juvenile Oregon Forestsnails are similar in appearance, although juvenile snails have thinner, transparent shells, particularly towards the outermost whorl, and no bleaching of shell colour. Juveniles generally do not have a thickened apertural lip.

Oregon Forestsnail is not likely to be confused with other landsnails within its B.C. range with the exception of Pacific Sideband (*Monadenia fidelis*). However, the Pacific Side-band does not have a white, thickened apertural lip and when multiple specimens are compared, the overall size of Pacific Sideband is greater than Oregon Forestsnail. Morphological comparisons with other similar land snails found within the global geographic range of Oregon Forestsnail are detailed in the COSEWIC (2002) status report.

3.2 Life Cycle and Reproduction

The life cycle of Oregon Forestsnail appears closely tied to seasonal temperature, day length, humidity, and climate conditions within the habitat patch it occupies. In general, snail activity levels depend on a combination of day length, moisture, and temperature (Solem and Christensen 1984; Prior 1985). A recent Oregon Forestsnail study assessed population size, reproductive timing and habitats, seasonal behaviors, and juvenile activity over a four-year period at Trinity Western University Ecological Study Area (TWU-ESA) in Langley, B.C. (Steensma *et al.* 2009). This study provides most of the information summarized below.

3.2.1 Seasonal Activity

Fifteen Oregon Forestsnail individuals were tracked by harmonic detection finder to follow their seasonal pattern over two years (see Steensma *et al.* 2009). In general, mating begins as early as February, lasting through early June. As the warmer and drier summer months approach, snails seek shelter deep within litter, under logs or the bark of coarse woody debris, or in similar shelter places within the deciduous forests where they predominantly live (see Section 3.3). This aestivation period lasts several weeks and in mid to late September the species becomes active again for the wet fall months. Once the first frost occurs, the individuals enter hibernation until the following spring. Winter hibernation begins sometime in late October to late November and lasts until late February, when temperatures are below 10.6^{o}C, and often drop to freezing overnight (Steensma *et al.* 2009).

During hibernation Oregon Forestsnails seek shelter by burying themselves 2–7 cm within leaf litter, moss, soil, or other forms of cover; they form an ephiphragm and orient themselves with the aperture of the shell upwards (Steensma *et al.* 2009). Adult snails are not likely to move during the hibernation period, although five tracked adults moved (average distance 14 cm) during the hibernation period, and may have fed during this time (Steensma *et al.* 2009). Juveniles have been observed at one site during hibernation months (Hawkes and Gatten 2011; Edworthy *et al.* 2012).

3.2.2 Mating

Oregon Forestsnail is hermaphroditic but it is unlikely that self-fertilization occurs (this could decrease fitness as has been seen in other gastropods) (Forsyth 2004). Like most native gastropods in southwestern B.C., this species is most active during the wet spring months when mating takes place. Oregon Forestsnail mating pairs have been observed at three sites in B.C., showing snails are active beginning in early February with the peak mating period from early March through early May (Steensma *et al.* 2009), and as late as June (Kus 2005).

Prior to mating, Oregon Forestsnail aggregates in clusters of 8–14 snails and shows social behaviour of antennal and shell touching. Numerous gastropod species exhibit group aggregations, or huddles: groups of slugs aggregate together to prevent water loss (Cook 1981a, 1981b; Prior 1981, 1985; Prior *et al.* 1983). Huddles create a high humidity microenvironment and reduce dehydration. Oregon Forestsnail mating has been observed to occur directly on or

within proximity (< 3 m) of coarse woody debris (e.g., logs). Stinging nettle (*Urtica dioica*) also grew < 1 m from mating pairs, as observed at three out of four pairs at TWU-ESA (Steensma *et al.* 2009). Mating first occurred when day length was greater than 11 hours, was with one individual, and was observed to last 225–229 minutes (Steensma *et al.* 2009).

3.2.3 Nesting

Oregon Forestsnail nesting in B.C. has been observed from April 20 to June 20, peaking in mid-May, and has been found near the edge or interior of forest habitats (Steensma *et al.* 2009). Oregon Forestsnail nesting and egg-laying are documented from three different sites in B.C.: Cemetary Hill, Nicomekel Slough, and TWU-ESA (B.C. Conservation Data Centre 2012). At the TWU-ESA, 53 nests were surveyed over a two-year period with adult snails digging a 6–10 cm flask-shaped hole, the equivalent of their body size, with their foot. Oviposition occurs after adult Oregon Forestsnails dig or burrow into new or existing nesting holes (Steensma *et al.* 2009). Most snails dig new nests although some nested within pre-existing depressions in soil, in moss, and under coarse woody debris (Steensma *et al.* 2009). Snails have also been observed ovipositing at the base of vegetation, such as Creeping Buttercup (*Ranunculus repens*), and occasionally within the same burrow as another snail and within gravel substrate (Edworthy *et al*. 2012).

3.2.4 Hatching and Juveniles

Juvenile snails hatched approximately 8–9 weeks after oviposition (Steensma *et al.* 2009). Asynchronous hatching has been observed. Juveniles began dispersing from the nest site within hours of hatching. Following hatching, snail activity included climbing < 1 m on tall vegetation close to the nest. Vegetation favoured by juvenile Oregon Forestsnail individuals included stinging nettle, reed canarygrass *(Phalaris arundinacea*), Indian-plum (*Oemleria cerasiformis*), and Himalayan balsam (*Impatiens glandulifera*). Older juveniles (not hatchlings) were observed feeding on stinging nettle (Steensma *et al.* 2009).

3.2.5 Adult Maturation

Adults likely reach reproductive maturity by two years and have a life span of at least five (Steensma *et al.* 2009) to eight years (COSEWIC 2002). This results in an estimated generation time of two to five years.

3.3 Populations and Distribution

The global range of Oregon Forestsnail is entirely within western North America (Figure 2). The northernmost extent of its range is in southwestern B.C. The range extends south through the Puget Trough in Washington State and to the Willamette Valley in west-central Oregon. The easternmost records are from west of Hope, B.C., south-central Washington, and north-central

Oregon in the Columbia River Valley. Based on recent records (within the past 10 years) and the historic records (combined), the global range extent is estimated at 135,000 km^2.

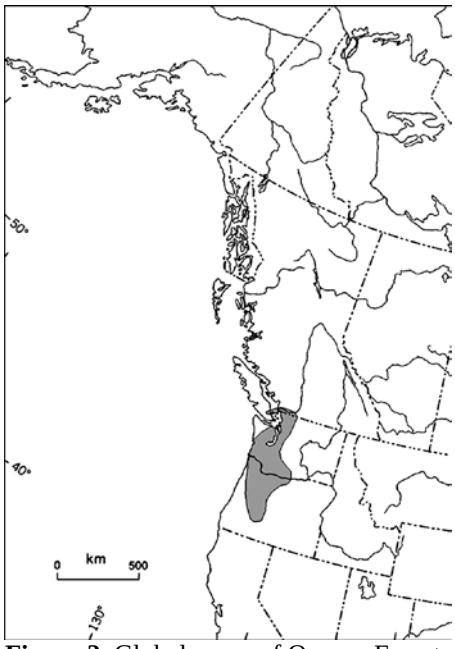

Figure 2. Global range of Oregon Forestsnail, based on Pilsbry (1940, Figure 508) and B.C. records (B.C. Conservation Data Centre 2012).[2]

The Canadian range of Oregon Forestsnail is restricted to B.C. within the coastal lowlands of the Lower Fraser Valley and one record on southeastern Vancouver Island (Figure 3; Appendix 1). Within the Lower Fraser Valley the most northeastern record is from near Hope, and the most western record is in Tsawwassen, with records throughout the Lower Fraser Valley within the municipal areas of Chilliwack, Mission, Abbotsford, Langley, Burnaby, Surrey, and Delta. On Vancouver Island, Oregon Forestsnail is known from the community of Westholme near Duncan (B.C. Conservation Data Centre 2012). There are no known records on the Gulf Islands. All records are from elevations lower than 360 m above sea level.

[2] Originally published in COSEWIC (2002).

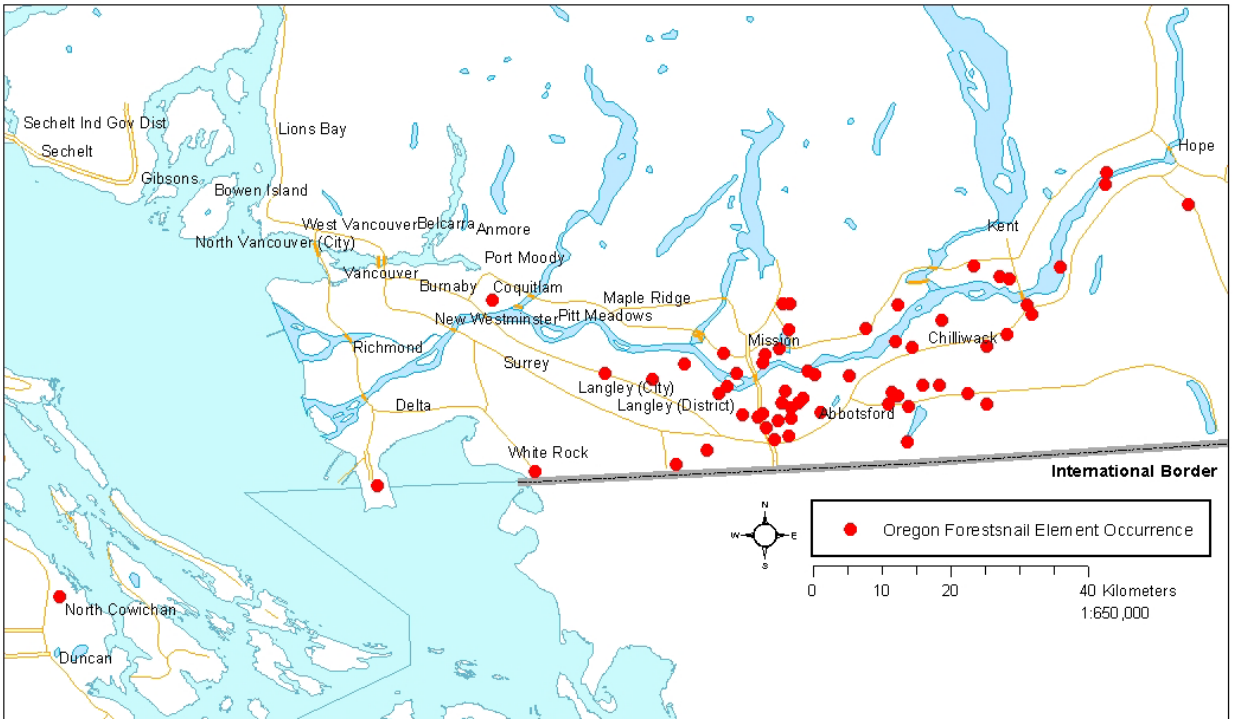

Figure 3. B.C. Oregon Forestsnail sites from 1901 to 2011 (B.C. Conservation Data Centre 2012).

Oregon Forestsnail records in B.C. date from 1901 to 2011 (B.C. Conservation Data Centre 2012). Based on recent records (within the past 10 years) and the historic records (combined), the range extent for B.C. is 3313 km^2 (including the unsuitable salt-water Strait of Georgia, between Vancouver Island and the Lower Fraser Valley). The occurrence on Vancouver Island is < 1 km^2. Oregon Forestsnail extent of occurrence based on recent records only (since year 2000) is similar to the known historic extent of occurrence.

As of August 2011 there are 67 known sites[3] (B.C. Conservation Data Centre 2012). The biological area of occupancy calculated by summing the area of all sites is approximately 670 ha (B.C. Conservation Data Centre 2012).

Based on habitat assessments on Vancouver Island, it is possible that Oregon Forestsnail may occur within the lower elevation wet valley bottoms on the eastern side of the island (approximately 100 km north and south of the community of Westholme) although extensive search effort within these areas has yet to reveal any new sites (see Appendix 2).

The presence of Oregon Forestsnail shells is often used as an indicator of site occupancy by live individuals because: (1) shells are concentrated sources of calcium and as such likely are consumed or disintegrate in short amounts of time (i.e., if the shell is present, the snail has not

[3] A site refers to the location of an Oregon Forestnail population. A site may be comprised of numerous habitat patches. A habitat patch is recorded by the presence of one or more individuals. A site is synonymous with the term "element occurrence," used by the B.C. Conservation Data Centre. An element occurrence is a spatial representation of a species at a specific area. An element occurrence generally delineates a species population, and represents the geo-referenced biological feature that is of conservation or management interest.

been dead long); (2) Oregon Forestsnail is reported incidentally during other wildlife surveys and not during the ideal survey window (i.e., snails may be hibernating or aestivating), and a shell would likely be visible on the litter surface (in the open) as opposed to a live individual that would likely take cover; and (3) specific Oregon Forestsnail surveys are often not completed during optimal activity periods.

Surveys for Oregon Forestsnail have primarily been by wandering transects through suitable habitat with the main objective to record snail presence, abundance, and habitat information (Appendix 2). Wandering transects follow no pre-determined grid or fixed route and allow the surveyor to change course depending on habitat suitability. Transect routes are usually tracked using a handheld Global Positioning System (GPS) unit to quantify search effort. This methodology has not allowed for population sizes or trends, mostly because sites are not revisited. No baseline information exists on historical abundance of Oregon Forestsnail, making estimates of population trends not possible.

At the most studied population of Oregon Forestsnail in B.C. (TWU-ESA), population estimates among four study areas within this population ranged from 7 to 47 snails with an overall mean density of 1.0 snail/m^2 (Steensma *et al.* 2009). At another Oregon Forestsnail population (Chilliwack), the estimated density of Oregon Forestsnail was highest in riparian habitats (0.14 snail/m^2) and second-growth mixed deciduous forests (0.13 snail/m^2) (Hawkes and Gatten 2011). These data were not gathered in the breeding season, which is considered ideal timing; however, they were collected in the wet fall when snails are known to be active and visible. Until a survey is completed in the spring, the Chilliwack results should be treated with uncertainty.

There are insufficient data to provide an accurate abundance of Oregon Forestsnail across the entire species' range in B.C. However, Oregon Forestsnail sites mapped by the B.C. Conservation Data Centre (2012) and information gathered during the preparation of this document provide some information on Oregon Forestsnail abundance. Oregon Forestsnail site abundance information ranges from one individual (at least 17 sites) to abundance counts > 20 snails (9 sites). The greatest number of snails recorded in a single survey was > 670 individuals at Colony Farms – Metro Vancouver Regional Park (Parkinson and Heron 2010).

There is minimal information on population fluctuation and trends for Oregon Forestsnail. Natural population fluctuations for snails are likely the result of numerous abiotic factors including moisture levels, weather patterns, and seasonal temperature fluctuations (such as early season frost) or erratic flooding. Biotic factors contributing to population fluctuations include parasites, predators, available minerals, and nutrients for healthy shell growth (e.g., through the consumption of plants such as stinging nettle), and availability of substrate within which to take refuge and/or lay eggs.

Although population trend data have not been collected for Oregon Forestsnail, associated Oregon Forestsnail habitat has shown a decline, particularly in the past 10 years. Urban and agricultural land development throughout the Lower Fraser Valley and southeastern Vancouver Island has removed forested habitat, reduced wetland cover, and resulted in a loss of streams. As such, it is likely that historically Oregon Forestsnail exhibited a more extensive metapopulation structure within suitable habitats throughout its known range in southwestern B.C.

3.4 Needs of Oregon Forestsnail

3.4.1 Habitat and Biological Needs

Oregon Forestsnail habitat requirements appear to be closely linked to the abiotic and biotic factors that limit an individual's physiological stress: minimizing dehydration; optimizing osmotic uptake of minerals through the integument (whether beneficial [e.g., water, calcium] or harmful [e.g., pesticides, chemicals]); and the amount of available consumptive mineral content (e.g., food) necessary for healthy shell growth. Abiotic factors that limit moisture, such as temperature, water availability, and day length, contribute to the overall activity patterns of gastropods and their presence within a habitat patch. Biotic factors such as coarse woody debris and understory vegetation allow for the moisture retention and high relative humidity (numerous studies summarized in Prior 1985; Steensma *et al.* 2009). Moisture and microhabitat features, including soil organic matter content and friability, coarse woody debris, understory vegetation, and bryophyte layers, define snail activity and reproductive success, foraging, and persistence within a habitat patch (Prior 1985). Information used to describe Oregon Forestsnail habitat in B.C. includes the collective efforts of occurrence records with the B.C. Conservation Data Centre (2012).

General description

- Low elevation (30–360 m above sea level)
- Deciduous and mixedwood broad-leaf forests with sustained high moisture, relative humidity, and multi-structured microhabitat that maintains high moisture levels.
- Riparian areas and landscape attributes with high site index (forest growth productivity) including ravines, gullies, and depressions containing both permanent and ephemeral watercourses; the wooded edges of streams, marshes, seasonally flooded and wet lowland areas; and similar habitats (B.C. Conservation Data Centre 2012).
- Forest interfaces and edge habitats where moisture is retained (Waldock 2002).

Forest overstory composition

- Typical habitat includes deciduous and mixedwood species with dominant overstory composition > 40% (B.C. Conservation Data Centre 2012).
- Forest stand ages range from 20 to > 80 years (B.C. Conservation Data Centre 2012).
- Overstory composition includes large bigleaf maple (*Acer macrophyllum*), black cottonwood (*Populus trichocarpa*), and scattered western redcedar (*Thuja plicata*).
- Additional trees present include paper birch (*Betula papyrifera*), trembling aspen (*Populus tremuloides*), red alder (*Alnus rubra*), and grand fir (*Abies grandis*) (B.C. Conservation Data Centre 2012).

Dominant shrub species composition

- Oregon Forestsnail tends to inhabit areas with dense shrub vegetation that functions to minimize moisture and evaporative loss from this vegetative layer. In riparian areas, the dense vegetation may be less than other less moist areas.
- Oregon Forestsnail habitats have variable native shrub species composition including a suite of the following species: devil's club *(Oplopanax horridus*), elderberry (*Sambucus racemosa*), false azalea (*Menziesia ferruginea*), beaked hazelnut (*Corylus cornuta*), Indian-plum *(Oemleria cerasiformis*), oceanspray (*Holodiscus discolor*), red-osier dogwood (*Cornus stolonifera*), rose (*Rosa* sp.), salmonberry (*Rubus spectabilis*), salal (*Gaultheria shallon*), saskatoon (*Amelanchier alnifolia*), common snowberry (*Symphoricarpos albus*), thimbleberry (*Rubus parviflorus*), and vine maple (*Acer circinatum*) (B.C. Conservation Data Centre 2012).

Herbaceous plant composition

- Oregon Forestsnail inhabits areas with dense herbaceous plant cover consisting of live and senescent vegetation, which provide food and cover during all life stages. Snails are often found at the base of large vegetation clumps or plants (e.g., leaf litter at the base of trees, shrubs, and ferns).
- Herbaceous composition includes bedstraw (*Galium* sp.), bleeding heart (*Dicentra formosa*), buttercup (*Ranunculus* sp.), cow parsnip (*Heracleum maxiumum*), enchanter's nightshade (*Circaea alpina*), false lily-of-the-valley (*Maianthemum dilatatum*), foamflower (*Tiarella trifoliata*), fringecup (*Tellima grandiflora*), Cooley's hedge nettle (*Stachys chamissonis* var. *cooleyae*), horsetail (*Equisetum* sp.), miner's lettuce (*Claytonia* sp.), pathfinder (*Adenocaulon bicolor*), skunk cabbage (*Lysichiton americanum*), starflower (*Trientalis* sp.), stinging nettle, thistle (*Cirsium* sp.), tiger lily *(Lilium columbianum)*, trillium (*Trillium ovatum* var. *ovatum*), twistedstalk (*Streptopus* sp.), vanilla leaf (*Achlys triphylla*), waterleaf (*Hydrophyllum* sp.), and creeping buttercup (*Ranunculus repens*) (B.C. Conservation Data Centre 2012).
- Ferns commonly recorded within Oregon Forestsnail habitat include bracken fern *(Pteridium aquilinum)*, ladyfern *(Athyrium filix-femina)*, northern maidenhair fern (*Adiantum aleuticum*), and swordfern (*Polystichum munitum*) (B.C. Conservation Data Centre 2012).

Presence of stinging nettle within the habitat patch

- Most habitats of Oregon Forestsnail contain patches of stinging nettle (B.C. Conservation Data Centre 2012; Edworthy *et al.* 2012). Stinging nettle appears to have high importance to Oregon Forestsnail populations especially for mating and egg-laying (COSEWIC 2002; Waldock 2002; Steensma *et al.* 2009). The daily consumption of stinging nettle is likely needed for healthy shell growth, as the plant contains high levels of calcium and other essential minerals needed to maintain shell durability. Stinging nettle is of significant importance to other land snails (Iglesias and Castillejo 1998). Waldock (2002) examined the association of Oregon Forestsnail with the stinging nettle in detail at TWU-ESA in Langley, and found a positive correlation between the abundance of the snails and stinging nettle. The presence of stinging nettle indicates moist, rich soils with high amounts of nitrogen and phosphorus (Pojar and MacKinnon 1994).

- There are two species of stinging nettle within B.C.: *Urtica dioica* is native to B.C. and *Urtica gracilis* is non-native. It is unknown if Oregon Forestsnail exhibits a preference or obligate association with one or both of these stinging nettle species.

Soil characteristics

- Rich, mesic and soft, productive, moist, well-developed mull-type[4] litter layer soils are important habitat requirements at all life stages (Cameron 1986; COSEWIC 2002; Steensma *et al.* 2009; B.C. Conservation Data Centre 2012).
- Litter depth (leaf needle) is typically 5–10 cm (Durand, pers. comm., 2012) and often greater than 15 cm in depth. This deep litter layer provides shelter, hibernation, and aestivation sites (Steensma *et al.* 2009; B.C. Conservation Data Centre 2012).
- Soil pH was recorded at 6.4–6.9 from one site in Langley (Steensma *et al.* 2009).
- Soil temperature was recorded at 9.9–13°C from one site in Langley (Steensma *et al.* 2009).

Coarse woody debris

- Oregon Forestsnail is recorded from habitats with abundant coarse woody debris.
- Coarse woody debris is of various stages of decay.
- Size ranges from large-diameter pieces to a forest floor composed of thin, compact needle litter.
- Coarse woody debris is an important habitat attribute for Oregon Forestsnail activity: mating, nesting, aestivation, hibernation, and egg laying (Steensma *et al.* 2009) and offers protection against daily or seasonal variations in temperature and water availability (as summarized in Prior 1985; Steensma *et al.* 2009).
- Decaying logs retain moisture and allow for the growth of a thick and healthy moss layer, which provide essential shelter during warm and dry weather conditions. It is important for Oregon Forestsnail to have a suitable resting site from which moisture can be absorbed through the foot; contact re-hydration is crucial for survival of gastropods (Prior 1985).
- Large diameter, damp rotten logs may act as dispersal corridors and shelter during seasonal drought (Burke *et al.* 1999) and provide sites for aggregating and mating (Steensma *et al.* 2009; B.C. Conservation Data Centre 2012).
- Oregon Forestsnail has been observed ovipositing within well-decayed wood (Steensma *et al.* 2009; B.C. Conservation Data Centre 2012).

Moisture requirements

- Moisture is a large influence on habitat suitability for Oregon Forestsnail and its presence within a habitat patch. Snails are continually susceptible to dehydration and experience constant evaporative water loss through the lung surface and integument as well as through the constant deposition of a dilute mucous trail left during locomotion. Gastropods seek shelter and microhabitat that retain water, humidity, and cool temperatures, and activity patterns predominantly coincide with preventing dehydration (Prior 1985).

[4] Rich, moist soil composed of a thick humus organic layer, decomposing deciduous leaf litter, some mineral soil content, and the presence of invertebrate soil fauna.

- Oregon Forestsnail mating pairs require humidity greater than 76% with optimum humidity 81–100%. These results suggest this environmental factor may have more of an influence over mating activity than air temperature (ranged from 7.1 to 17.0^{o}C) (Steensma *et al.* 2009).
- Soil parameters measured at three out of seven Oregon Forestsnail mating sites at TWU-ESA recorded 30–37% soil moisture (Steensma *et al.* 2009).

3.4.2 Limiting Factors to Oregon Forestsnail

Dispersal ability
The dispersal ability of Oregon Forestsnail is likely poor, and it is unclear how much spatial area (habitat) is required to sustain a population within a site or habitat patch. One study showed daily maximum distance at 4.5 m and the maximum displacement over three years at 32.2 m (Edworthy *et al.* 2012). By their very nature, snails are sedentary and cryptic animals, and their natural ability to colonize new areas is likely poor.

Northernmost extent of global range
Oregon Forestsnail is at the northernmost extent of its global range, which likely increases the species' susceptibility to climatic and stochastic population fluctuations.

Require humid environments
When the forest floor becomes increasingly exposed to wind and sunlight, and there is less vegetation growing throughout the understory, terrestrial molluscs are more vulnerable to dehydration (Prior 1985; Burke *et al.* 1999) and experience high rates of evaporative water loss through their skin (Dainton 1954a, 1954b; Machin 1964a, 1964b, 1964c; Burton 1964, 1966; Prior *et al.* 1983; as cited in Prior 1985). Snails are known to initiate "water seeking" responses to dehydration after a short-term reduction in locomotor activity (Prior 1985). The physiology and activity patterns of Oregon Forestsnail inherently make them susceptible to continuous water loss through dehydration. All snails deposit a dilute mucous trail, and experience constant evaporative water loss through the lung surface and integument. Numerous ecological and physiological studies show a relationship between body temperature, hydration and locomotor activity (Machin 1975; Peake 1978; Burton 1983; Riddle 1983; Martin 1983 as cited in Prior 1985). Within two hours, active slugs can lose 30–40% of their initial body weight and habitat selection by slugs is correlated with water availability (Prior 1985). Although this information pertains to slug species, it is likely similar for Oregon Forestsnail.

Soil mineral composition
Soil mineral content (including magnesium and calcium) and pH may play an important factor in snail microhabitat preference. Although unstudied in Oregon Forestsnail, these factors have been known to affect habitat preferences in other gastropods (Wareborn 1969; Hylander *et al.* 2004).

Native predators
Potential native invertebrate predators include the carnivorous Robust Lancetooth snail (*Haplotrema vancouverense*) and ground beetles (e.g., Snail-killer Carabid, *Scaphinotus angusticollis*) (K. Ovaska, pers. comm., 2008; L. Sopuck, pers. comm., 2008). Both species are believed to be gastropod specialists (Thiele 1977) and will follow the slime trails of slugs. Robust Lancetooth has been observed to attack and kill slugs (Ovaska and Sopuck, unpubl. data,

2000). These (and other) invertebrate predators are common throughout the same habitats as Oregon Forestsnail, although there is no known obligate association with the species. Concentration of predators in small habitat patches where little escape cover is available will potentially increase predation rates on Oregon Forestsnail. Competition and predation as a limiting factor may become more of a threat when combined with competition and predation from introduced species and further development pressures. Additional invasive vertebrate predators include Canada Goose (*Branta canadensis*) at some sites.

4 THREATS

Threats are defined as the proximate activities or processes that have caused, are causing, or may cause in the future the destruction, degradation, and/or impairment of the entity being assessed (population, species, community, or ecosystem) in the area of interest (globe, nation, or subnation). For purposes of threat assessment, only present and future threats are considered.[5] Threats presented here do not include biological features of the species or population such as inbreeding depression, small population size, and genetic isolation; or likelihood of regeneration or recolonization for ecosystems, which are considered limiting factors.[6]

For the most part, threats are related to human activities, but they can be natural. The impact of human activity may be direct (e.g., destruction of habitat) or indirect (e.g., invasive species introduction). Effects of natural phenomena (e.g., fire, hurricane, flooding) may be especially important when the species or ecosystem is concentrated in one location or has few occurrences, which may be a result of human activity (Master *et al.* 2009). As such, natural phenomena are included in the definition of a threat, though should be applied cautiously. These stochastic events should only be considered a threat if a species or habitat is damaged from other threats and has lost its resilience, and is thus vulnerable to the disturbance (Salafsky *et al.* 2008) so that this type of event would have a disproportionately large effect on the population/ecosystem compared to the effect they would have had historically.

[5] Past threats may be recorded but are not used in the calculation of Threat Impact. Effects of past threats (if not continuing) are taken into consideration when determining long-term and/or short-term trend factors (Master *et al.* 2009).

[6] It is important to distinguish between limiting factors and threats. Limiting factors are generally not human induced and include characteristics that make the species or ecosystem less likely to respond to recovery/conservation efforts.

4.1 Threat Assessment

The threat classification below is based on the IUCN-CMP (World Conservation Union–Conservation Measures Partnership) unified threats classification system and is consistent with methods used by the B.C. Conservation Data Centre and the B.C. Conservation Framework. For a detailed description of the threat classification system, see the CMP website (CMP 2010). Threats may be observed, inferred or projected to occur in the near term. Threats are characterized here in terms of scope, severity, and timing. Threat "impact" is calculated from scope and severity. For information on how the values are assigned, see Master *et al.* (2009) and table footnotes for details. Threats for the Oregon Forestsnail were assessed for the entire province (Table 1).

Table 1. Threat classification table for Oregon Forestsnail.

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]
1	Residential & commercial development	High	Large (31–70%)	Serious (31–70%)	High
1.1	Housing & urban areas	High	Large (31–70%)	Extreme (71–100%)	High
1.2	Commercial & industrial areas	High	Large (31–70%)	Extreme (71–100%)	High
1.3	Tourism & recreation areas	Low	Small (1–10%)	Slight (1–10%)	High
2	Agriculture & aquaculture	Low	Restricted (11–30%)	Moderate (11–30%)	High
2.1	Annual & perennial non-timber crops	Low	Restricted (11–30%)	Moderate (11–30%)	High
2.2	Wood & pulp plantations	Negligible	Negligible (<1%)	Slight (1–10%)	Moderate
2.3	Livestock farming & ranching	Low	Small (1–10%)	Slight (1–10%)	High
3	Energy production & mining	Low	Small (1–10%)	Extreme (71–100%)	Moderate
3.2	Mining & quarrying	Low	Small (1–10%)	Extreme (71–100%)	Moderate
3.3	Renewable energy	Negligible	Negligible (<1%)	Moderate (11–30%)	High
4	Transportation & service corridors	Medium	Large (31–70%)	Moderate (11–30%)	High
4.1	Roads & railroads	Medium	Restricted (11–30%)	Serious (31–70%)	High
4.2	Utility & service lines	Low	Restricted (11–30%)	Moderate (11–30%)	Moderate
5	Biological resource use	Low	Small (1–10%)	Serious - Moderate (11–70%)	High
5.1	Hunting & collecting terrestrial animals	Negligible	Negligible (<1%)	Serious (31–70%)	High
5.2	Gathering terrestrial plants	Negligible	Negligible (<1%)	Unknown	High
5.3	Logging & wood harvesting	Low	Small (1–10%)	Serious (31–70%)	High
6	Human intrusions & disturbance	Low	Large (31–70%)	Slight (1–10%)	High
6.1	Recreational activities	Low	Large (31–70%)	Slight (1–10%)	High
6.2	War, civil unrest, & military exercises	Negligible	Negligible (<1%)	Negligible (<1%)	High

Threat #	Threat description	Impact[a]	Scope[b]	Severity[c]	Timing[d]
7	Natural system modifications	Low	Small (1–10%)	Serious (31–70%)	High
7.1	Fire & fire suppression	Unknown	Large (31–70%)	Unknown	High
7.3	Other ecosystem modifications	Low	Small (1–10%)	Serious (31–70%)	High
8	Invasive & other problematic species & genes	Medium - Low	Pervasive (71–100%)	Moderate - Slight (1–30%)	High
8.1	Invasive non-native/alien species	Medium - Low	Pervasive (71–100%)	Moderate - Slight (1–30%)	High
9	Pollution	Unknown	Small (1–10%)	Unknown	High
9.3	Agricultural & forestry effluents	Unknown	Small (1–10%)	Unknown	High
10	Geological events	Not Calculated	Small (1–10%)	Serious (31–70%)	Unknown
10.1	Volcanoes	Not Calculated	Unknown	Unknown	Low
10.2	Earthquakes/tsunamis	Not calculated	Small (1–10%)	Serious (31–70%)	Unknown
10.3	Avalanches/landslides	Negligible	Negligible (<1%)	Moderate (11–30%)	Unknown
11	Climate change & severe weather	Not calculated	Restricted – Small (1–30%)	Slight (1–10%)	Low
11.2	Droughts	Unknown	Pervasive (71–100%)	Unknown	Low
11.4	Storms & flooding	Not calculated	Restricted - Small (1–30%)	Slight (1–10%)	Low

[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 threat 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%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity are unknown); Not Calculated: impact not calculated as threat is outside the assessment timeframe (e.g., timing is insignificant/negligible or low as threat is only considered to be in the past); Negligible: when scope or severity is negligible; Not a Threat: when severity is scored as neutral or potential benefit.
[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%; Negligible < 1%).
[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%; Negligible < 1%; Neutral or Potential Benefit ≥ 0%).
[d] **Timing** – High = continuing; Moderate = only in the future (could happen in the short term [< 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.

4.2 Description of Threats

The overall province-wide Threat Impact for this species is Very High to High.[7] The greatest threat is IUCN-CMP Threat 1 Residential and commercial development. Additional threats are discussed below under the Threat Level 1 headings and a summary of the threats by site is provided in Appendix 1.

Oregon Forestsnail's geographic range in southwestern B.C. coincides with the most densely populated and developed part of the province. There has been extensive habitat loss from historic activities (e.g., logging, agriculture, urbanization). In particular, low elevation (< 300 m) habitats within the Coastal Western Hemlock (CWH) biogeoclimatic zone have been extensively modified over the past century as a result of urbanization, forestry, and agriculture. Little of the original forest remains and most habitat patches are < 100 ha. Urban and agricultural development, combined with natural succession, fire suppression, and infilling/draining of lowland wetland riparian habitats, has likely led to the isolation of populations and subsequent inability of Oregon Forestsnails to disperse and recolonize habitat patches. Eventually, isolation combined with threats and limiting factors likely led to its extirpation within some areas of suitable habitat in B.C.

Restricting Oregon Forestsnail sites into smaller habitat patches likely increases the snails' vulnerability to dehydration (e.g., of the forest floor [Prior 1985; Burke *et al.* 1999]), flooding of the forest floor, reduced genetic diversity, and harmful fluctuations in microclimate (Prior 1985).

IUCN-CMP Threat 1. Residential & commercial development

1.1 Housing and urban areas and 1.2 Commercial and industrial areas
Natural habitats, large ravines, and riparian areas that represent core habitats for Oregon Forestsnail coincide with the local government jurisdictions of Abbotsford, Mission, Chilliwack, Langley, Fort Langley, and Hope. Expanding human population in these lowland urban areas threatens habitats. Human activities associated with urban developments, specifically those that include clearing or removing Oregon Forestsnail habitat and/or altering natural hydrological patterns that result in habitat conditions that are too dry or wet for prolonged periods, can impact the microhabitat and overall forest stand structure necessary to sustain populations of Oregon Forestsnail.

At a minimum, there have been 73 separate urban housing developments within the core geographic range of Oregon Forestsnail (Abbotsford, Chilliwack, Agassiz, Maple Ridge, Mission and Langley). Of these developments, at least 17 urban housing developments (see Greater Vancouver Real Estate 2011) within the municipalities of Mission, Abbotsford, and Chilliwack appear to have resulted in direct natural deciduous forest habitat conversion and may have

[7] 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 High, 1 Medium, 1 Medium-Low, 5 Low, and 3 Unknown/Not calculated (Table 1). The overall threat considers the cumulative impacts of multiple threats.

impacted Oregon Forestsnail habitat or populations (estimated from Google Earth satellite imagery viewing through Greater Vancouver Real Estate 2011). These urban developments include large-scale new communities with new infrastructure, such as schools, roads, and central shopping amenities and in some cases golf courses and other recreational infrastructure. Most of this development has been within privately owned natural land on Sumas Mountain and other areas of rural Abbotsford, Vedder Mountain, Whatcom, and other natural areas of Chilliwack, within the Lower Fraser Valley (Greater Vancouver Real Estate 2011).

Today, most of the remaining large natural habitats within the core range of Oregon Forestsnail are in private ownership (either owned by the local government or by a private development company [proponent]). Each municipal government has an Official Community Plan with specific areas designated for future housing and commercial development to service the increase in human population. The *Local Government Act* requires a private landowner who is subdividing their property to dedicate 5% of the land subject to subdivision as a park or to pay cash in lieu of the land. This does not necessarily provide habitat for species at risk; however, local government may be more inclined to take monetary compensation that can then be allocated to community projects elsewhere in the municipality over park land if the Official Community Plan does not designate the type and location of future parkland. As well, if someone is developing a property but is not subdividing (e.g., building a home, barn), this dedication is not required (Green Bylaws Toolkit 2012). Some municipalities have environmentally sensitive development permit areas and can direct development away from these sensitive areas with high ecological (species at risk) values; however, if this is a gap in a municipality's official community plan, then ecosystem values such as Oregon Forestsnail do not get protected.

Industrial and business park expansion plans are published for some municipalities within the Lower Fraser Valley, such as the City in the Country Plan specific to the City of Abbotsford. This plan projects the need for "1,300 acres of employment-generating industrial and business park lands over the next 20 years" with "future residential development accommodated through hillside development…not accommodated by expansion into the Agricultural Land Reserve" (City of Abbotsford 2004).

1.3 Tourism and recreational areas

The demand for tourism and recreational areas within the Lower Fraser Valley and southeastern Vancouver has increased substantially within the past decade. Natural areas continue to be developed into golf courses, campgrounds, parks, and recreation facilities.

This threat applies to two known Oregon Forestsnail sites, although likely more sites because often golf course or recreational developments within existing protected areas are not accurately captured in threat assessments. In the past 10 years, numerous golf courses have been developed within the Lower Fraser Valley within natural habitat that may have had occurrences of Oregon Forestsnail: Abbotsford (two courses), Chilliwack (five courses), Langley (two courses), Aldergrove (one course), and Hope (one course).

Within existing parks, as well as regional and municipal properties, habitat conservation and recreational development potentially conflict with Oregon Forestsnail conservation. Potential

threats include construction of new trails and rights-of-way within highly used areas such as Colony Farms, Brunette River Greenway, Brae Island, Cheam Wetlands; creation of new camp sites (e.g., Hope and Chilliwack areas - at least two sites); and creation of golf courses in the Abbotsford, Chilliwack, and Hope areas. For example, within Neilson Regional Park there is a planned expansion of a children's playground into a large patch of stinging nettle where Oregon Forestsnail is known to occupy (J. Heron, pers. obs., 2011). In a separate site also within Neilson Park, Fraser Valley Regional District, Oregon Forestsnail is known to occupy patches of stinging nettle that border a baseball diamond in the park.

Expansion of recreational areas increases the frequency of road and trail building, which may act as corridors (into natural habitats) that facilitate the rapid spread of invasive species (e.g., plant seeds attach to car tires and become dislodged at new sites) (Trombulak and Frissell 2000) (see IUCN-CMP Threat 8).

IUCN-CMP Threat 2 Agriculture and aquaculture

2.1 Annual and perennial non-timber crops

Coniferous forest habitat that is within the Agricultural Land Reserve is subject to clearing and conversion. In some cases, landowners/managers may clear land in anticipation of agricultural development, although no actual crops, grazing, or agricultural practices will occur on the land for a number of years. At present, there is no environmental assessment required for species at risk presence surveys before clearing of land for agricultural purposes. This is a potential threat at many agricultural sites within the Lower Fraser Valley with verges of natural habitat surrounding the agricultural field (e.g., Oregon Forestsnail has been observed adjacent to fields) (C. Bianchini, pers. comm., 2012). This applies to remnant areas of habitat (e.g., ditchside verges, crop verges, and the perimeter of agricultural fields) where Oregon Forestsnail may remain in small habitat patches.

2.2 Wood and pulp plantations

Wood and pulp plantations are throughout the Chilliwack and Hope areas. The first hardwood tree farm licence in the Lower Fraser Valley was granted in 1985 and as a result many of the old-growth cottonwood stands were harvested (Pollon 2010). Conifer plantations do not manage for a diverse, multi-layer understory. Small gaps in wet areas may act as a population sink where Oregon Forestsnail may remain. As well, ongoing harvesting within these stands continues to take place and destroy habitat and these remaining patches.

2.3 Livestock farming and ranching

Detrimental impacts to Oregon Forestsnail habitat from livestock grazing have been recorded from at least three sites (B.C. Conservation Data Centre 2012). The impacts to gastropods from grazing are unknown, but trampling of sensitive riparian areas is often a result of livestock congregating adjacent to watercourses and there would be direct mortality caused by trampling of individuals and habitat (e.g., stinging nettle and other herbaceous plants).

IUCN-CMP Threat 3. Energy production and mining

3.2 Mining and quarrying
Gravel mining is a localized threat at sites in the Lower Fraser Valley, particularly on areas of Sumas Mountain. The overall footprint is small at this time but may expand in the future and results in complete habitat loss where it occurs.

3.3 Renewable energy
Independent Power Projects are numerous throughout the Lower Fraser Valley and impact potential habitat (riparian areas) where Oregon Forestsnail may occur. The overall footprint from these power projects is small, however the cumulative riparian habitat loss due to these substations has potential to impact the species overall.

IUCN-CMP Threat 4. Transportation and service corridors

4.1 Roads and railroads
With increasing human population comes the need for associated transportation infrastructure and access to both new and existing urban areas. Proposed transportation routes are often planned through areas that have the least impact to existing private landowners, such as land (frequently also natural areas) owned by the local or provincial government, land currently within the Agricultural Land Reserve (although the land may be privately owned), or land through natural areas owned by one private landowner or company.

Oregon Forestsnail habitat includes ravines and gullies where both ephemeral and permanent natural watercourses flow. Proposed transportation routes through natural areas frequently result in changes to existing watercourses (e.g., if a roadway bisects a creek; ongoing road and highway expansion projects include plans to divert infill and alter watercourses). At least 10 sites with Oregon Forestsnail have ongoing/finished major works within the past 10 years. Additional sites include areas near Westholme (Vancouver Island) along a railway right-of-way.

Within the geographic range of Oregon Forestsnail extensive roads and other similar transportation corridors already fragment much of the remaining natural habitat and contribute to other threats including increased frequency of use by humans (IUCN-CMP Threat 6.1). Roadsides act as corridors into natural habitats and are known to facilitate the rapid spread of introduced species (e.g., plant seeds attach to car tires, and become dislodged at new sites) (Trombulak and Frissell 2000). The potential spread of introduced species along roadsides may impact local populations through competition and predation, as well as changes to native vegetation ultimately leading to changes in microclimate moisture regimes necessary to sustain Oregon Forestsnail populations (e.g., limit dehydration) (see IUCN-CMP Threat 8.1).

4.2 Utility and service lines
Service lines lead to population isolation; and increased drought from edge effects and stand/wind penetration, leading to increased mortality and ecosystem changes through introduced species. Plans for expansion of hydro rights-of-way and infrastructure are ongoing

throughout the Lower Fraser Valley, particularly in areas within large urban developments that require new/improved utility infrastructure. This threat applies to at least five known sites.

At present, there is ongoing construction of a transmission line from Coquitlam to Hope through much potential and unchecked habitat for Oregon Forestsnail. This habitat loss is not in the same areas as roads and the overall impacts are cumulative.

IUCN-CMP Threat 5. Biological resource use

5.1 Hunting and collecting terrestrial animals

There are a few observations of citizens collecting terrestrial snails for consumption (C. Bianchini, pers. comm., 2012); however, the scope of this threat is thought to be negligible at this time. It is also likely that once an individual has removed the readily available snails (e.g., they have cleaned out the snails, up to 70% in an area), it is not likely that the same area will be revisited in the future.

5.2 Gathering terrestrial plants

Stinging nettle is of cultural significance to First Nations people in the region. As well, both First Nations and members of the general public consume the plant. With an increased awareness of local native plants, the consumption of native species and the widespread social trend to consume locally grown produce, some local farms provide stinging nettle to their subscribers. It is likely that these farms are just gathering the plant and not cultivating it (e.g., crops). Currently, this threat is thought to have a negligible impact on Oregon Forestsnail.

5.3 Logging and wood harvesting

The B.C. range of Oregon Forestsnail has been impacted from extensive historic logging and forest resource extraction activities. The forest land base, particularly within the rural areas of Mission, Chilliwack, and Hope, continues to be intensively managed due to the high demand for forest products. Forest management practices, including pre-commercial thinning, pruning, removal of select tree species, fertilization practices, patch-size harvesting, and clearcut harvesting, likely have detrimental effects on populations of Oregon Forestsnail.

Pre-commercial thinning and pruning practices reduce the quantity and/or alter the timing of leaf and branch litter that would otherwise fall to the forest floor and provide shelter for Oregon Forestsnail. Pruning activities that remove lateral branches reduce the overall forest canopy, which results in lower relative humidity and subsequent desiccation of the forest floor. The active removal of trees and machinery used may compact ground cover, crush individuals of Oregon Forestsnail, disturb coarse woody debris and shelter sites, and cause localized impacts within a harvested area. Present day intensive forest management practices target large dead coarse woody debris removal during the second rotation of forest harvesting. Thus, large coarse woody debris may be in short supply in intensively managed forests. These logs are likely important for maintaining stable microclimates for developing eggs, and thus suitable microhabitat for Oregon Forestsnail.

Harvest of forest stands isolates subpopulations further, decreases available habitat, and increases drought from edge effects and stand/wind penetration, leading to increased mortality and ecosystem changes through introduced species. Numerous Oregon Forestsnail records are from provincial Crown land operating under the Chilliwack Forest District (B.C. Ministry of Forests, Lands and Natural Resource Operations). The Chilliwack Forest District covers approximately 1.4 million ha (B.C. Ministry of Forests, Lands and Resource Operations 2012). Potential habitats under 350 m elevation would apply to Oregon Forestsnail habitat.

Areas on Sumas and Vedder Mountains still have small habitat patches used for logging, although once logged the land use will likely change. Hope and Chilliwack areas (easternmost extent of range) have ongoing logging. Harvesting of forest stands isolates subpopulations further, decreases available habitat and increases drought from edge effects and stand/wind penetration, leading to increased mortality and ecosystem changes through introduced species. Soil compaction is a concern during logging, as heavy machinery is often used to harvest trees. This threat applies to 11 sites.

There is also ongoing illegal harvest of older growth western redcedar and hardwood trees throughout the range of Oregon Forestsnail. The impacts of illegal harvest are unknown.

IUCN-CMP Threat 6. Human intrusions and disturbance

6.1 Recreational activities

Recreational activities within Oregon Forestsnail habitat include camping, hiking (e.g., Sumas Mountain Regional Park), foot and bicycle traffic (e.g., Brunette River Greenway – Metro Vancouver Regional Park), and the use of all terrain vehicles (ATVs) and trail bikes (e.g., private land), especially off-trail bikes (e.g., Sumas Mountain). Such activities can result in degradation of habitat quality through soil compaction and can also cause accidental mortality especially along trail edges.

Effects from recreational activities can be pronounced in areas where the species is restricted to small habitat patches (e.g., Brunette River Greenway – Metro Vancouver Regional District Park; Neilson Park – Fraser Valley Regional District). For example, inadvertent trampling of the site could result in significant mortality, especially during the spring breeding period when the snails are active on the forest floor.

Areas with particularly high recreational use include those habitats within Metro Vancouver and Fraser Valley Regional District parks; habitats on Sumas Mountain on B.C. Crown and private land (including local government land); portions of the TSU-ESA; and provincial parks such as Cultus Lake Provincial Park (Chilliwack) and Bridal Falls Provincial Park (outside Hope).

Hiking, ATV, and related activities may also increase the spread of introduced species (see IUCN-CMP Threat 8.1). Recreational use of trails for horseback riding also likely impacts habitat (e.g., trampling of trails/edges and defecation, which increases the spread of fungus, seeds).

The threat of recreational activities applies to at least 58 sites, although at many sites the damage to the species or its habitat is likely limited in scope to trail sides.

6.2 War, civil unrest and military exercises

Activities occurring on Department of National Defence (DND) land that are considered necessary for national security include not only military training but training by other organizations, such as police forces. The Canadian Forces and Royal Canadian Mounted Police (RCMP) both conduct dismounted (on foot) training in forested areas belonging to DND. In addition to training, development to meet operational requirements and maintenance (such as road maintenance) are necessary on training areas to maintain their usefulness.

Populations of Oregon Forestsnail on DND land have been found away from roads in forested areas that will continue to be maintained as such, and are only occasionally used for dismounted training. Although training has been ongoing at the site for over 25 years, the soils do not appear to have been compacted by this use. The fact that there are still extant populations with juveniles indicates that this threat is negligible.

IUCN-CMP Threat 7. Natural system modifications

7.1 Fire and fire suppression

Burke et al. (1999) cited fire as a threat to gastropod populations in Washington State. The threat of fire is present throughout the entire range of Oregon Forestsnail, particularly within large natural tracts of land, in areas adjacent to roadways, and rights-of-way and in recreational areas where campfires occur.

Deciduous forests within the range of Oregon Forestsnail remain moist and wet throughout the year, but the threat of forest fires is possible, particularly in July through September.

Human activities that increase the threat of fire include careless attendance to campfires, discarded cigarettes, improperly wired camping equipment, and machinery used within wilderness areas. Forests fires are yearly occurrences, although efforts are made to control the frequency, size, and spread of fire through fire suppression programs (e.g., brush burning).

Brush clearing, piling, and periodic burning of vegetation and woody debris occur on private and public lands throughout the range of Oregon Forestsnail. Although burning would only impact small areas of land, there is the possibility of overlap with unknown occurrences of Oregon Forestsnail. The smoke generated from periodic brush burning, and the resultant char and burned debris are also detrimental to habitat quality.

All Oregon Forestsnail locations are threatened by fire, however, not at the same time. If or when a fire will occur at a particular site is unknown and the overall impact from fire is not known at this time.

7.3 Other ecosystem modifications

Mowing and cutting of vegetation within sites (often as a form of fire suppression) adversely affect Oregon Forestsnail. Removal of vegetation may impact Oregon Forestsnail through decreasing available moisture retention within habitats and increasing dehydration stress to individuals and direct mortality; as gastropod activity patterns predominantly coincide with preventing dehydration (Prior 1985). This threat is present throughout a small portion of its range especially at the urban interface; roadsides, trails and other rights-of-way; agricultural areas; and recreational areas control campfires.

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

8.1 Invasive non-native/alien species

Introduced gastropods, invertebrates, and plant species have been recorded from most Oregon Forestsnail habitats, although the scope of introduction and suite of species present is not fully known. Greater than 90% of sites have introduced species present, particularly Himalayan blackberry (*Rubus armeniacus*) and other non-native plants, introduced gastropods, earthworms, and various introduced Carabid beetles. Invasive terrestrial gastropods can out-compete and predate upon Oregon Forestsnail.

Introduced invertebrates, particularly introduced gastropods, may pose a threat to Oregon Forestsnail through competition for food and shelter or through predation (COSEWIC 2002). Rollo and Wellington (1979) demonstrated intra- and interspecific aggression among slugs and competition for refuges. Introduced gastropods of European origin are widespread within urban and agricultural areas within the Lower Fraser Valley and southern Vancouver Island, and several species have penetrated forested habitats (Forsyth 1999, 2001). These species continue to spread into new areas with inadvertent assistance from humans when nursery plants, garden ornamentals, or other materials with adhering soil are transported or when garden waste is discarded (Forsyth 1999). Roads are also known to increase the spread of introduced species and predation pressure on gastropods (Trombulak and Frissell 2000).

Three introduced species are locally common in the Lower Fraser Valley: Giant Gardenslug (*Limax maximus*), Dusky Arion (*Arion subfuscus*), and Longneck Fieldslug (*Deroceras panormitanum)*, are particularly aggressive. The introduced, carnivorous Dark-bodied Glass-snail (*Oxychilus draparnaudi*) is locally common in southern Vancouver Island (Victoria area) and greater Vancouver areas (Forsyth 1999) and probably also occurs within the range of Oregon Forestsnail in the Lower Fraser Valley. Dark-bodied Glass-snail could potentially be a significant predator of Oregon Forestsnail eggs and young (K. Ovaska, pers. comm., 2003). This species has been identified as a potential threat to native gastropods in other areas where it has been introduced (Frest and Rhodes 1982). Other introduced gastropod species that may compete with Oregon Forestsnail include Grovesnail (*Cepaea nemoralis*) and other species of slugs, such as the Chocolate Arion (*Arion rufus*) and the Gray Fieldslug (*Deroceras reticulatum*).

Although most invasive gastropods species are primarily in areas of high human use and alteration, some have spread into intact coniferous forest habitats and increased their range extent (K. Ovaska, pers. comm., 2008). Within forests in Washington State, Chocolate Arion is documented from within old-growth forests, and may be displacing native Banana Slug

(*Ariolimax columbianus*) (Burke *et al.* 1999). Concentration of snails into small habitat patches with less overall shelter and escape cover is likely to increase their vulnerability to predation.

Some invasive plant species are known to change the forest floor vegetation and soil structure and facilitate an increase in light penetrating the understory vegetation to the forest floor. Increases in light levels lead to drier microclimate, understory conditions, and desiccation to the forest floor; they also increase dehydration stress to gastropods that depend upon high water and humidity levels. Invasive plants, such as Scotch broom (*Cytisus scoparius*), gorse (*Ulex europaeus*), English holly (*Ilex aquifolium*), and spurge-laurel (*Daphne laureola*) are likely to invade disturbed areas. English ivy (*Hedera helix*) is known to spread and displace the native vegetation on forest floors. Native gastropods are not known to live within vegetation patches of English ivy (Burke *et al.* 1999). English holly and Himalayan blackberry are also widely spread invasive plants within native ecosystems within southern Vancouver Island, and are known to displace native vegetation and may impact native stinging nettle. Oregon Forestsnail appears to be able to survive within habitat that has Himalayan blackberry (e.g., Colony Farms – Metro Vancouver Regional Park).

The threat of invasive species likely exists at all Oregon Forestsnail sites; however, there is some uncertainty as to the level of impact of this threat.

IUCN-CMP Threat 9. Pollution

9.3 Agricultural and forestry effluents

The use of pesticides, especially those aimed at gastropods, has potential to harm Oregon Forestsnail populations by directly killing both individuals and eggs. The only application of pesticides that specifically target gastropods that is likely to occur is on privately owned properties close to houses, barns, or other human structures where Oregon Forestsnail is mistaken for a pest species. Overall, the general use of herbicides within parks and protected areas is diminishing due to municipal and regional bylaws that limit the use of these chemicals (e.g., City of Richmond). Provincial initiatives that consider the ban on home use of pesticides for cosmetic purposes throughout B.C. are ongoing (Nagel 2011). However, pesticide bans are controversial in some municipalities (e.g., Cassidy 2011).

Agricultural and forestry effluents are likely to harm Oregon Forestsnail habitat and individuals. For example, the use of herbicides to control regeneration of bigleaf maple on commercial forestry lands may also impact snail populations in adjacent, mature stands, through run-off. Young bigleaf maple regeneration within conifer plantations competes with commercial tree species and herbicide treatments (either stump or foliage applications) are applied to control competing vegetation. This herbicide treatment can potentially harm or reduce habitat available to land snails.

Oregon Forestsnail is frequently recorded from forest and trail edge habitats, with at least three sites known to occur adjacent to well-used recreational trails within urban parks. Other land snails, such as Copse Snail (*Arianta arbustorum*), prefer moving along road verges and avoid crossing roads, including unpaved roads only 3 m wide (Baur and Baur 1990). Spraying herbicides to control road or trail-side vegetation likely harms gastropods within these verges,

and the cumulative and persistent effects of herbicides within these environments may lead to long-term declines in gastropod numbers. Herbicides are used less today and many municipalities have bans on certain herbicides, but it is unclear how extensive this practice was (or is currently) within the range of Oregon Forestsnail.

The close association of Oregon Forestsnail with stinging nettle may indirectly be detrimental to Oregon Forestsnail habitat. This is because stinging nettle may be targeted for removal in recreational areas with high human use due to the plant's ability to cause skin irritation.

It is possible agricultural run-off could impact the species. The snail has been found adjacent to agricultural and urban run-off areas, so the overall impact to the species is unknown. Increasing blueberry acreage throughout the Fraser Valley includes many sites potentially adjacent to Oregon Forestsnail habitat. Concern for fruit pests such as Spotted Wing Drosophila (*Drosophila suzukii*) has resulted in intensive spraying of hedgerows, riparian areas, and other vegetation that includes wild fruits capable of serving as refuge for Spotted Wing Drosophila. This may in turn be a problem for edge species such as Oregon Forestsnail. Human activities such as pesticide and fertilizer application threaten Oregon Forestsnail in much of the remaining areas of suitable habitat, particularly those adjacent to the urban/agricultural interface.

This threat applies to 13 known sites, although there are likely additional sites adjacent to agricultural areas where effluent run-off occurs. The impact of this threat is unknown and requires research.

IUCN-CMP Threat 10. Geological events

10.2 Earthquakes/tsunamis

The distribution of Oregon Forestsnail records and potential habitat includes areas of the Lower Fraser Valley that could potentially be impacted from rising water levels as a result of an earthquakes or tsunamis. However, the timing of such events is unknown.

10.3 Avalanches/landslides

Oregon Forestsnail habitat includes steeper hillsides and riparian areas where minor landslides and washouts could occur, particularly in areas with unstable historic road construction and improper culvert drainage. The forested areas of Chilliwack and Hope are where this threat is most likely to apply. Overall, this threat is thought to be negligible as the amount of Oregon Forestsnail habitat thought to be at risk is negligible.

IUCN-CMP Threat 11. Climate change and severe weather

11.2 Droughts

Increased summer droughts may affect occupied Oregon Forestsnail habitats and will decrease the available site moisture that allows for suitable microhabitat. Combined with other threats, such as water diversion and infilling, drought within natural habitat may increase in the next 10 years. The impact of this threat is unknown.

11.4 Storms and flooding

Some areas of Oregon Forestsnail habitat such as the valley bottom within the Lower Fraser Valley is within the potential flood zone of the Fraser River (B.C. Ministry of Environment 2011b). The greatest vulnerability to flood risk within the range of Oregon Forestsnail includes parts of Langley, Pitt Meadows, Chilliwack, Kent, Abbotsford, Tsawwassen, Mission, Hope, Port Coquitlam, and Surrey (Fraser Basin Council 2011). The Lower Fraser Valley has experienced major floods: the largest in 1894 and the second largest in 1948. Within the next 50 years there is a one-in-three prediction that a flood of similar magnitude will occur within the Lower Fraser Valley (Fraser Basin Council 2011). Overall the severity of this threat is thought to be slight.

5 RECOVERY GOAL AND OBJECTIVES

5.1 Population and Distribution Goal

The population and distribution goal is to maintain current (and new) populations and supporting habitat for Oregon Forestsnail throughout the species natural range and distribution in British Columbia.

5.2 Rationale for the Population and Distribution Goal

Overall the population and distribution goal aims to ensure no Oregon Forestsnail populations become extirpated. As Oregon Forestsnail has a restricted range in B.C. and low dispersal capability, it will likely always be considered “endangered” unless a significant number of new sites are found and the species’ geographic range in Canada is expanded. Historical abundance and distribution information for this species show only a few confirmed extant populations and historic museum records. There is no information to indicate that the species was previously more widespread; therefore, an objective to actively increase the number of populations, which may allow for down listing of the species, is not appropriate.

The population and distribution goal for Oregon Forestsnail cannot be quantified due to knowledge gaps, as population size is unknown at most sites. The resources, time commitments, and difficulty with estimating populations, coupled with the difficulty of tagging and monitoring small gastropods, make population estimates labour-intensive and logistically difficult. The above population and distribution goal sets a minimum population objective (> 1 snail) for each site. This allows the survival/recovery habitat to be aimed at describing and protecting the habitat needed to ensure the site persists.

5.3 Recovery Objectives

1. To identify and prioritize important Oregon Forestsnail habitat throughout the species’ range in B.C.

2. To secure protection[8] for Oregon Forestsnail habitats within the species' range.
3. To assess and reduce threats at all known sites in B.C.
4. To address knowledge gaps (e.g., population ecology, habitat associations, dispersal) that currently prevents quantitative population and distribution objectives from being established.

6 APPROACHES TO MEET OBJECTIVES

6.1 Actions Already Completed or Underway

Actions listed below have been categorized by the action groups of the B.C. Conservation Framework. Status of the action group for this species is given in brackets.

Compile Status Report (complete)

- COSEWIC report completed (COSEWIC 2002). Update due 2012.

Send to COSEWIC (complete)

- Oregon Forestsnail designated Endangered (COSEWIC 2002). Re-assessment due 2012.

Planning (in progress)

- B.C. Recovery Plan completed (this document, 2012).

Habitat Protection and Private Land Stewardship[9] (in progress)

From 2000 to 2011 there have been substantial search efforts and surveys for Oregon Forestsnail within the species' range in B.C. (Appendix 2). Cumulative search effort has focused on southeastern Vancouver Island, many of the southern Gulf Islands, and areas throughout the Lower Fraser Valley and the Sunshine Coast. Survey effort has also focused on the edges of the species' known range, yet despite the intense search effort, there has been no substantial increase in the known range since the initial status report (COSEWIC 2002).

Surveys (years) by local conservancy groups for species at risk working on a number of the Gulf Islands have not recorded Oregon Forestsnail

Oregon Forestsnail is easily identifiable and often recorded as an incidental observation submitted to the B.C. Conservation Data Centre (L. Gelling, pers. comm., 2011). In the past 10 years, local government biologists and conservancies have worked to raise the profile of Oregon

[8] 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.
[9] Most land within the range of Oregon Forestsnail is privately owned, either by local government or by private citizens. Currently there is no legislative protection specifically for Oregon Forestsnail habitat on provincially or privately owned lands in B.C.

Forestsnail amongst professional biologists working within the species' range. As a result, researchers, conservancies, biologists, naturalists, and members of the public voluntarily send records to the B.C. Conservation Data Centre (2011) and information on the species' patchy distribution and habitat association has increased substantially.

Oregon Forestsnail habitat adjacent to natural watercourses is indirectly protected through provisions of the B.C. *Water Act*.

Oregon Forestsnail habitat is also indirectly protected under provisions in the *Riparian Areas Regulation* under the B.C. *Fisheries Act*, which requires habitat buffers to remain around watercourses (depending on the size of the watercourse); however, habitat buffer sizes are often not large enough to protect the entire population of the snail.

Oregon Forestsnail is recommended for listing as Identified Wildlife under the *B.C. Forest and Range Practices Act*. At present, the species is not listed under this Act. Once listed under this Act, it will be possible to protect known habitat for this species within Wildlife Habitat Areas on provincial Crown land.

Oregon Forestsnail has been found in Bridal Veil Falls Provincial Park and Cultus Lake Provincial Park, which are afforded protection through the legal provisions of the *BC Parks Act*. Currently there are no specific management provisions within the respective park master plans for Oregon Forestsnail; however, park staff is aware of the Oregon Forestsnail occurrences in these popular recreational areas.

Metro Vancouver (regional district) land managers are aware of the Oregon Forestsnail and are working to incorporate best management practices into park maintenance planning within parks where the species has been recorded (West Area Parks, M. Merkens, pers. comm., 2011; East Area Parks, J. Jarvis, pers. comm., 2011; and Central Area Parks A. Evelly, pers. comm., 2011).

There are no local (municipal and regional) government bylaws that specifically protect Oregon Forestsnail; however, numerous development permit applications (depending on the jurisdiction) require environmental assessments that include wildlife values and consider impacts to natural habitats as part of the approval process. Some municipalities have an Official Community Plan that designates environmentally sensitive development permit areas and can direct development away from these sensitive areas with high ecological (species at risk) values.

Oregon Forestsnail populations have been recorded from four private conservation areas in the Lower Fraser Valley. One is the TWU-ESA, which is approximately 50 ha of habitat that is partially covenanted under the B.C. Ministry of Environment, for the protection of fish habitat. The other three properties are owned and/or managed by the Fraser Valley Conservancy (L. Fox, pers. comm., 2011): South Fraser Way (1 ha); Auchenway (0.5 ha); and McKee Property (3.2 ha). Another property is managed by Fraser Valley Conservancy, but owned by the City of Abbotsford.

A management plan for Oregon Forestsnail has been put in place at the Area Support Unit (ASU) Chilliwack military lands managed by the Department of National Defence to prevent harm to individuals or destruction of habitat important for the snail (A. Manweiler, pers. comm., 2011).

6.2 Recovery Planning Table

Table 2. Recovery planning table for Oregon Forestsnail.

Conservation Framework action group	Actions to meet objectives	Threat[a] or concern addressed	Priority[b]
Objective 1. To identify and prioritize important Oregon Forestsnail habitat throughout the species' range in B.C.			
Habitat Protection; Land Stewardship	1. Complete spatial mapping of all suitable Oregon Forestsnail habitats within the B.C. range using information in habitat description. Delineate and label these spatial areas into sites.	Knowledge gap	Essential
Habitat Protection; Land Stewardship	2. Create habitat rating system that categorizes Oregon Forestsnail sites as high, medium, low, etc.	Knowledge gap	Essential
Habitat Protection; Land Stewardship	3. From spatial mapping, prioritize sites for Oregon Forestsnail inventory based on habitat suitability rating, previous/ongoing inventory or known records; and categorize into habitat protection measure options based on land tenure (e.g., level of government, private, agricultural lands), and other pertinent information.	Knowledge gap	Essential
Habitat Protection; Land Stewardship	4. Create standard protocol for gathering habitat information at each site to be inventoried (e.g., proper timing, when to look, where to look, protocols). This will assist with habitat suitability rating (e.g., as prioritized sites for protection) and identifying survival/recovery habitat.	Knowledge gap	Essential
Habitat Protection; Land Stewardship	5. Work with South Coast Conservation Program to contact private landowners with priority sites for inventory. Complete private landowner contact and request for inventory.	Knowledge gap	Beneficial
Habitat Protection; Land Stewardship	6. Inventory high priority habitat on Crown (federal and provincial) lands within the range of Oregon Forestsnail to prevent land from being disposed, or forest activities from impacting populations on Crown lands.	Knowledge gap	Essential

Conservation Framework action group	Actions to meet objectives	Threat[a] or concern addressed	Priority[b]
Objective 2. To secure protection for Oregon Forestsnail habitats through active engagement with all levels of government and landowners within the species' range.			
Habitat Protection; Land Stewardship	7. Where Oregon Forestsnail is recorded on Crown lands (federal and provincial), initiate protection measures under existing legislation and government policy.	All	Essential
Habitat Protection; Land Stewardship	8. Recommend Oregon Forestsnail to be listed as Identified Wildlife under B.C. *Forest and Range Practices Act*.	5.3	Essential
Habitat Protection; Land Stewardship	9. Work with municipalities to use environmental protection tools as afforded under current legislation (e.g., Development Permit Areas, Riparian Areas Regulation). In addition, collaboratively work together to outline and formulate new environmental protective tools that are specific to each local government, that enable locally led protection for private landowners within each jurisdiction (e.g., establish wording to assist with bylaws, Sensitive Development Permit Areas, and pesticide restrictions, specific to the local government).	All	Essential
Habitat Protection; Land Stewardship	10. Work with South Coast Conservation Program to contact private landowners regarding stewardship options and other protective measures at sites where inventory resulted in Oregon Forestsnail occurrences. Combine information with other species at risk habitat needs, and define priority sites for stewardship and protection opportunities.	Knowledge gap	Necessary
Habitat Protection; Land Stewardship	11. Work with South Coast Conservation Program, additional non-government organizations, as well as government partners, to develop specific best management practices guidelines for private land owners based on the land use (e.g., land managers, housing developers, small property owners, and residents; local government lands; and consultants who work with these private landowners) and include options for managing habitat for forest-floor invertebrates under different land use practices.	All	Necessary
Habitat Protection; Land Stewardship	12. Work with South Coast Conservation Program, additional non-government organizations as well as government partners, to increase public understanding and knowledge of Oregon	5.1 6.1 8.1 9.3	Necessary

Conservation Framework action group	Actions to meet objectives	Threat[a] or concern addressed	Priority[b]
	Forestsnail and associated threats to the species. (e.g., prepare a fact sheet or at-risk brochure on all rare terrestrial gastropods in south western B.C.; promote the inclusion of the species in interpretive materials by local government bodies and by provincial and national parks within the species' potential range; provide information on the species at the B.C. Conservation Data Centre website, other provincial websites on species at risk, and the federal agencies responsible for species at risk; develop and present workshops on conservation and restoration of remnant forest ecosystems in the Lower Fraser Valley lowlands and southern Vancouver Island.)		
Habitat Protection; Land Stewardship	13. Spatially map areas that are protected at each of the site(s) identified in Actions 1 and 2 outlined above. After five years of stakeholder engagement, re-evaluate approach.	Knowledge gap	Necessary
Habitat Protection; Land Stewardship	14. Work with parks and protected areas to ensure Oregon Forestsnail is integrated into park management planning activities. Actions such as signage, vegetation management options around occupied habitats, and identification training for parks staff. At all levels of government, implementing recommendations within such plans will ensure threats to the species are minimized within these protected areas.	6.1 7.1 8.1 9.3	Essential
Habitat Protection; Land Stewardship	15. Amend provincial park management plans to include management practices that enable the protection of Oregon Forestsnail habitat.	6.1 7.1 7.3 8.1 9.3	Essential
Objective 3. To assess and reduce threats at all known sites in B.C.			
Habitat Protection; Land Stewardship	16. When completing inventory, attempt to list, quantify, and rate threats to habitat at each known site through standard protocol thereby assessing reasons snails may or may not be present within certain habitats. Work this threat assessment categorization into Best Management Practices Guidelines and advice during environmental assessments.	All	Essential
Habitat Protection; Land Stewardship	17. Using outputs from Objective 1 - Actions 1 and 2, overlay spatial information that shows flood information, forest fire information, immediate	1.1 1.2 1.3 7.1	Beneficial

Conservation Framework action group	Actions to meet objectives	Threat[a] or concern addressed	Priority[b]
	development applications (e.g., *Water Act* approval applications, sensitive ecosystems and other relevant environmental information). This will reveal habitats that may be more vulnerable to these related threats and allow for an estimation of impact should one of these threats occur.	11.2 11.4	
Habitat Protection; Land Stewardship	18. Investigate distribution and habitat use patterns of Oregon Forestsnail in relation to those of introduced predators and competitors.	Knowledge gap 8.1	Beneficial
Habitat Protection; Land Stewardship	19. Work with Invasive Species Council to increase understanding of the importance of native gastropods (to the agricultural, public and gardening community) and the difference between native and non-native species and encourage citizens to prevent the accidental introduction of invasives into new habitats and/or encourage the control of invasives through environmentally friendly means.	8.1 9.3	Beneficial
Habitat Protection; Land Stewardship	20. Establish protocol and test sites to monitor the impacts of pesticide run-off on both Oregon Forestsnails and their habitat from properties adjacent to known sites.	9.3	Beneficial
Habitat Protection; Land Stewardship	21. Work with land developers to ensure that they include the needs of the species in land use plans for urban and rural areas containing Oregon Forestsnail habitat and that habitat is not degraded by developments near occupied habitat.	1.1 1.2 1.3	Essential
Habitat Protection; Land Stewardship	22. In parks and recreational areas, identify site-specific threats to minimize damage to Oregon Forestsnail habitat caused by erosion and destruction of vegetation, e.g., fire management (prevention or suppression activities); restrict intensive recreational activities use within known occupied habitats; and invasive species removal/management programs.	6.1 7.1 8.1 9.3	Essential
Monitor Trends	23. As part of long-term monitoring program, assess changes in habitat use and distribution due to the effects of climate change (e.g., more frequent drought).	11.2 11.4	Beneficial
Monitor Trends	24. Map the spatial habitat loss from the threats of residential, commercial, transportation infrastructure, and recreational development in	Knowledge gap 1.1 1.2	Necessary

Conservation Framework action group	Actions to meet objectives	Threat[a] or concern addressed	Priority[b]
	the Lower Fraser Valley and southeastern Vancouver Island in the past 5, 10, and 50 years.	1.3	
Objective 4. To address knowledge gaps (e.g., population ecology, habitat associations, dispersal, etc.) that currently prevent quantitative population and distribution objectives from being established.			
Monitor Trends	25. Develop protocols and implement test sites that monitor (through mark-recapture studies) salvaged populations of Oregon Forestsnail.[c] Concurrently establish mark-recapture studies at protected sites. Gather information on, for example, movements, subsequent threats (e.g., invasive species competition), and other factors.	Knowledge gap	Essential
Monitor Trends	26. Develop monitoring program at known sites (e.g., establish cover boards) to monitor Oregon Forestsnail activity patterns. Investigate the vegetative habitat components and organic components (e.g., coarse woody debris) of each site, and determine what habitat attributes are favoured by Oregon Forestsnail.	Knowledge gap	Necessary

a Threat numbers according to the IUCN-CMP classification (see Table 1 for details).

b Essential (urgent and important, needs to start immediately); Necessary (important but not urgent, action can start in 2–5 years); or Beneficial (action is beneficial and could start at any time that was feasible).

c For example, from *Water Act* Section 9 approvals that permitted alterations to watercourses and subsequent destruction of Oregon Forestsnail populations and habitat.

7 INFORMATION ON HABITAT NEEDED TO MEET RECOVERY GOAL

Threats to Oregon Forestsnail habitat have been identified and habitat is limiting for this species. To meet the population and distribution goal for Oregon Forestsnail in B.C., it is necessary to know the specific habitat requirements of this species. In addition, it is recommended 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

A description of the habitat attributes needed for the survival/recovery of Oregon Forestsnail has been provided in Section 3.3.1. This description is based on current knowledge of the habitat that Oregon Forestsnail occupies, although there are some aspects of the species' habitat requirements/preferences that require further study.

It is recommended that sites with suitable habitat are geospatially described. A schedule of studies outlining the work necessary to further describe survival/recovery habitat is provided in Table 3.

7.2 Studies Needed to Describe Survival/Recovery Habitat

Table 3. Studies needed to describe survival/recovery habitat to meet the recovery goal for Oregon Forestsnail.

Description of activity	Outcome/rationale	Start date
Conduct habitat assessments that record descriptive measures at known site (e.g., coarse woody debris, moisture, soil attributes, plant species composition, subspecies of stinging nettle recorded at sites).	Enables comparison of sites for habitat values.	2013
Conduct mark-recapture studies on Oregon Forestsnail.	Gain a better understanding of home range, dispersal, and sink-source habitat dynamics; whether snails cross trails or roadways or other physical barriers.	2013
Spatially define habitat polygons at each Oregon Forestsnail site (with suitable habitat and abundant populations) using established mapping techniques, plant community classification, coarse woody debris classification guidelines, and other existing resources for describing habitat attributes.	Enables spatially defined habitat at each site, to direct actions to minimize threats.	2013

7.3 Specific Human Activities Likely to Damage Survival/Recovery Habitat

Activities described in Table 4 include those likely to damage survival habitat for Oregon Forestsnail; however, destructive activities are not limited to those listed. See also Section 4 for a description of how the threats to Oregon Forestsnail can remove habitat completely or reduce the function of the habitat and attributes necessary for population viability.

Table 4. Specific human activities likely to damage survival/recovery habitat for Oregon Forestsnail.

Specific activity	Description of how activity would destroy critical habitat	Related threat[a]
Hydrological modification of site (e.g., urban and commercial land development, hauling away or removing coarse woody debris; cutting the wood into pieces; removing bark, or otherwise destroying coarse woody debris containing a nest)	Any activity that changes the hydrology of the site (microclimate of the area) and increases the potential for either flooding or drying of the nest site is considered damaging.	1.1 1.2 1.3 4.1 6.1
Changes to soil (e.g., recreational activities such as	Excavating, contaminating, or compacting soil can physically destroy, move, or alter the nest site within the	6.1 9.3

Specific activity	Description of how activity would destroy critical habitat	Related threat[a]
mountain biking and all-terrain vehicle use within occupied habitats, excavating, herbicides)	forest litter and can affect its future occupancy or productivity.	
Removal of the tree canopy (e.g., forest harvest, clearing for development, campground expansion, trail or road maintenance/construction)	Removal of the overstory/forest canopy causes drying of the microclimate and eliminates a long-term source of CWD. Removal of forest canopy from the immediate vicinity of the nest will result in drier forest floor conditions, which can be deleterious to the eggs.	1.1 1.2 1.3 4.1 5.3
Removal of the understory (e.g., forestry activities; herbicide and other chemical applications; fire suppression activities, including mowing, pruning, and brush burning [at inappropriate times of the year])	Removal of the understory habitat can lead to desiccation and/or reduced humidity at the site.	5.3 7.1 7.3 9.3
Modification of understory (e.g., planting, spread of invasive species by dumping unwanted compost or vegetation)	Planting or dumping of unwanted compost or vegetation can result in the spread of introduced plants into parks, protected areas, or other natural habitats. Invasive plants can impact the microhabitat and understory forest floor structure within sites.	8.1

[a] Threat numbers according to the IUCN-CMP classification (see Table 1 for details).

8 MEASURING PROGRESS

The successful implementation of recovery actions for Oregon Forestsnail will be indicated through monitoring of populations and habitat trends through time. Oregon Forestsnail may have an annual life cycle and therefore population sizes may vary substantially from year to year and overall population (on a scale of decades) may vary within areas of suitable habitat. Population monitoring will allow for an indication of possible extirpation at a given site, changes in area of extent at a given site, and whether the number of extant populations is stable or increasing. The recovery plan will be reviewed in five years to assess progress and to identify additional approaches or changes that may be required to achieve recovery.

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

Objective 1: To identify and prioritize important Oregon Forestsnail habitat throughout the species range in B.C.

- Spatial mapping of potential Oregon Forestsnail habitat within its B.C. range is completed by 2016.
- Identification and inventory of 5% of potential habitat within the species' range is inventoried each year.

Objective 2: To secure protection for Oregon Forestsnail habitats within the species range.

- Oregon Forestsnail has been recommended for listing as Identified Wildlife under the provincial *Forest and Range Practices Act* by 2016.
- Stewardship agreements and/or covenants for 25% of known Oregon Forestsnail sites have been established on local government lands by 2016.

Objective 3: To assess and reduce threats at all known sites in B.C.

- Specific management practices guidelines for Oregon Forestsnail for each landowner or land manager, specific to the threats of the site have been drafted by 2016.

Objective 4: To address knowledge gaps (e.g., population ecology, habitat associations, dispersal) that currently prevent quantitative population and distribution objectives from being developed.

- Studies addressing knowledge gaps have been initiated by 2016.

9 EFFECTS ON OTHER SPECIES

The Oregon Forestsnail, as with other herbivorous land snails, performs important ecological functions in forest ecosystems as decomposers and consumers of live and decaying plant matter (see Mason 1970; Richter 1979, 1980ab; Gervais *et al.* 1998). Some species also function as dispersal agents for plant seeds and fungal spores, including fungi that form essential mycorrhizal associations with tree roots. The significance of the Oregon Forestsnail in such processes is unknown but may be considerable given the species' relatively large size and local abundance in suitable moist habitats.

Oregon Forestsnail can be observed in high abundance at some sites (B.C. Conservation Data Centre 2012) and may provide a significant food source for other invertebrates, birds and/or small mammals. In particular, the concentration of calcium within shells is likely a significant source for other invertebrates in the ecosystem. There are likely parasitic arthropods that rely on this species to complete their life history, although the obligatory links between these species' are not fully known.

In addition to Oregon Forestsnail, approximately 464 provincially listed (Red or Blue-listed) species at risk inhabit the coastal lowlands of southeastern Vancouver Island and the Lower Fraser Valley (B.C. Conservation Data Centre 2012) and more than 155 of these species have been assessed by COSEWIC (COSEWIC 2010; B.C. Conservation Data Centre 2012).

Coordinated, ecosystem-based approaches are needed to ensure Oregon Forestsnail recovery activities are compatible with recovery activities for other species and ecosystems within its range. Stewardship activities that result in protection or public awareness of the conservation values of Oregon Forestsnail habitat are expected to benefit all wild native species that use these ecosystems. The protection and /or suitable management of key areas will help to restore these ecosystems over the long term. There are no negative impacts anticipated as a result of recovery efforts for this species.

Survey and habitat assessments for Oregon Forestsnail may increase knowledge about other gastropod species at risk within similar habitats and overlapping geographic range including:

- Puget Oregonian Snail (*Cryptomastix devia*) (COSEWIC Extirpated 2002). The two species overlap in their habitat use and geographic distribution in both the Lower Mainland (Conservation Data Centre 2008) in the United States (Pilsbry 1940).
- Blue-grey Taildropper slug (*Prophysaon coeruleum*) (COSEWIC Endangered 2006), an older forest associate, which is known from only a few localities in Canada, all on southern Vancouver Island.
- Evening Fieldslug (*Deroceras hesperium*) (Data Deficient 2003).
- Threaded Vertigo (*Nearctula* sp. 1) (Special Concern 2010).
- Dromedary Jumping-slug (*Hemphillia dromedarius*) (Endangered 2003) on southern Vancouver Island.
- Warty Jumping-slug (*Hemphillia glandulosa*) (Special Concern 2003), on southern Vancouver Island.

Plant species that may benefit as a result of recovery efforts for Oregon Forestsnail (note COSEWIC status is in brackets):

- Scouler's corydalis (*Corydalis scouleri*) (Threatened 2001).
- Phantom orchid (*Cephalanthera austiniae*) (Threatened 2000).
- Coastal wood fern (*Dryopteris arguta*) (Special Concern 2001).
- Streambank lupine (*Lupinus rivularis*) (Endangered 2002).
- Tall bugbane (*Actaea elata*) (COSEWIC Endangered, 2001) in the Lower Mainland forests.

The mixed deciduous and coniferous lowland and riparian ecosystems of the Lower Mainland and southern Vancouver Island are overall at risk from urban and rural development, fragmentation and ecological changes from introduced species. Ecosystems that are composed of older deciduous stands with a component of bigleaf maple and an extensive epiphyte component that includes club moss (*Selaginella oregana*) and abundant true mosses (*Hylocomium splendens, Leucolepis menziesii, Isothecium stoloniferum,* and *Neckera menziesii*), lichens (*Cladonia, Nephroma,* and *Crocynia* spp.), and the licorice fern (*Polypodium glycyrrhiza*) are important for many species, including additional at risk arthropods. These ecosystems would benefit from a detailed evaluation of habitat quality and threats facing them from human activities, and habitat work for Oregon Forestsnail will benefit this ecosystem as a whole. Older bigleaf maples support rich epiphyte (moss, lichen, liverwort, fern) communities and contribute significantly to nutrient cycling and calcium sequestration through the weight of their leaf fall, high nutrient content, and relatively rapid decay rates; and they provide abundant coarse woody debris and nurse logs when they fall (Peterson *et al.* 1999).

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APPENDIX 1. OREGON FORESTSNAIL SITES AND LAND TENURE

Table A1. Oregon Forestsnail sites.

Site name[a]	Land tenure	No. of owners[b]	Size (ha)
Clayburn, Sahhacum Indian Reserve 1	First Nations (Sahhacum Indian Reserve 1)	1	0.78
Coquitlam River, west of	Private (Colony Farms – Metro Vancouver Regional Park)	1	5.4
Abbotsford, south of Clayburn	Private	1	0.19
Abbotsford, south of Highway 11	Private	1	0.19
Nicomen Island	Private	1	2.09
Mountain Slough	Private	Unknown	3.12
Silver Creek	Private	1	Unknown
Vedder Crossing	Private	1	Unknown
Clayburn Creek	Private	1	0.21
Hunter Creek (Hope)	Crown land	1	78.14
Chilliwack, Mount Shannon	Private	2	9.54
Mission, south of Wharton Creek (including Westminster Abbey)	Private	3	0.73
Mission, West Heights	Private	Unknown	0.19
Sumas Mountain, Mckee Peak	Private	2	6.8
Willband Creek	Private	1	0.78
Tones Creek, south of	Private	1	0.2
Poignant Creek	Private	1	12.5
Abbotsford, Eleanor Avenue	Private	1	0.2
Abbotsford	Private	2	2.2
Abbotsford, Marshall Road	Private	1	0.2
Chilliwack Mountain	Private	2	12.9
Chilliwack, Prairie Central and Patterson Road	Private	3	13.3
Chilliwack, south shore of Fraser River	Private	3	312
Hatzic Prairie, Lagace Creek	Private	1	0.38
Pemberton Hills	Private	2	10.9
Ridgedale, 5 km east of	Private	1	0.012
Straiton, Poignant Creek	Private	1	1.8
Sumas Mountain	Private	1	N/A
Tsawwassen	Private	1	0.73
Watt Creek (Cultus Lake)	Crown land (Cultus Lake Provincial Park)	1	2.35
Westholme, northeast of Road/Railway Junction	Private; First Nations	2	8.85
Yarrow, south of		1	4.47

Site name[a]	Land tenure	No. of owners[b]	Size (ha)
Abbotsford, Douglas Taylor Park	Local Government (City of Abbotsford Park)	1	0.78
Chilliwack, Ryder Creek	Private	3	33.74
Tamihi Creek	Crown land; Private	2	4.10
Aldergrove; Aldergrove Regional Park	Private (Fraser Valley Regional District)	1	1.18
Cultus Lake, northwest of; Vedder Mountain	Crown land (Cultus Lake Provincial Park); Private	2	19.18
Luckakuck Creek, Squiaala Indian Reserve 7	First Nations	1	5.39
Chester Creek, Mission	Private	1	0.28
Sperling	Private	1	3.12
Vedder Mountain, Browne Road	Private	1	0.78
Abbotsford, Downes Road	Private	1	12.5
Cemetery Hill	Private	1	3.12
Fort Langley, approx. 3 km south of; Trinity Western University	Private (conservation land); Crown land (leased)	2	0.78
Sumas Mountain Road	Private	1	3.12
Sumas Mountain, West Slope	Private	1	3.12
Wharton Creek	Private	1	3.12
Sumas Mountain, Cox Road	Private	1	0.78
Bridal Veil Falls	Crown land (Bridal Veil Falls Provincial Park); Private; First Nations	3	3.9
Cheam	Private (Cheam Lake Wetlands Fraser Valley Regional Park)		3.9
Chilliwack, Dunville Creek	Private; Crown land	2	2.34
Hatzic Lake, 1 km north of	Private; Crown land	1	1.56
Hatzic Lake, 4.5 km north of	Crown land	1	0.78
Hope, southwest of	Crown land	1	
Hopyard Hill	Private	1	
South Surrey, Little Campbell River	Private (Metro Vancouver Regional District); Private	2	1.56
Vedder Canal, Bergman Road	Private	1	0.78
Sumas Mountain, South Slope	Private	5	0.78
D'herbomez Creek	Private	1	0.28
Herrling Island Road	Private	1	3.12
Nicomen Slough	Private	1	3.12
Total			**615 ha**

[a] Site name is the name assigned to the element occurrence record as recorded in the Conservation Data Centre database.
[b] Population spans numerous properties, does not mean joint ownership of property.

APPENDIX 2. THREATS APPLICABLE TO EACH SITE

Table A2. Threats applicable to each Oregon Forestsnail site.

Site name[a]	Threat number[b]														
	1.1	**1.2**	**1.3**	**2.3**	**4.1**	**4.2**	**5.3**	**6.1**	**7.1**	**8.1**	**8.2**	**9.3**	**11.1**	**11.2**	**11.4**
Clayburn, Sahhacum Indian Reserve 1	0	0	0	0	1	0	0	0	1	1	0	0	1	1	1
Coquitlam River, west of	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
Abbotsford, south of Clayburn	1	1	0	0	1	0	0	1	1	1	1	1	1	1	1
Abbotsford, south of Highway 11	1	1	0	0	0	0	0	1	1	1	1	1	1	1	1
Nicomen Island	0	0	0	0	0	0	1	0	1	1	0	0	1	1	1
Mountain Slough	1	0	0	0	0	0	0	1	1	1	0	1	1	1	1
Silver Creek	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1
Vedder Crossing	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1
Clayburn Creek	1	1	0	0	0	0	0	1	1	1	0	0	1	1	1
Hunter Creek (Hope)	1	0	0	0	0	0	0	1	1	1	0	0	1	1	1
Chilliwack, Mount Shannon	1	0	0	0	0	0	0	1	1	1	0	0	1	1	1
Mission, south of Wharton Creek (including Westminster Abbey)	1	1	0	0	0	0	0	1	1	1	0	1	1	1	1
Mission, West Heights	1	1	0	0	1	0	0	1	1	1	0	1	1	1	1
Sumas Mountain, Mckee Peak	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Willband Creek	1	1	0	0	1	1	0	1	1	1	0	1	1	1	1
Tones Creek, south of	0	0	0	0	1	1	0	1	1	1	0	1	1	1	1
Poignant Creek	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Abbotsford, Eleanor Avenue	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Abbotsford	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Abbotsford, Marshall Road	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Chilliwack Mountain	1	1	0	0	1	0	1	1	1	1	0	0	1	1	1
Chilliwack, Prairie Central and Patterson Road	0	0	0	0	1	0	1	1	1	1	0	0	1	1	1

Site name[a]	Threat number[b]														
	1.1	**1.2**	**1.3**	**2.3**	**4.1**	**4.2**	**5.3**	**6.1**	**7.1**	**8.1**	**8.2**	**9.3**	**11.1**	**11.2**	**11.4**
Chilliwack, south shore of Fraser River	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Hatzic Prairie, Lagace Creek	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Pemberton Hills	1	1	0	1	1	0	0	1	1	1	0	0	1	1	1
Ridgedale, 5 km east of	1	1	0	0	1	0	1	1	1	1	0	0	1	1	1
Straiton, Poignant Creek	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Sumas Mountain	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Tsawwassen	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Watt Creek (Cultus Lake)	1	1	1	0	1	0	0	1	1	1	0	0	1	1	1
Westholme, northeast of Road/Railway Junction	1	1	0	1	1	0	0	1	1	1	0	0	1	1	1
Yarrow, south of	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Abbotsford, Douglas Taylor Park	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Chilliwack, Ryder Creek	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1
Tamihi Creek	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1
Aldergrove, Aldergrove Regional Park	0	0	0	0	0	0	0	1	1	1	0	1	1	1	1
Cultus Lake, northwest of; Vedder Mountain	0	0	0	0	1	0	1	1	1	1	0	0	1	1	1
Luckakuck Creek, Squiaala Indian Reserve 7	0	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Chester Creek, Mission	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Sperling	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Vedder Mountain, Browne Road	1	1	0	1	1	0	0	1	1	1	0	1	1	1	1
Abbotsford, Downes Road	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Cemetery Hill	1	1	0	0	1	0	0	1	1	1	0	1	1	1	1
Fort Langley, approx. 3 km south of; Trinity Western University	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1

Site name[a]	**Threat number**[b]														
	1.1	**1.2**	**1.3**	**2.3**	**4.1**	**4.2**	**5.3**	**6.1**	**7.1**	**8.1**	**8.2**	**9.3**	**11.1**	**11.2**	**11.4**
Sumas Mountain Road	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Sumas Mountain, West Slope	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Wharton Creek	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Sumas Mountain, Cox Road	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
Bridal Veil Falls	1	1	0	0	1	0	0	1	1	1	0	1	1	1	1
Cheam	0	0	1	0	0	0	0	1	1	1	0	0	1	1	1
Chilliwack, Dunville Creek	1	1	0	0	1	0	1	1	1	1	0	0	1	1	1
Hatzic Lake, 1 km north of	0	0	0	0	1	1	1	1	1	1	0	0	1	1	1
Hatzic Lake, 4.5 km north of	0	0	0	0	1	1	1	1	1	1	0	0	1	1	1
Hope, southwest of	1	1	0	0	0	0	0	0	1	1	0	0	1	1	1
Hopyard Hill	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
South Surrey, Little Campbell River	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1
Vedder Canal, Bergman Road	1	1	0	0	1	0	0	1	1	1	0	1	1	1	1
Sumas Mountain, South Slope	1	1	0	0	1	0	0	1	1	1	0	0	1	1	1
D'herbomez Creek	1	1	0	0	1	1	1	1	1	1	0	0	1	1	1
Herrling Island Road	0	0	0	0	1	0	1	1	1	1	0	0	1	1	1
Nicomen Slough	0	0	0	0	1	0	1	1	1	1	0	0	1	1	1
Total number of sites with applicable threat	**42**	**40**	**2**	**3**	**44**	**5**	**11**	**58**	**61**	**61**	**3**	**13**	**61**	**61**	**61**

[a] Site name is the name assigned to the element occurrence record as recorded in the Conservation Data Centre database.

[b] Threat numbers according to the IUCN-CMP classification (see Table 1 for details).

APPENDIX 3. GASTROPOD SURVEYS

Table A3. Gastropod surveys for Oregon Forestsnail on Vancouver Island, Gulf Islands and Lower Fraser Valley, B.C. Note Search Effort Time (hours) and Search Effort Distance (km) have often not been measured during surveys.

Survey year	Report citation	Total # of sites surveyed	# Lower Mainland or Sunshine Coast sites surveyed	# Vancouver Island sites surveyed	# Gulf Islands sites surveyed	Search Effort Time (hours)	Search Effort Distance (km)
1984	Cameron 1986	38	N/A	N/A	N/A	N/A	N/A
1999–2003	Ovaska and Sopuck 2000, 2001, 2002a, 2003a	26	2	24	0	N/A	N/A
2000-2001	Ovaska *et al.* 2001	142	38	104	0	196.6	N/A
2002	Ovaska and Sopuck 2002b	3	0	3	0	71.6	5.6
2003	Ovaska and Sopuck 2003b	52	30	22	0	19.25	N/A
2003	Ovaska and Sopuck 2003c, 2004a	43	0	30	13	N/A	N/A
2003–2004	Ovaska and Sopuck 2004b	43	4	39	0	131.1	N/A
2004–2005	Ovaska and Sopuck 2005	47	47	0	0	57.9	N/A
2006	Ovaska and Sopuck 2006a	26	0	26	0	N/A	N/A
2006	Ovaska and Sopuck 2006b	21	0	21	0	N/A	N/A
2007	Ovaska and Sopuck 2007a	6	0	6	0	N/A	9.2
2007	Ovaska and Sopuck 2007b	6	0	6	0	N/A	
2008	COSEWIC 2010	17	4	13	0		
2008	Ovaska and Sopuck 2008	22	0	22	0	N/A	N/A
2009	Bains *et al.* 2009	10	10	0	0	43	49.6

Survey year	Report citation	Total # of sites surveyed	# Lower Mainland or Sunshine Coast sites surveyed	# Vancouver Island sites surveyed	# Gulf Islands sites surveyed	Search Effort Time (hours)	Search Effort Distance (km)
2008	Ovaska and Sopuck 2009a	6	0	6	0	N/A	N/A
2008	Ovaska and Sopuck 2009b	22	0	22	0	N/A	N/A
2008–2009	Ovaska and Sopuck 2009c	22	0	22	0	N/A	N/A
2009	Department of National Defence 2009	6	0	6	0	N/A	N/A
2010	Ovaska and Sopuck 2010	10	0	10	0	N/A	7.2
2010	Parkinson and Heron 2010	5	5	0	0	30	34.3
2009	Sopuck and Ovaska 2010a	5	0	0	5	N/A	N/A
2010	Sopuck and Ovaska 2010b	1	1	0	0	N/A	N/A
2011	J. Heron, pers. data, 2011	39	39	0	0	144	418.9
2009–2011	Ovaska *et al.* 2011	5	5	0	0	N/A	N/A
1990–2011	R. Forsyth, pers. data, 2011	450	N/A	N/A	N/A	75.5	N/A
Total: 1984–2011		**1083**	**232**	**382**	**18**	**826.9**	**524.8**