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OREGON FORESTSNAIL BEST MANAGEMENT PRACTICES GUIDEBOOK




PREFACE

British Columbia is recognized globally for its exceptional wildlife, diversity of ecosystems and its rich natural resources. The Ministry of Environment and Climate Change Strategy (ENV) works to maintain these valuable natural assets, which are at the heart of many recreational end economic activities enjoyed by British Columbians in all regions of the province.

British Columbia Ministry of Environment and Climate Change Strategy has responsibility for the protection and stewardship of BC's environment. To achieve this goal, the Ministry develops policy and legislation, regulations, codes of practice, environmental contracts and covenants (legal agreements). In addition, the Ministry sets science- and results-based objectives and standards for activities that affect biodiversity. It monitors and reports on selected species and habitats, and acquires information on habitat and species health.

Clear goals, objectives, meaningful performance measures and science-based tools guide Ministry actions in improving environmental management. Regulatory frameworks allow headquarters and regional staff to set and report on standards for environmental quality, and for discharges and emissions to air, land and water. Regulatory compliance is addressed through policy development, enforcement and publicly reporting the results of compliance monitoring.

An Increasing Role for Stewardship:

While the Ministry takes a leading role in the protection of BC's natural resources, species, and habitats, environmental protection and stewardship is the responsibility of all British Columbians. Stewardship of natural resources is integral to maintaining and restoring the province's natural diversity, and achieving the Ministry's important environmental mandate. A stewardship approach involves all British Columbians taking responsibility for the well being of the environment by acting to restore or protect a healthy environment.

The Ministry is actively pursuing opportunities for sharing the responsibility of environmental protection. As a Ministry, ENV looks to establish vital partnerships and move forward together to protect the environment and the health of all British Columbians. The Ministry is listening to and developing partnerships with governments, First Nations, communities, academic institutions, industries, volunteer organizations, and citizens. The involvement of these partners in the shared environmental protection and stewardship of BC's resources is essential because of their local knowledge, resources and expertise. The environment will benefit as a result of an increased level of responsible environmental stewardship ethics, immediate and long-term

improvements to environmental health and an increased awareness of ecosystem needs among the partners.

What will this document do for me?

This document exists to help you act as a steward of the environment. The information in this document helps to ensure that your proposed development activities are planned and carried out in compliance with the various legislation, regulations, and policies that apply to your activity. By understanding the standards your activities must meet, you can choose an appropriate set of best practices to help you carry out your activities to achieve the required standards.

This document provides information on management measures that will benefit Oregon Forestsnail (*Allogona townsendiana*) and associated native terrestrial gastropod fauna (slugs and land snails) found within moist deciduous and mixed-wood forest stands on the Lower Mainland and southern Vancouver Island. The best management practises (BMPs) recommended here will help fulfil requirements towards protection of gastropods at risk but do not replace consultation with a professional biologist who is knowledgeable on the local fauna, who can evaluate needs for a particular situation or site and provide advice on legal requirements. Where multiple species at risk are present, the recommended management measures for each species should be carefully evaluated to identify possible conflicts and opportunities for multi-species management (see South Coast Conservation Program (http://www.sccp.ca/) for framework).

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1. Introduction

This document was initiated by the BC Ministry of Environment and Climate Change Strategy in response to the need to protect and manage habitats of the many species at risk that occur in the Lower Fraser Valley. The assessment of several species of native terrestrial gastropods (slugs and snails) by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and their subsequent listing under the federal *Species At Risk Act* has prompted numerous queries to the Ministry on protection requirements and appropriate management, particularly for the endangered Oregon Forestsnail (*Allogona townsendiana*), within sites designated for development. In Canada, Oregon Forestsnail is known only from the Lower Fraser Valley and from one isolated locality on Vancouver Island (COSEWIC 2002, 2013). Its distribution coincides with the most heavily populated parts of the province, where its forest habitats are shrinking as a result of urban development, agriculture, and other human land uses. This document describes approaches and measures to help ensure that the needs of this species are met.

2. Purpose/Scope

This document is intended to help urban planners, developers, park managers, gardeners, farmers, land stewards, private landowners and other stakeholders to protect Oregon Forestsnail and other native land snails and their habitat and to design appropriate best practices for sites where species at risk are found. The focus is the endangered Oregon Forestsnail, but the recommended measures will also benefit other native slugs and snails that share similar habitats, including other species at risk.

3. Background

3.1 Importance of Land Snails and Slugs

Native forest slugs and land snails (terrestrial gastropods) perform important ecological roles and contribute to the health of the ecosystems they occupy. Unlike introduced invasive slugs and snails, they rarely become garden or agricultural pests. By consuming large quantities of live, dead, and decaying vegetation they facilitate the turnover of nutrients and minerals and aid in decomposition (Mason 1970; Richter 1979, 1980). In turn, they are consumed by a variety of invertebrate and vertebrate predators. Snails concentrate calcium and other minerals in their shells, which are then released in forms usable by other organisms when the snails die or are consumed by predators. Many gastropods feed on fruits of forest understorey plants and fungi, aiding seed and spore dispersal (Richter 1980; Gervais *et al*. 1996). These fungi include species that form essential, symbiotic (or mycorrhizal) associations with tree roots; the fungi help the roots absorb minerals and water from the soil, so enhancing the plants' ability to withstand environmental stresses. Thus, slugs and snails contribute to the health of the forest ecosystem.

Declines of non-marine molluscs, including land snails, are a global phenomenon that often goes unnoticed and undocumented (Lydeyard *et al.* 2004; Regnier *et al*. 2009). There is an urgent need to investigate and document gastropod faunas and population trends of species at risk across the landscape and manage their habitats in multi-use areas so that biodiversity and ecological values are preserved. In British Columbia, about 40 native terrestrial gastropods occur on the Lower Mainland and Vancouver Island (Forsyth 2004). Several species reach the northern limits of their distribution in these regions and are found nowhere else in Canada, including Oregon Forestsnail. Populations at the northern extremity of a species' distribution may possess unique ecological adaptations and provide a reservoir of variability that allows the species to respond to changing environmental conditions. The BC red- and blue-lists include several gastropod species that are of conservation concern (BC Species Explorer: http://www.env.gov.bc.ca/atrisk/toolintro.html), and some are also listed nationally under the federal *Species at Risk Act* (SARA). Currently, Oregon Forestsnail is one of three federally listed terrestrial gastropods known from the Lower Mainland; Threaded Vertigo (*Nearctula* sp. A; special concern), a small semi-arboreal snail, occurs on the Sunshine Coast, Vancouver Island, and Gulf Islands; Puget Oregonian (*Cryptomastix devia*), a large snail that occupied similar habitats as Oregon Forestsnail, is now believed to be extirpated from Canada. In addition to Oregon Forestsnail, the following *SARA*-listed species occur on Vancouver Island: Blue-grey Taildropper (*Prophysaon coeruleum*) – endangered (down-listed by COSEWIC to threatened in

2016); Dromedary Jumping-slug (*Hemphillia dromedarius*) – threatened; Warty Jumping-slug (*Hemphillia glandulosa*) – special concern; Haida Gwaii Slug (*Staala gwaii*) – special concern, occurs on Vancouver Island and Haida Gwaii. Although not documented, Blue-grey Taildropper and Warty Jumping-slug may potentially occur in Oregon Forestsnail habitats.

3.2 Distribution of Oregon Forestsnail

The range of Oregon Forestsnail extends from southwest British Columbia to west-central Oregon. In British Columbia, the species occurs in the Lower Mainland from Burnaby east to the Chilliwack River Valley and north to Hope (Figure 1; COSEWIC 2013). The snail is most frequently encountered in the Abbotsford, Chilliwack, Mission, and Kent areas. Oregon Forestsnail is known from a single locality on Vancouver Island, near Crofton on the southeast coast of the island.

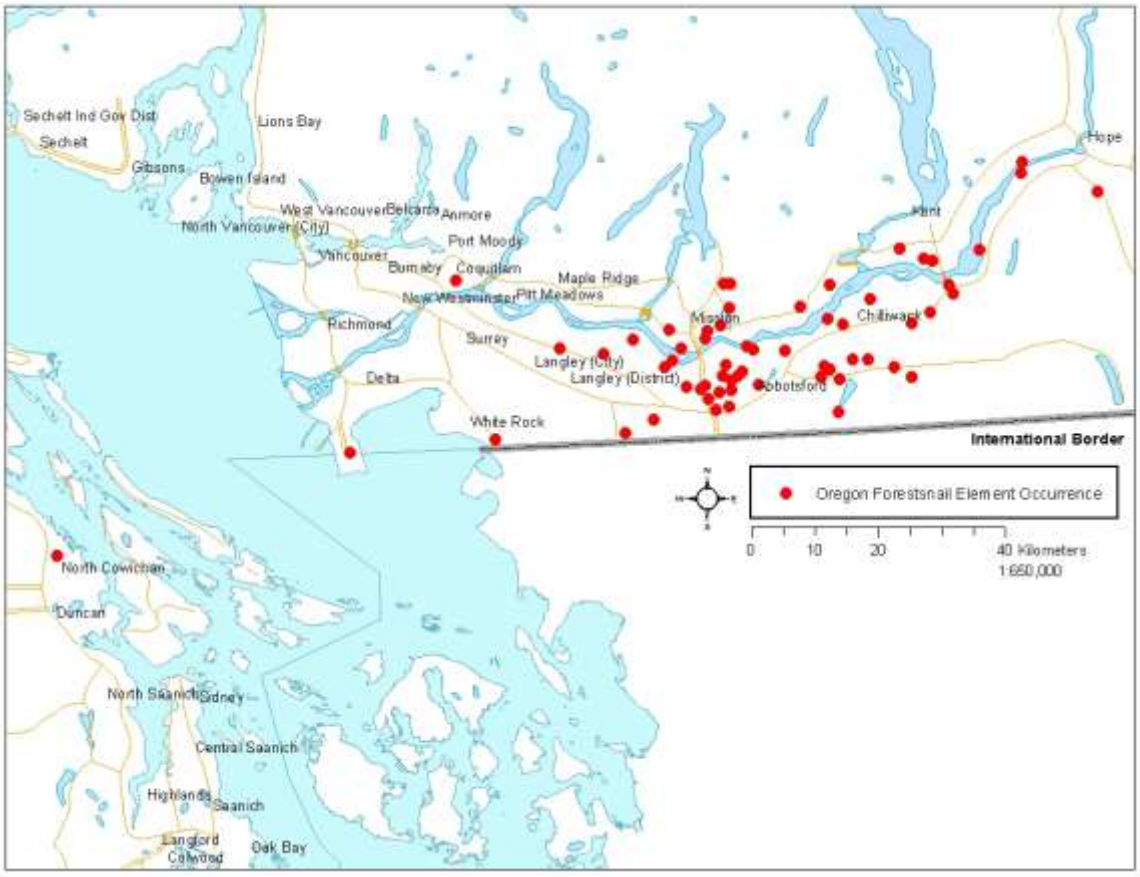

FIGURE 1. DISTRIBUTION OF OREGON FORESTSNAIL IN BRITISH COLUMBIA. NOTE THERE ARE SOME RECORDS THAT ARE NOT YET PUBLICALLY AVAILABLE ON THE BC SPECIES AND ECOSYSTEMS EXPLORER WEBSITE AND/OR HAVE NOT YET BEEN UDPATED.

3.3 Species Description

Oregon Forestsnail is a large snail with adult shell width ~28–35 mm. The shell is globular and slightly flattened. Diagnostic features include fine ridges and grooves on the shell, giving it a somewhat rough texture, and a shell aperture with a white, thickened rim or lip that flares outward (Figure 2). The outer layer of the shell (periostracum) is straw-yellow to light or reddish brown and is often partially worn off, exposing the whitish under-layer. The animal itself is pale brown. Juveniles resemble adults, but their shell lacks the white, thickened lip; very small juveniles (<5 mm shell width) can be difficult to identify. Eggs are laid in clusters of up to ~35 in moist sites, usually in shallow burrows in soil or leaf litter, and cannot be readily distinguished from eggs of other snails and slugs. Consult guidebooks (e.g., Forsyth 2004) for a detailed description of this and other species of terrestrial gastropods. See Section **Other species of gastropods** for species of snails that co-occur with Oregon Forest Snail and with which it may be confused.

3.4 Other Species of Gastropods

Many other species of snails and slugs co-occur with Oregon Forestsnail. In British Columbia, Puget Oregonian, another large (adult shell width 20 – 23 mm) and superficially similar snail, is known only from historical records and is presumed to be extirpated; however, pockets of this snail could still exist in the province, and the species should be included in the list of target species in surveys of Oregon Forestsnail habitats. Other large native snails, such as Pacific Sideband (*Monadenia fidelis*), Northwest Hesperian (*Vespericola columbianus*), and Lancetooth snails (*Haplotrema vancouverense* and *Ancotrema* species), and numerous small snails with adult shell diameter less than 1 cm, commonly occur in habitats occupied by Oregon Forestsnail. With the exception of Oregon Forestsnail and Puget Oregonian, none of the above species are currently listed as species at risk (see Section **Importance of land snails and slugs** for listed species of slugs in southwest British Columbia).

Oregon Forestsnail can be distinguished from all other snails within its range in British Columbia by the thickened white rim or lip around the aperture of the adult shell. An exception is the Puget Oregonian that also has a similar thickened apertural lip; however, Puget Oregonian has a denticle (a white protuberance) within the aperture of the adult shell, seen when the shell is viewed from below and the animal is retracted into the shell; this structure is lacking from the Oregon Forestsnail's shell. The shell of Pacific Sideband is typically chestnut brown with a light band (a yellowish unbanded form also exists) and larger (adult shell width 22 – 36 mm) than the shell of Oregon Forestsnail (23 – 30 mm), but there is much overlap in size. Northwest Hesperian (*Vespericola columbianus*) is smaller (adult shell width 10 – 17 mm), and the outer

layer of the shell is usually covered with small hair-like projections. Lancetooth snails have a flattened, greenish yellow shell, as well as a thin apertural lip. The shell of the introduced Grovesnail (*Cepea nemoralis*; shell width 20 – 25 mm) is usually but not always striped, and unstriped individuals could be confused with Oregon Forestsnail. However, the shell of Grovesnails is glossy and lacks the white, thickened rim of the shell opening; the umbilicus is closed in adults. Introduced Brown Gardensnail (*Cornu aspersum*; adult shell width 27 – 32 mm) has a more conical shell, fewer whorls, and larger apertural opening than Oregon Forestsnail, and also lacks the thickened apertural lip. See Figure 3 for images of other co-occurring large snails.

Figure 2. Oregon Forestsnail; adult with thickened white rim around shell opening (top left and right, and bottom right); juvenile (bottom left); photos by Jennifer Heron (top left and right) and Kristiina Ovaska (bottom).

Oregon Forestsnail

Puget Oregonian

Pacific Sideband, pale form

Pacific Sideband, typical dark form

Northwest Hesperian, smooth-shelled form

Northwest Hesperian, typical “hairy-shelled” form

Grovesnail, striped form (introduced)

Brown Gardensnail (introduced)

Figure 3. Sample of large snails that occur within Oregon Forestsnail’s distribution in British Columbia. Photos by Kristiina Ovaska.

3.5 Habitat and Biological Needs

Oregon Forestsnails inhabit moist deciduous or mixed-wood forests at low elevations, usually below 360 m. They often occur in association with Bigleaf Maple (*Acer macrophyllum*) but are sometimes found in stands dominated by cottonwoods (*Populus balsamifera var. trichocarpa*) or other deciduous trees (COSEWIC 2002, 2013). The snails are often found in riparian areas along streams, along forest edges, and in small forest gaps. They prefer sites with abundant moisture-loving herbaceous plants and ferns. In many areas the snails show a close association with Stinging Nettle (Waldock 2002; Rekers 2006; Steensma *et al.* 2009). Productive soils, leaf litter, and coarse woody debris are thought to be important for mating, egg-laying, shelter, and hibernation (Cameron 1986; Ovaska and Sopuck 2003; Steensma *et al.* 2009). Although the snails often occur in forest edge situations and are sometimes found in wet meadows, proximity to shade provided by forest cover is deemed important as it helps maintain moist conditions throughout the year.

Moist forest floor conditions influence habitat suitability for Oregon Forestsnail and its presence within a habitat patch. Snails in general are continually susceptible to dehydration and experience evaporative water loss through the lung surface and integument as well as through the constant deposition of a slime trail left during movement. Snails seek cool and humid microhabitats to conserve moisture, and their activity patterns are largely governed by their need to prevent dehydration (Prior 1985).

Oregon Forestsnails are hermaphroditic (i.e., they possess both female and male reproductive organs) and lay a cluster of 34 eggs, on average (Steensma *et al.* 2009), in suitable moist locations on the forest floor. The eggs are usually laid in flask-shaped depressions that the snails excavate in the substrate (COSEWIC 2002; Steensma *et al*. 2009), but they may also be laid in leaf litter, and occasionally in moss or under coarse woody debris (Steensma *et al*. 2009).

Summary of important habitat features for Oregon Forestsnail:

- Elevation below 360 m
- Deciduous or mixed-wood forest, forest edges, and canopy gaps
- Bigleaf Maples often present
- Moist forest floor conditions
- Well-developed litter layer (≥5 cm deep)
- Soils that permit burrowing and nest construction
- Herbaceous vegetation, such as Stinging Nettle
- Decaying logs or other cover

Biophysical attributes of Critical Habitat (Environment and Climate Change Canada 2016b):

- 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
- dense understory vegetation, to provide cover and maintain moisture
- coarse woody debris and leaf litter, to provide cover and substrate for aestivation and nesting

Habitat features important for the Oregon Forestsnail in British Columbia are described below, based primarily on summaries in COSEWIC (2002, 2013), BC Recovery Strategy (Oregon Forestsnail Recovery Team 2012; Environment and Climate Change Canada 2016b) and BC Conservation Data Centre (2017), unless otherwise noted:

GENERAL DESCRIPTION

- Low elevation (below 360 m asl) moist deciduous and mixed-wood forests with deciduous composition more than 40 %.
- Riparian areas, including ravines, gullies and depressions containing both permanent and ephemeral watercourses; wooded edges of streams, marshes, seasonally flooded and wet lowland areas and similar habitats.
- Forest – meadow interfaces and edge habitats where moisture is retained (Waldock 2002).

FOREST OVERSTOREY COMPOSITION

- Stand age: 20 to over 80 years.
- Common tree species: large Bigleaf Maple, Black Cottonwood, scattered Western Redcedar (*Thuja plicata*).
- Additional deciduous trees: Paper Birch (*Betula papyrifera*), Trembling Aspen (*Populus tremuloides*), Red Alder (*Alnus rubra*), Grand-fir (*Abies grandis*).

DOMINANT SHRUB SPECIES COMPOSITION

- Dense shrub vegetation that helps retain moisture and reduces evaporative water loss on the forest floor.

- Variable shrub species composition including: Devil's Club *(Oplopanax horridus*)*,* Elderberry (*Sambucus racemosa*), False Azalea (*Menziesia ferruginea*), Hazelnut (*Corylus cornuta*), Indian Plum *(Oemleria cerasiformis*), Ocean Spray (*Holodiscus discolor*), Red Osier Dogwood (*Cornus stolonifera*), Rose (*Rosa* sp.), Salmonberry (*Rubus spectabilis*), Salal (*Gaultheria shallon*), Saskatoon (*Amelanchier alnifolia*), Snowberry (*Symphoricarpos albus*), Thimbleberry (*Rubus parviflorus*), Trailing Blackberry (*Rubus ursinus*) and Vine Maple (*Acer circinatum*).

HERBACEOUS PLANT COMPOSITION

- Dense herbaceous plant cover, which provides food and shelter during all life stages.
- Herbaceous plants include (but are not restricted to): Bedstraw *(Galium* sp.*),* Bleeding Heart (*Dicentra formosa*)*,* Buttercup (*Ranunculus* sp.)*,* Cow Parsnip (*Heracleum lanatum*), Enhanter's Nightshade (*Circaea alpina)*, False Lily-of-Valley (*Maianthemum dilatatum*), Foam Flower (*Tiarella trifoliata*), Fringecup (*Tellima grandiflora*), Cooley's Hedge Nettle (*Stachys chamissonis var. cooleyae*), Herb Robert (*Geranium robertianum*)*,* Horsetail (*Equisetum* sp.), Miner's lettuce (*Claytonia* sp.*)*, Pathfinder (*Adenocaulon bicolor*), Skunk Cabbage (*Lysichiton americanum*), Starflower (*Trientalis* spp.*)*, Stinging Nettle (*Urtica dioica*), Thistle (*Cirsium* sp.), Tiger Lily *(Lilium columbianum)*, Trillium (*Trillium ovatum*), Twisted Stalk (*Streptopus* spp.), Vanilla Leaf (*Achlys triphylla*), Waterleaf (*Hydrophyllum tenuipes*), Creeping Buttercup (*Ranunculus repens*). Various introduced plants also occur within Oregon Forest Snail habitats, such as Himalayan Balsam (*Impatiens glandulifera*) and Reed Canary Grass (*Phalaris arundinacea*). Although in some cases they may be indicative of suitable moist forest floor conditions, they are not considered part of the species' niche, as the snails have not coevolved with them. Fern species: Bracken *(Pteridium aquilinum)*, Lady Fern *(Athyrium filix-femina)*, Northern Maidenhair Fern (*Adiantum aleuticum*), Swordfern (*Polystichum munitum*).

PRESENCE OF STINGING NETTLE WITHIN THE HABITAT PATCHES

- Stinging Nettle appears to have high importance to Oregon Forestsnail (Waldock 2002; COSEWIC 2002; Steensma *et al.* 2009). Most occupied sites on the Lower Mainland contain patches of Stinging Nettle (BC Conservation Data Centre 2017). At a site in Langley where the species was studied in detail, Waldock (2002) showed a positive correlation between the abundance of the snails and Stinging Nettle.
- There are two species of Stinging Nettle within B.C.: *Urtica dioica* is native to B.C. and *U.gracilis* is non-native. It is unknown whether Oregon Forestsnail exhibits a preference for the native species.

- Stinging Nettles contain high levels of calcium and other essential minerals, needed for shell growth. The presence of Stinging Nettle indicates moist, rich soils with high amounts of nitrogen and phosphorus (Pojar and MacKinnon 1994). Stinging Nettle is of importance as forage for other land snails (Iglesias and Castillejo 1998).

SUBSTRATE COMPOSITION

- Soils: moist, loamy substrates with fine particle size that allow burrowing and construction of a nesting cavity; for nesting, firmer substrates that preserve the shape of the nest cavity but still permit digging are often used.
- Soil pH: neutral or slightly alkaline; pH of 6.4 – 6.9 was recorded at a productive Oregon Forestsnail site in Langley (Steensma *et al.* 2009).
- Litter layer: mull-type[1] litter; litter depth (leaf/needle) 5 – 10 cm (Durand 2006) or greater. Deep litter layer provides shelter, hibernation, and aestivation sites (COSEWIC 2002; Steensma *et al.* 2009).

COARSE WOODY DEBRIS

- Abundant coarse woody debris is often but not always present. It is thought to be important for aestivation, hibernation, and mating activities (Steensma *et al.* 2009), as it offers protection against fluctuations in temperature and moisture.
- Decaying logs retain moisture and allow for the growth of a deep moss layer, which provide shelter during adverse environmental conditions.
- Large diameter, damp rotten logs provide refuges during seasonal drought (Applegarth 2000) and aggregating and mating sites (Steensma *et al.* 2009).

MOISTURE REQUIREMENTS

- Moist forest floor conditions are essential.
    - Shade provided by forest canopy and understory plants helps conserve moisture.
    - 3-dimensional forest floor structure with coarse woody debris and/or deep litter layer provide moist refuges during dry periods.

[1] 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.

3.6 Movements and Dispersal

Oregon Forestsnails are relatively sedentary and use the same habitats year-around. The snails have a scattered and patchy distribution pattern throughout the northern part of their global range, suggesting poor dispersal abilities.

Limited information suggests that individual snails confine their movements to small areas. The average home-range of 10 individual snails followed for up to 10 months in high-quality habitat at a Langley study site was 32.6 m^2 (range: 3.7 – 71.9 m^2); the greatest width of the home range was 26 m (Rekers 2006). In subsequent studies at the same site, home ranges of 21 tracked adult snails were slightly larger, ranging from 13 to 332 m^2 (minimum convex polygon method; P. Lilley and K. Steensma unpubl. data 2011). Home ranges were frequently long and narrow, and most movements were directional. This observation aligns with other studies that indicate that snails follow microhabitat features, including creek channels and logs and other forms of coarse woody debris, as well as their own and conspecific slime trails (Prior 1985). Oregon Forestsnails are most active and appear to roam more widely during spring breeding period (March through May) (COSEWIC 2002; Steensma *et al.* 2009; J. Heron pers. obs. 2011). Where essential habitat features, such as hibernation or egg-laying sites, are widely dispersed, or where the habitat is of low quality, individual snails may undertake longer movements and maintain larger home ranges.

Although individual home ranges are small, this is not equivalent to the habitat area necessary to sustain a population of snails. Minimum size of habitat that can support a viable population is unknown but must contain habitat features required for all seasonal activities and developmental stages. Oregon Forestsnail has been found in habitat patches of < 1 ha, but the long-term viability of these populations in fragmented habitats is uncertain (COSEWIC 2013). An area of 20 ha is proposed for Critical Habitat polygons for Blue-grey Taildropper, another endangered terrestrial gastropod from British Columbia (Environment and Climate Change Canada 2016a), based on inferences from other invertebrates. The degree of habitat connectivity that is required within this area is uncertain. For Oregon Forestsnail, Critical Habitat is defined by an area with a radius of 32.2 m, equivalent to the average home range of individuals, surrounded by a 50 m Critical Function Zone to maintain minimum constituent microhabitat properties where the snails are found (Environment and Climate Change Canada 2016b). Polygons around single records of the species may not be large enough to sustain a population of the snails, as they are based on requirements of a single individual, while overlapping polygons around multiple individuals at a site better represent the spatial needs of the population.

Active dispersal of Oregon Forestsnails among occupied habitat patches is expected to be minimal due to their limited movement capabilities. Natural and artificial barriers also restrict movements. Baur and Baur (1990) found that the land snail *Arianta arbustorum* prefers moving along road verges and avoids crossing roads, including unpaved roads of only 3 m wide. Seasonal weather patterns are also likely to constrain movements. Passive dispersal or transport aided by other wildlife (mammals or birds) is unlikely (COSEWIC 2002). Inadvertent displacement of Oregon Forestsnail eggs, juveniles or adults by humans with moss-covered woody or leaf litter used for mulch could potentially occur but is unlikely.

3.7 Limiting Factors to Oregon Forestsnail

- **Dispersal ability:** The dispersal ability of Oregon Forestsnail is poor. By their very nature, snails are relatively sedentary, and their natural ability to colonize new areas without human assistance is limited.

- **Northernmost extent of global range:** Oregon Forestsnail occurs at the northernmost extent of its global range in British Columbia, which likely increases the species' susceptibility to climatic and stochastic population fluctuations.

- **Requirement of humid environments:** Oregon Forestsnails require moist habitats for reproduction and foraging. When the forest floor becomes increasingly exposed to wind and sun, terrestrial gastropods become more vulnerable to dehydration (Applegarth 2000; Prior 1985) and experience high rates of evaporative water loss (review in Prior 1985). In general, land snails are less vulnerable than slugs to dehydration, and many, including Oregon Forestsnail, are able to generate a specialized mucus plug to seal the opening to the shell during unfavorable periods, so limiting water loss. This adaptation protects them to some degree from dry conditions, but foraging and reproductive activities can be seriously impeded. Their eggs have little resistance to water loss, and reproductive success depends on the availability of moist microhabitats.

- **Soil Mineral Composition:** Soil mineral content (including magnesium and calcium) and pH is an important factor in land snail distributions and microhabitat use. Although unstudied for Oregon Forestsnail, these features are known to affect habitat preferences in other gastropods (Wareborn 1969; Hylander *et al.* 2005).

4. Key Issues of Concern

Oregon Forestsnail reaches the northernmost extent of its geographic range in southwest British Columbia, where most of its distribution coincides with the most densely populated and developed part of the province in the Lower Fraser River Valley. Historically, this area has experienced extensive habitat loss and alteration from human activities including logging, agriculture, and urbanization. In particular, low elevation (<300 m) habitats have been extensively modified over the past century. Little of the original forest remains, and most natural habitat areas are relatively small (<100 ha). Ongoing habitat conversion, combined with a scattered distribution pattern of the snails, suggest that suitable habitats are becoming increasingly fragmented.

Oregon Forestsnail continues to face many threats from human activities. According to COSEWIC (2013) assessment, the main threats to the species over the next 10-year period are: (1) Residential and commercial development, including development of tourism and recreational areas; (2) Transportation and service corridors, including road and utility corridor creation and expansion; and (3) Invasive and other problematic species. Other threats that may be locally important include: Human intrusions and disturbance from recreation, dog-walking and all-terrain vehicle use; Agriculture, including new land conversions and intensification of uses of existing agricultural lands; Energy production and mining including gravel, mainly quarrying; Biological resource use, mainly logging and wood harvesting; and Natural system modifications, including fire and fire suppression. Pollution, mainly from agricultural and forestry effluents, and more frequent and intense summer droughts, as predicted for the area with climate change, were identified as potentially serious but unknown threats.

Residential & commercial development, including development of tourism and recreational areas (predicted impact high). Remnant natural habitats, large ravines, and riparian habitats represent core areas for Oregon Forestsnail in the Lower Fraser Valley. Expanding human population and associated developments in these lowland areas threaten habitats. Protection for agricultural lands continues to push new developments up the hillsides, where remnant forest habitats occur, encroaching on areas occupied by Oregon Forestsnails. In addition to direct habitat loss from developments, human activities associated with urban developments, specifically those that alter natural hydrological patterns and result in drier conditions or in flooding for prolonged periods, reduce available moist microhabitats on the forest floor and degrade forest stand structure necessary to sustain Oregon Forestsnails. The demand for tourism and recreational areas is also increasing, and remnant natural areas continue to be

converted into golf courses, campgrounds, parks, and recreational facilities, dog recreation areas, and existing facilities continue to be expanded.

Transportation and service corridors (predicted impact high). Extensive networks of roads and other transportation corridors already fragment much of the remaining natural habitat in the Lower Fraser Valley. Expected human population growth is likely to lead to further improvements and expansion of the transportation infrastructure. Increased roads, trails, pipelines, and other linear developments lead to habitat loss and modification, enhancing cumulative habitat loss from other sources and compounding their impacts. Impacts of linear developments can be greater than indicated by the area of habitat lost as a result of edge effects and habitat fragmentation. Service lines can increase isolation of populations and increase wind penetration and evaporative water loss on the forest floor, so decreasing habitat quality for the snails. However, not all effects of service lines are necessarily harmful, and under some circumstances in closed canopy forest, they may create or maintain edge habitats suitable for the snails. Transportation routes are often planned to avoid developed or densely populated areas and as a result will intersect remaining natural habitats and open up access to new areas. Access provided by roads will also facilitate recreational use and the spread of introduced invasive species.

Invasive and non-native/alien species (predicted impact medium – low). Introduced invasive gastropods, other invertebrates, and plants have been recorded from most Oregon Forestsnail habitats. While their impacts are negative and potentially significant, their magnitude is uncertain. With increased access and human use of natural habitat, introduced species that are potentially problematic for this and other native gastropods continue to invade new areas. Introduced gastropods are often spread inadvertently with nursery plants and garden ornamentals, as well with discarded garden waste and other materials (Forsyth 1999). 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 locations) (Trombulak and Frissell 2000). The spread of introduced species can impact snail populations through competition and predation, as well as through changes to native vegetation, leading to reduced moisture regimes on the forest floor. Concentration of snails into small habitat patches with less overall shelter and escape cover is likely to increase their vulnerability both to competition and to predation from natural and introduced predators.

Ground beetles are known predators of land snails (Thiele 1977), and several introduced species occur within Oregon Forestsnails range. Introduced gastropod species that may compete with Oregon Forestsnail include Grovesnail (*Cepaea nemoralis*), which can reach exceedingly high densities in suitable habitats, and several species of slugs, such as the Dusky

Arion (*Arion subfuscus*), Chocolate Arion (*Arion rufus*), Giant Gardenslug (*Limax maximus*), and Grey Fieldslug (*Deroceras reticulatum*). Rollo and Wellington (1979) demonstrated intra- and interspecific aggression among slugs and competition for refuges. Longneck Fieldslug (*D. panormitanum/invadens)* and Glass-snails (*Oxychilus* species) could potentially be important predators of eggs and young of native gastropods.

Invasive plant species are known to change the forest floor vegetation and soil structure and alter solar radiation penetration to the forest floor and soil moisture conditions. Invasive plants that form dense thickets and crowd out native understorey vegetation are potentially particularly harmful for snails through their effects on forest floor structure, microclimates, and food supply of live and decaying plant material. Invasive plants within the snails' range include Scotch Broom (*Cytisus scoparius*), Gorse (*Ulex europaeus*), Himalayan Blackberry (*Rubus discolor*), Holly (*Ilex aquifolium*), English Ivy (*Hedera helix*), and Spurge Laurel (*Daphne laureola*). Native gastropods appear to be absent from patches of English Ivy (Applegarth 2000), but some native species of gastropods, as well as several introduced species, are able to inhabit patches of Spurge Laurel (Ovaska and Sopuck 2017). The responses of Oregon Forestsnail to habitat modification by these and other invasive plants have not been studied.

Recreational activities (predicted impact low). Recreational activities within Oregon Forestsnail habitat include camping, hiking, foot and bicycle traffic, dog-walking and the use of all terrain vehicles (ATVs) and trail bikes. Off-trail activities in particular, can result in degradation of habitat quality through soil compaction and can also cause accidental mortality. Hiking and recreational activities confined to trails usually have little or no impact, but potentially significant mortality may occur locally where well-used trails intersect snail habitat, especially in spring when the snails are most active and often seen crossing trails. Effects from recreational activities can be pronounced in areas where the species is restricted to small habitat patches. Intensive management of vegetation, such as removal or trimming of Stinging Nettle patches favoured by the snails, within recreational areas or recreational trails can also reduce habitat quality.

Agriculture (predicted impact low). Clearing of land for agricultural purposes has been a major factor in the loss and modification of natural habitats within Oregon Forestsnail's range, but this threat is considered largely historical. Clearing of land for crops or pasture and intensification of practices on existing agricultural lands still occurs but to a limited extent. The impacts to gastropods from grazing by livestock are largely unknown, but trampling of sensitive riparian habitats occupied by Oregon Forestsnail is a potential threat as livestock tend to congregate along watercourses.

Logging and wood harvesting (predicted impact low). The B.C. range of Oregon Forestsnail has been impacted from extensive historical 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 clear-cut harvesting, likely have detrimental effects on Oregon Forestsnail through their effects on forest floor microclimates and moisture regimes but are unstudied.

Fire and fire suppression (predicted impact low). Fire suppression activities such as brush burning and mowing will adversely affect Oregon Forestsnail. Snails in general appear to be intolerant of fire (review in Jordan and Black 2012), and fire is considered a significant threat to populations and communities of land snails (Applegarth 2000; Nekola 2002). Active ongoing management to minimize the risk of fire is implemented at the urban interface, roadsides, trails and other right-of-ways, and agricultural areas, and to control campfires. Brush clearing, piling and periodic burning of vegetation and woody debris occur on private and public lands throughout the range of Oregon Forestsnail. Mowing and cutting of vegetation at sites occupied by the snails may also be harmful by decreasing moisture retention in the habitat and increasing dehydration stress to individuals. Conversely, these activities may also help retain the open nature of the habitat preferred by the snails and retard vegetation succession in edge habitats.

Mining and quarrying (predicted impact low). Gravel mining is a localized threat at sites in the Lower Fraser Valley, particularly on areas of Sumas Mountain. The overall footprint is currently small but may expand in the future. It results in complete habitat loss for the snails where it occurs.

Agricultural and forestry effluents (predicted impact unknown). Use of pesticides, especially those aimed at gastropods, has potential to harm Oregon Forestsnail populations through direct mortality. Agricultural and forestry effluents most likely to cause harm to Oregon Forestsnail habitat and individuals are general herbicides used to control vegetation. 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. Oregon Forestsnail is frequently recorded from forest and trail edge habitats. 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. Herbicides are used less today, and many municipalities have bans on certain herbicides.

Climate change and severe weather, including droughts, storms and flooding (predicted impact unknown). Increased summer droughts may affect Oregon Forestsnail habitats and decrease the availability of moist microhabitats required by the snails for survival. Combined with other threats, such as water diversion and infilling, increased frequency and intensity of droughts during the active season could have significant consequences to Oregon Forestsnail populations, but the impacts are unstudied and unknown.

5. Objectives

The practices and measures in this guidebook are intended to contribute towards recovery of Oregon Forestsnail populations in British Columbia, as specified in the recovery strategy for the species (Oregon Forestsnail Recovery Team 2012). Stewardship activities by landholders and other stakeholders play a large part in this process.

The long-term recovery goal for Oregon Forestsnail is to ensure the persistence of historical, existing, and newly located sites where the species is present in Canada, through habitat protection. The short-term (over the next 5 years) goal is to minimize threats to Oregon Forestsnail and its habitat at each known location. The following management objectives are intended to help landowners, developers, and other stakeholders to design a management program that is consistent with these goals:

- Ensure that adequate knowledge of the presence and distribution of the species within the study area is obtained before any developments or modifications are made.
- Protect key habitats from land development or modification through stewardship activities or securement of lands.
- Maintain or enhance habitat connectivity to allow for movement of snails among habitat patches.
- Manage habitats so that habitat degradation is minimized and the population continues to persist at the site for the long term (>100 years).

6. Standards

LEGAL REQUIREMENTS

The federal *Species at Risk Act* (SARA) is designed to protect Canada's species at risk and their critical habitat. The Act came into force in June 2004. SARA directly protects listed individual organisms, their residences, and identified critical habitat on federally administered lands and for aquatic species and migratory birds wherever they occur. The B.C. Government agreed in 1996 to provide complementary protection to listed species under its jurisdiction through the national *Accord for the Protection of Species at Risk* and plans to meet this objective primarily through the use of cooperative stewardship and existing legislation, such as the *Wildlife Act* and its amendments. SARA stresses that cooperative solutions with the involvement of all stakeholders be attempted before the use of regulated solutions.

The *Canadian Environmental Assessment Act*, as amended by SARA, requires that a formal environmental assessment be conducted for projects that may affect species at risk or their habitat where the federal government has decision-making authority (as defined in the Act if the federal government is acting as a proponent, land manager, source of funding or regulator). Through the 1996 national *Accord for the Protection of Species at Risk*, the B.C. Government agreed to provide a similar process on lands under its jurisdiction. Given that the B.C. Government has responsibility for private, municipal, and regional lands through the *B.C. Local Government Act* and *B.C. Community Charter*, municipalities and regional districts have authority to ensure that species at risk are included in environmental assessments, development permits, and land use planning.

The response of the development proponent or regulator to the findings of an environmental assessment (i.e., whether to protect habitat or establish buffers) is not directly mandated by legislation. The process instead emphasizes the importance of cooperative stewardship by government, industry, private landowners, and non-governmental organizations to ensure that sufficient habitat is protected and /or rehabilitated for this species. This document describes actions that municipalities, regional districts and developers can take to ensure the recovery of Oregon Forestsnail and other gastropod species at risk. Following these guidelines helps demonstrate due diligence towards protection and recovery of this species.

The most up-to-date information on species at risk in Canada is available at Environment Canada's website: http://www.speciesatrisk.gc.ca/; or at the SARA Public Registry: http://www.sararegistry.gc.ca/. For information on species at risk in British Columbia, visit: http://wlapwww.gov.bc.ca/wld/.

7. Best Management Practices

7.1 Approach to Protection and Management

The needs of species at risk, including Oregon Forestsnail, should be taken into account when planning new developments or infrastructure upgrades, whether they involve the construction of a single building or an entire subdivision, or upgrading park facilities. Mitigation planning should be started early in the process when changes to the design of the project are still possible. The planning stage is the most important phase of the mitigation process and includes obtaining information on the distribution of the species and its habitats on the property, followed by determining locations and configuration of set-asides, buffers, and management areas, and assessing the need for possible additional mitigation measures. The second, the construction phase, includes on-the-ground activities to ensure that the construction footprint is minimized and that sensitive habitats are protected as planned and are not disturbed by construction activities. The third, the post-construction phase, consists of ensuring that the protected habitats remain functional and in good condition and that site maintenance activities are carried out in a manner that do not harm the species.

In development areas, the best option is to locate the development away from important habitats and to ensure that habitat connectivity is maintained. This may be accomplished either by shifting the location of the project footprint or by establishing reserve areas and riparian buffers of sufficient width within the development area; these reserves should connect to surrounding habitat within the landscape. Where there are no options for shifting the development or establishing secure, protecting habitat within the development area, reserve areas of at least equal size and quality in the vicinity of the development or in other areas within the species' range should be set aside to compensate for the loss of habitat. In both cases, formal protection, such as a conservation covenant, should be applied to the reserves and other set-asides to ensure that they receive long-term protection. Salvage (i.e., moving animals away from the development site) is never to be considered a primary mitigation measure and only applies in special circumstances. Any planned relocation of snails should be discussed with FLNRO Species At Risk Biologists prior to the beginning of any relocation or salvage activity and a comprehensive monitoring program should be in place (see Section **Translocations** for detailed guidelines).

Within multi-use areas, such as regional or municipal parks, and private residential lands within, any new infrastructure including structures, roads, trails, parking areas, or visitor facilities are to

be planned carefully so as to avoid damage to important habitat features. Management measures are often necessary to maintain functionality of the habitat over the long term. Actions may involve controlling invasive shrubs, such as Scotch Broom or Himalayan Blackberry that form dense thickets and degrade habitat quality, rerouting trails away from riparian areas and from important habitats for Oregon Forestsnail, such as Stinging Nettle patches, and/or changing management practices to avoid disturbance to these and other Oregon Forestsnail habitats.

7.2 Overview of Steps to Mitigation Planning and Implementation

The following outline is provided to guide mitigation planning and implementation.

1. Compile information on existing occurrence records and delineated Critical Habitat areas of Oregon Forestsnail at and in the vicinity of the project area.

2. Prepare a preliminary habitat suitability map using existing resources and mapping.

3. Conduct surveys for the presence of Oregon Forestsnail within the proposed development area. Survey all areas, including those deemed as low quality for Oregon Forestsnail. It is recommended that a qualified resource professional be hired to conduct surveys and surveys be conducted at the appropriate time of year. See Section **Survey methodology** for appropriate timing, frequency, and methods.

4. Collect habitat information for Oregon Forestsnail throughout the development area, including but not restricted to biophysical attributes for Critical Habitat (see Appendix 1).

5. Map Oregon Forestsnail occurrences, Critical Habitat polygons, and habitat features using GIS applications.

6. Use habitat, existing Critical Habitat, and Oregon Forestsnail occurrence information to refine the boundaries of habitat polygons in the preliminary habitat suitability map.

7. Superimpose on the habitat suitability map the proposed boundaries of the development area and determine which areas will be left undisturbed as set-asides or reserves, and calculate the area of:
    a. Development Area - the entire area where development will occur.
    b. Impact Site - areas where proposed development footprint overlaps with occupied or suitable Oregon Forestsnail habitat, which will no longer be habitable by Oregon Forestsnail following development.

c. Areas intended as compensation sites or other areas left undisturbed within or outside the development area; these include reserves, riparian buffers, and other features that will not be included in the impact site. These are areas that are left natural in perpetuity and not likely to be developed in the future.
d. Residual Impact Site - sites that will indirectly be affected by planned development over the next 10 years. Examples include 10-15 metres on either side of a roadway; trail sides; areas where creeks flow under roadways.

8. Consider additional mitigation measures on how to minimize harm to Oregon Forestsnail or other species or habitat attributes; such measures may include timing of construction or post-construction habitat management measures.
9. Use Best Management Practices described in this document to plan the development and manage construction and post-construction activities, so as to minimize harm to Oregon Forestsnail and its habitats.
10. Discuss proposed mitigation with regional FLNRO Species At Risk Biologists.
11. Conduct follow-up monitoring as appropriate for particular projects, and engage in adaptive management and modify management practices as needed as new information becomes available.

Summary of steps for mitigating development impacts for Oregon Forestsnail:

1. Planning phase:
    a. Compile information on existing occurrence records and delineated Critical Habitat for the project area and surrounding landscape.
    b. Prepare a preliminary habitat suitability map to guide survey efforts.
    c. If suitable habitat exists on the property:
        i. Develop survey design and select an appropriate survey method.
        ii. Conduct surveys during appropriate time of year and weather conditions.
        iii. Refine the habitat suitability map based on ground truthing and survey results.
        iv. Overlay the project footprint on the map and calculate the area of impact
    d. Develop mitigation plan
        i. Delineate reserves & buffers using habitat suitability mapping as a guide.
        ii. Consider whether other mitigation measures are needed.
    e. Discuss the mitigation plan with regional FLNRO Species At Risk Biologists.
2. Construction phase:
    a. Ensure that riparian buffers and other set-asides are clearly marked on the ground and protected from inadvertent disturbance.
    b. Minimize construction footprint:
        i. Use designated areas for turning around and parking vehicles and for temporary stock piles of materials.
        ii. Control foot traffic to avoid unnecessary soil compaction.
3. Post-construction phase & maintenance activities:
    a. Use integrated pest management practices and avoid contamination of habitats by chemical pesticides, herbicides, or fertilizers.
    b. Maintain natural hydrological patterns, and avoid storm water run-off to snail habitats.
    c. Maintain suitable forest floor structure in set-asides, including coarse woody debris and leaf litter.
    d. Control invasive plants, as needed, to maintain snail habitats in a natural state.
4. Monitoring
    a. Monitor habitat condition and persistence of the snail population within the set-asides.
    b. Engage in adaptive management.

7.3 Planning Phase of Mitigating Human Impacts on Oregon Forestsnail

Compile existing information

The first step is to find out whether Oregon Forestsnail or other species at risk occur or are likely to occur within the study area, using existing information and field surveys. Sources for existing distribution records of gastropods include BC Ministry of Environment and Climate Change Strategy Species and Ecosystems Explorer (http://srmapps.gov.bc.ca/apps/eswp), BC Conservation Data Centre (http://www.env.gov.bc.ca/cdc), South Coast Conservation Program (http://www.sccp.ca/), FLNRO and ENV species at risk biologists and non-government species specialists. The recovery strategy for Oregon Forestsnail (Environment and Climate Change Canada 2016b) should be consulted for delineated Critical Habitat. The distributions of most gastropods in the province, including Oregon Forestsnail, are incompletely known. Therefore, if a site contains potentially suitable habitat and is within the range of the species, it is appropriate to proceed with field surveys regardless of whether previous records from the vicinity of the study site are available.

Habitat suitability assessment

The next step is to find out what habitats are present within the study area and assess their suitability for Oregon Forestsnail. Polygons of habitats deemed suitable based on habitat features described in Section **Habitat and biological needs** are delineated on a base map with appropriate resolution. This step should be undertaken, even if the entire project area is within a designated Critical Habitat polygon to provide detailed and up to date information on habitats within the study area; the habitat may have changed since the records on which the polygons are based were obtained. This preliminary habitat map is useful for guiding survey efforts and, once ground truthed, for identifying biophysical attributes of the habitat important for the species and determining which areas are to be left undisturbed as reserves or set-asides for Oregon Forestsnail and other wildlife. Resources for habitat assessment include aerial orthophotos, satellite imagery, forest cover maps, and biophysical mapping. Low elevation mixed-wood or deciduous forest with Bigleaf Maple and riparian areas all form good habitats for Oregon Forestsnail and often can be located from maps. Ground visits are required to locate key microhabitat features, such as patches of Stinging Nettle, areas with suitable soils for egg-laying, seepage areas, and small forest gaps favoured by the snails.

The map will be refined after an on-the-ground survey for snails and suitable habitat features has been conducted. The project area, impact area, and set-asides will be overlaid on the habitat map, and the areas of each will be calculated. This GIS map will form the basis of mitigation implementation.

7.4 Survey Methodology

If the study site contains potentially suitable habitat for Oregon Forestsnail, surveys are necessary to obtain information on the species' presence, abundance, and location of important habitat features, including biophysical attributes of Critical Habitat (see Section 3.5 HABITAT AND BIOLOGICAL NEEDS). Study design and survey methods will depend on the objectives of the surveys, site-specific conditions including the size of the study area, and available resources. Proper planning is necessary to ensure that surveys are carried out effectively and at sufficient detail so that the objectives of the study are met. It is helpful to consider the following questions: What information is to be collected? How is the information to be used? How can the information be collected most effectively within the scope of the project and available resources? If the objective is simply to find out whether the species occurs on the property, methods such as opportunistic, time-constrained surveys that require relatively little investment may be sufficient. On the other hand, if the objective is to obtain information on the population size, intensive mark-recapture methods are required. For

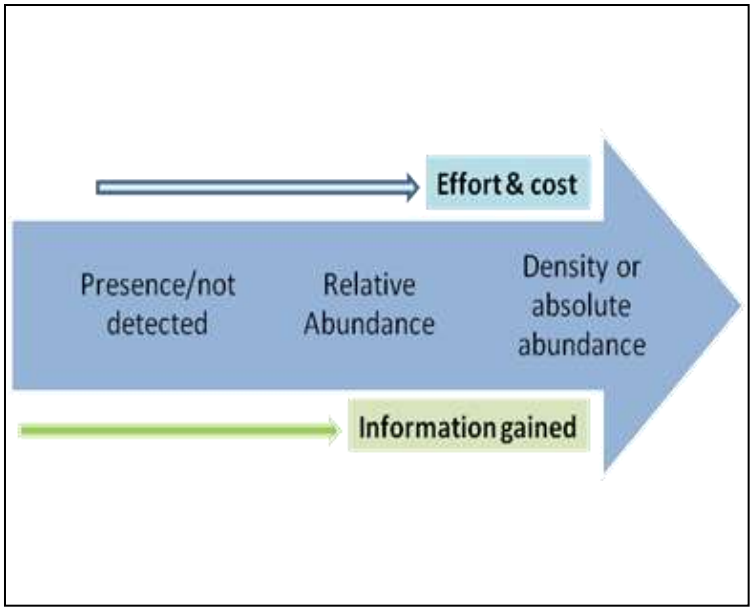

Figure 4. Relationship of survey intensity with effort and information gained.

designing reserve areas, riparian buffers, and other set-asides as part of mitigating impacts of developments, information requirements are most often somewhere between these two extremes and intermediate in terms of cost and effort; a measure of relative abundance is usually sufficient (see Figure 4).

Field surveys should be conducted at an appropriate time of the year and under suitable environmental conditions. Surveys are best conducted when Oregon Forestsnail is most likely to be encountered on the forest floor, although empty shells can be found throughout the year. Both Oregon Forestsnail and Puget Oregonian snail are active during the day and often can be located visually on or near the surface of the ground. In B.C., the snails are most active from late March or early April to the end of June during periods when the ground is moist and temperatures are moderate (Steensma *et al.* 2009). Therefore, spring – early summer is optimal for surveys. The snails hibernate during cold periods in the winter (November – mid-March) and aestivate during dry periods in the summer (July – August); surveys during these times are inappropriate. Multiple surveys per year are recommended to increase chances of detecting rare species.

Empty snail shells are often found during surveys, and a distinction should be made between dead and live snails when recording data. Sites with empty shells only may no longer support the species or the shells may have been carried there by flood waters or predators, especially where accumulations of shells are found. The shell of Oregon Forestsnail is relatively thick, and empty shells may remain on the forest floor for extended periods, especially in drier sites. If remnants of the outer, pigmented layer (periostracum) are present, the snails can be assumed recently dead, whereas if the entire periostracum is worn off, exposing the white shell material underneath, the snail can be assumed long dead, up to several years or even decades. The age of empty shells cannot usually be ascertained because site-specific conditions strongly influence decay rates.

The following sections describe survey methods recommended for Oregon Forestsnail. It is beneficial to seek the advice of a professional biologist who is familiar with both the species and methodologies to design an appropriate survey strategy. Stratified random sampling designs (i.e., only a portion of the habitats are searched) are recommended unless the study area is very small and the entire area can be surveyed (see Krebs 1989 and 2014 updates for methodologies). As a general rule, the sampling effort allocated to different habitat types should be proportional to their presence on the property.

Summary of survey methods:

- Opportunistic time-constrained searches
- Point searches along meandering or parallel transects
- Quadrat surveys
- Cover-objects & traps
- Mark-recapture

OPPORTUNISTIC TIME-CONSTRAINED SURVEYS

Level of effort: Low

Information provided: Basic presence/not detected type of data. If the species is found, presence is confirmed. However, absence is very difficult to show with any degree of confidence and requires multiple searches.

Suitability: This method may be appropriate in some circumstances, for example when the area in question is very small or in marginal habitat. It can also be used as a reconnaissance survey, followed by more intensive and informative methods.

Description: One or more observers opportunistically walk through the area of interest, visually searching the forest floor for snails, paying particular attention to microhabitat features favoured by the snails, such as nettle patches, accumulations of leaf litter, bases of decaying stumps, and decaying logs and bark. The search effort should be quantified by recording the time spent searching, area searched, and number of people engaged in searches.

Timing: When the snails are active; April – June are optimal but surveys can also be carried out from July – September after heavy rains (at least 15 mm of rain on several days). Prolonged warm and dry periods are to be avoided. November – mid-March is not appropriate, nor is very dry and hot periods from July to September.

Number of surveys: 3 surveys are recommended (or until the species is found).

POINT SEARCHES ALONG MEANDERING OR PARALLEL TRANSECTS

Level of effort: Moderate

Information provided: An index of relative abundance in different habitats

Suitability: Appropriate for designing mitigation measures for developments and follow-up monitoring where information on population sizes or movements is not required. The method is best suited for large snails (shell diameter > 1 cm), including Oregon Forestsnail, but will likely underestimate abundance of small snails and smaller juveniles of Oregon Forestsnail.

Description: The methods presented here are modified from the protocols developed for locating rare species of terrestrial gastropods under the Northwest Forest Plan in the United States (Duncan *et al*. 2003). Habitat-based polygons are selected for surveys based on preliminary habitat mapping, and tentative survey routes are plotted on maps. If the study area

is small, the entire area can be searched systematically, for example along parallel or meandering transects or a combination of the two. It is helpful to download the transect lines, or at least their end-points, onto handheld GPS units to ensure that the entire area is covered and that observers confine their movements to their designated areas, which for meandering transects can be within a particular habitat polygon. This transect design is often the simplest to apply in the field, unless the area to be covered is very large. Other approaches to meandering transects include "random walk" methods, which consist of the observer repeatedly selecting a new random direction (e.g., by spinning the compass) after walking a predetermined distance.

In the field, each observer walks slowly along a pre-determined pattern or survey route and visually scans the ground and vegetation for snails active on the surface. The observer conducts intensive time-constrained searches (referred to as point searches) where concentrations of suitable microhabitat features are found, augmented by opportunistic searches while walking between subsequent points. The emphasis is on searching a large number of habitat features along the route, covering all potential microhabitats. For point searches along survey routes, the observer will select patches of Stinging Nettle, dense herbaceous vegetation with fringe cup, ferns or other moisture-loving plants, seepages, accumulations of leaf litter at the base of large maples, or other suitable moist sites. At each point, the observer will intensively search a ~5 m-radius sampling area for 10 minutes, carefully examining natural cover objects such as logs, branches, and sloughed-off bark, under ferns, nettle patches and within the leaf litter. While walking between points, the observer will visually examine the ground surface for gastropods, paying particular attention to suitable habitat features as they are encountered. The searches should be conducted carefully, avoiding trampling of vegetation and disturbance to soils; all cover-objects searched should be carefully replaced. It is important to search all habitats that potentially harbour snails and to ensure that preferred habitats, including patches of Stinging Nettle, receive adequate coverage. Opportunistic point searches should constitute about one-third and intensive time-constrained searches of sample areas about two-thirds of the total search time. A stratified random sampling design should be used, with the length of the transects in each habitat polygon in accordance to the proportion of their occurrence on the property.

Timing: When the snails are active; April – June is optimal, but surveys can also be carried out from July – September after heavy rains. Prolonged warm and dry periods are to be avoided. November – mid-March is not appropriate, nor is very dry and hot periods from July to September.

Number of surveys: 3 surveys during the optimal period are recommended.

QUADRAT SURVEYS

Level of effort: Medium - high

Information provided: Surface density; extrapolation can be made to population size in different habitats, provided that adequate sampling has been conducted.

Suitability: Appropriate for designing mitigation measures for developments and for follow-up monitoring; also appropriate for monitoring population trends. The method is suitable for large snails including Oregon Forestsnail but will underestimate density of small snails and small juveniles of Oregon Forestsnail (e.g., shell width <10 mm). Quadrat surveys are semi-destructive, and while only small areas will be affected, the presence of rare plants or other sensitive species on the property should be considered before using this method.

Description: The method consists of thoroughly searching small areas of the forest floor, the boundaries of which are demarcated by quadrat frames, for snails. For Oregon Forestsnail, a 1 x 1 m quadrat size is deemed appropriate under most circumstances. It is important that (a) the placement of quadrats is randomized (within pre-determined constraints), and b) a sufficient number of quadrats are searched to allow for extrapolation. For convenience, quadrats can be placed along parallel systematic transects that intersect the study area, but their location along each transect should be determined randomly (e.g., by using random number tables). The number of quadrats needed depends on the density and dispersion of the snails at the particular site; in general, the sparser and more unevenly dispersed the snails are, the larger is the number of quadrats needed. Often some preliminary sampling is useful to guide the required sampling intensity. A stratified random sampling design should be used, with the number of quadrats in each habitat polygon in accordance to the proportion of their occurrence on the property.

In the field, the location of each quadrat is marked along transects, a quadrat frame is placed at the marked spots, and the litter layer and all cover objects within the area bounded by the frame is searched thoroughly for snails up to the surface of the compacted mineral soil layer. If the quadrat lands on a tree or rock or a spot that otherwise cannot be searched, it is to be moved to the next available spot; however, care should be taken to not to search only “easy”, flat spots that contain little cover for the snails.

Timing: When the snails are active; April – June are optimal but surveys could also be carried out from July – September after heavy rains. Prolonged warm and dry period are to be avoided. November – mid-March is not appropriate, nor is very dry and hot periods from July to September.

Number of surveys: 3 surveys during the optimal period are recommended.

CAPTURE-MARK-RECAPTURE (CMR) METHODS

Level of effort: High

Information provided: Population size and trends, including survivorship; movement patterns of snails

Suitability: Appropriate for research and monitoring studies where detailed information on the population size or structure or movements of snails are required. Mark-recapture is appropriate for projects involving translocations of snails to new habitats (see section GUIDELINES FOR TRANSLOCATIONS). Capture-mark-recapture methods provide the most accurate information on population sizes and parameters but are also the most labour- and cost-intensive. This level of sampling intensity is not required for most mitigation applications, except for translocations, which are to be viewed as a last option when designing mitigation.

Description: Snails within a particular area are captured and marked so that they can be recognized on subsequent occasions; they are then released either at their original capture locations or, if translocation or introduction is intended, at new sites. Various methods are available to analyze mark-recapture data, ranging from simple indices to complex, sophisticated models that provide detailed information on detection probabilities, survivorship, and population trends. The methods are based on either the analysis of the proportion of marked to unmarked animals (e.g., Lincoln and Schnabel indices) or on capture histories of marked animals over time (e.g., Jolly-Seber method and modeling using MARK software). The type of analysis used determines how snails are marked (e.g., individual versus batch marks) and how and what information is to be collected. Summaries and descriptions of different mark-recapture methods can be found in Krebs (1989 and 2014 updates); for information and downloads of Program MARK (White and Burnham 1999), see University of Colorado MARK website (undated).

The first step is to select a study area, which is then systematically and repeatedly searched for snails. A preliminary habitat map of the property should be prepared, followed by reconnaissance level surveys (e.g., opportunistic time-constrained surveys), as described in previous sections, to guide the selection of CMR plot locations. Study plots of 24 x 24 m have been used previously for Oregon Forestsnail (Steensma *et al.* 2009) and are adopted here as a standard plot size, unless other site- or project specific conditions apply. A minimum of three plots should be established, because the distribution and densities of Oregon Forestsnails vary greatly across the landscape. Using habitat mapping for guidance, the plots should be established in different habitat types.

On the ground, the plot boundaries are marked with stakes or string; corners of the plot should be marked adequately with more permanent markers so that they can be found later. It is useful to divide the study plot into 2 x 2 m grids, marked with numbered stakes at each corner (e.g., rows: 1 – 12; columns: A – L), to facilitate the recording of locations of snails within the plot and to confine movements of observers to designated routes during the surveys, allowing for systematic coverage.

To survey the plot, an observer will walk along the designated route, such as down each row from stake to stake, and scan the ground for snails active on the surface. The observer will also examine microhabitats where snails might be hiding, such as accumulations of leaf litter, bases of sword ferns, and coarse woody debris, along the route. Care must be taken to avoid stepping on snails or damaging the habitat (cork boots are not to be worn); decaying logs are not to be taken apart, and all cover-objects are to be replaced after examination. A search time of approximately 30 minutes is usually sufficient for one plot survey (Steensma *et al*. 2009), excluding time spent in data recording and processing of snails. It should be noted that CMR methods are not time-constrained, and the time required may vary according to habitat and terrain; sufficient time should be taken to adequately search the plot. If two observers are available, they should start from the opposite ends of the plot/route.

During the first survey, each Oregon Forestsnail (or other target species) found will be placed in an individually numbered bag, and its location in the plot (grid cell number), microhabitat (e.g., on the surface or under cover) and activity (e.g., feeding, moving, withdrawn into shell) will be recorded. Once the entire plot has been surveyed, the snails will be processed (marked, measured, and photographed) and then returned to the grid cells where they were found.

On subsequent surveys, the observer will follow the same procedure. The observer should alternate the direction of the survey every second time, starting from the opposite end, or if two observers are employed, their starting positions should be switched. Recaptured snails caught within the same survey period (3 surveys during subsequent days are recommended) can be photographed and released immediately; unmarked snails are placed in individual numbered bags for processing after the survey is completed.

Processing of snails involves measuring their size, marking the shell for identification, and taking a photograph of each marked individual for documentation and future reference. Shell width, measured across its widest points, provides an appropriate measure of the size of Oregon Forestsnail and other large snails in our area. Time permitting, shell height provides a secondary standard measure. Other information that should be noted is the condition of the shell, including any cracks or dents and amount of wear of the outer layer of the shell.

Marking snails: Snails can be marked either with unique marks that identify each individual or given a batch mark, depending on the study objectives. For batch marking, all individuals, or a subset of individuals, are given the same mark; for example, all individuals within a certain size class may be given the same mark that differs from that given to other size classes, or all individuals caught during the same sampling session or year may be given the same mark and different marks be used for the subsequent sessions or years. Individual marks are usually numbers or combinations of numbers and letters, whereas batch marks may be symbols or dots of different colours. Batch marks are faster to apply and may be all that are needed for simple population indices, whereas individual marks provide the most detailed information, as they allow for following capture histories and movements of individual animals over time. For detailed examination of movements, such as within translocation projects, individual marks are needed.

Marking or tagging snails: Snails can be marked with tags or paint marks attached to the shell (see review in Henry and Jarne 2007). The marks need to be sufficiently small or inconspicuous so that they don't hinder movements or activities of the snail or attract predators, and they must remain readable for the duration of the study with no or minimal mark loss. Tags can be glued onto the shell, e.g., with super glue. Paint marks can be applied directly to the shell. For batch marks and marks needed for a short duration only (weeks or a few months), paint marks, applied with a fine brush or marker pen work well. Felt-tip pen marks can be protected by applying a clear coating of varnish or nail polish over the mark. Small numbered tags designed for fish fingerlings or bees, for example, are available from various commercial sources and can be adapted for gluing onto the shell of Oregon Forestsnail. In general, glued tags are more durable than paint marks (Henry and Jarnes 2007) and suitable for longer-term studies, spanning months or years, whereas paint marks are suitable for shorter-term studies, spanning weeks or a few months. Appendix 2 summarizes recommended methods for Oregon Forestsnail.

Harmonic direction finder methods have been used with success for tracking movements of individual Oregon Forestsnails (Steensma *et al*. 2009) and other small, cryptic animals (Engelstoft *et al*. 1999) in British Columbia. The tag consists of a diode, which can be exceedingly small, and a thin copper antenna of at least 5 cm long, which can be coiled and glued onto the shell. Attaching the antenna on the shell of Oregon Forestsnail is cumbersome, and individual identification is not possible, so other methods of marking need to be used in conjunction with the harmonic direction finder tag. New innovative methods using passive integrated transponder (PIT) tags for individually marking and following movements of land snails are in development (K. Ovaska unpubl. data and pers. comm.) but are still to be tested on Oregon Forestsnail.

Timing: When snails are active; April – June is optimal; additional surveys may be conducted in summer after heavy rains or in fall (September – October).

Number of surveys: The minimum number of surveys for mark-recapture studies is three/year, but the accuracy of information improves with additional surveys. At least two survey sessions should be during the optimal period in spring – early summer. Depending on the objectives, surveys may be required in multiple years.

ARTIFICIAL COVER-OBJECTS AND TRAPS

Placing artificial cover-objects constructed of cardboard or other materials on the ground in suitable habitats enhances the chances of locating many species of gastropods (Boag 1990; Hawkins *et al*. 1998). Layered 30 x 30 cm corrugated cardboard cover-objects placed along transects or in a grid pattern have been used with success for a number of species of snails and slugs in British Columbia (e.g., Ovaska *et al*. 2016; Ovaska and Sopuck 2017). Artificial cover-objects imitate sloughed-off bark and provide moist refuges for gastropods. They are not traps as the animals are able to come and go at their will and therefore have no adverse effects associated with traps, such as inadvertent mortality. Another advantage of using cover-objects is that the same sites can be surveyed repeatedly with minimal disturbance to the habitat and the animals. However, artificial cover-objects may not be effective for Oregon Forestsnail, and visual searches of the surface and natural cover appear to be more suitable for this species.

Pitfall trapping is a method that is commonly used to collect samples of insects and other invertebrates, and it has been used with some degree of success to collect terrestrial gastropods. It consists of digging containers filled with a preservative or an attractant (such as beer) into the ground up to their rim and inspecting them after some period, up to several weeks later, for animals fallen into the traps. This method is **not** to be used in Oregon Forestsnail habitat for any animal species, as it will result in unacceptable mortality of snails.

RECORD KEEPING

Good sampling practice involves the collection of detailed field notes. For all survey methods described above information should be recorded on survey conditions, what was done and by whom, and habitat features and species found. For observations of Oregon Forestsnail, record the geoposition (GPS location), number found, their size (shell width), and habitat parameters. Other large snails, both native and introduced, should be counted and recorded as they are found during the surveys.

Additionally, the following list of observations should be recorded in the Field Survey Form for the sampling session and plot; habitat information does not need to be recorded for each repeat visit, unless it has changed.

- site name,
- geoposition
- names and personnel on sampling crew
- weather conditions:
    - percentage cloud cover
    - precipitation
    - relative humidity
    - index of vegetation and ground moisture
- other gastropod species encountered, including non-native gastropods
- habitat feature data should include:
    - vegetation composition and structure of tree canopy and understory
    - soil conditions (e.g., moisture content, compaction, and disturbance condition)
    - course woody debris abundance
    - habitat fragmentation

Appendix 1 lists details of the information to be collected about the site and of survey conditions and animals found. It also includes sample data forms for surveys. Data forms often need to be adjusted for particular studies, depending on objectives and types of surveys undertaken.

7.5 Identification and Vouchers

Adults of Oregon Forestsnail can be readily identified from shell characteristics (see Forsyth 2004). Good-quality photographs of the top and underside of the shell should be taken. If empty snail shells are found, 1-2 shells per site can be collected as vouchers. Avoid collecting live snails inadvertently; hibernating snails are often in an upside-down position (with the aperture facing up) and are withdrawn deep into the shell. Confirmation of identification should be sought from an expert. Photographs may be sent to ENV or BC Conservation Data Centre for this purpose.

7.6 BMPs for Land Development and Clearing

The best option for minimizing impacts on snails is to locate developments away from high-quality habitats in low-elevation deciduous and mixed-wood forests where Oregon Forestsnail is found. Where avoidance is not feasible, adoption of the following practices will help mitigate deleterious effects.

Buffers and Management Areas:

Set aside from development habitat patches where Oregon Forestsnail occurs or where the habitat is deemed to be of high quality. These management areas should be as large as possible, as accurate estimates of minimum patch size for viable populations are unavailable. *Conservation covenants* or *stewardship agreements* are an excellent way to ensure that these areas remain protected over the long term.

Using results of a habitat assessment and surveys, set boundaries for protected areas. Establish a buffer zone of undisturbed forest around groups of snail observations. Use signage, barriers and/or fencing to control human access to the area, as appropriate.

Maintain or enhance habitat connectivity both within the development area and within the landscape beyond this area through riparian buffer zones (see below), greenways, or other habitat protection initiatives; a habitat patch that is connected to other patches, larger forest stands, riparian buffer zones, or other greenways is much more likely to support viable populations of snails than patches that are isolated in midst of unfavourable habitat.

Leave buffers of undisturbed habitat along both sides of streams and around moist areas and around occurrences; ideally, such buffers should be at least 50 m wide or 1 ½ times the length of the tallest Bigleaf Maple tree within the habitat patch. Wider buffers are preferred and provide adequate shade and retain moist forest floor conditions. Where multiple species at risk occur, use the widest buffer width recommended. On very small sites, narrower buffers may be considered, but they may not be able sustain the micro-climatic habitat characteristics of shade and moisture necessary for a snail population.

Retain Bigleaf Maples, especially large diameter trees, wherever possible; even a few large maples at the edges of a forested area can provide valuable habitat for Oregon Forestsnail, especially if natural herbaceous vegetation is also maintained.

An assessment of water sources in an area, including springs, ponds, drainage patterns, draws, creeks (dry and with water), should take place as part of the planning process. These water sources contribute to soil moisture, vegetation composition, and micro-habitat conditions.

MANAGEMENT OF ACTIVITIES DURING CONSTRUCTION:

Clearly mark and protect areas not to be disturbed from damage by using sturdy temporary fencing.

Avoid altering natural patterns of drainage and ground water levels, both adjacent to and within habitat patches. Drainage and groundwater maintenance is essential for maintaining moist forest floor conditions and herbaceous vegetation required by the snails and other wildlife.

Restrict heavy machinery and vehicles to development areas; clearly mark areas were vehicles can turn around and where materials can be stock-piled.

Avoid inadvertently introducing and spreading exotic gastropods and other non-native species of plants and animals into snail habitat; this could be accomplished by cleaning soil adhering to machinery and workers' boots before entering the worksite. For example, the spread of exotic and invasive plant species such as English Ivy (*Hedera helix*), Himalayan Blackberry (*Rubus discolo*r), Spurge Laurel (*Daphne laureale*), and brome grass (*Bromus spp.*) can outcompete native vegetation.

Avoid compaction of soil, disturbance of herbaceous plants, and removal of coarse woody debris. Coarse woody debris provides shelter for Oregon Forestsnail during dry periods and is thought to be important during the mating period and as residences for Oregon Forestsnail.

Strictly manage construction waste and pollutants so that snail habitats are not contaminated.

MANAGEMENT OF ACTIVITIES AFTER CONSTRUCTION IS COMPLETE:

Within riparian buffers and management areas set aside for Oregon Forestsnail, maintain a multi-layered canopy with natural forest gaps and undisturbed forest edge habitats; avoid conversion of deciduous and mixed-wood forests into dense conifer-dominated stands.

Retain coarse woody debris, including large-diameter downed logs, on the forest floor; these provide shelter for Oregon Forestsnail and other wildlife.

Avoid disturbance to areas containing loamy soils and deep leaf litter, as such sites are used for egg-laying by Oregon Forestsnail.

Avoid brush burning, as snails are intolerant of burning.

Avoid storm water run-off from entering into Oregon Forestsnail management areas. The flow of excess storm water carries pollutants, debris, garbage, and other substances that may be

deleterious to the snails. Manage habitat along roadsides, greenways and trails as described in the following section.

7.7 BMPs for Roadside and Right-of-way Maintenance

Oregon Forestsnail is frequently found along rights-of ways in locations where roads, railways, powerlines, pipelines or other transportation or utility corridors intersect low-elevation, deciduous or mixed-wood forest stands, especially stands with Bigleaf Maple (Ovaska *et al.* 2001; COSEWIC 2002; Ovaska and Sopuck 2003, 2006). A number of observations of snails depositing eggs in shallow depressions that they dig in the ground are from these habitats, including mowed road edges (Ovaska *et al*. 2001). The only known population on Vancouver Island occupies a railway right-of-way and adjacent forest habitat (COSEWIC 2002; Ovaska and Sopuck 2003).

Within delineated Critical Habitat or in areas where known populations of Oregon Forestsnail exist, conduct surveys before clearing vegetation for right-of-way maintenance with the aim of identifying concentrations of snails and high-quality habitat patches (i.e., those containing biophysical features required by the snails). Transect surveys, described in Section 7.4 SURVEY METHODS, could be used for these purposes. For areas that require repeated routine maintenance over the year, one annual survey during the optimal time and conditions for snail activity may be sufficient; April – May is the most reliable period. During roadside and right-of-way maintenance, leave undisturbed patches of Stinging Nettle and other herbaceous vegetation where concentrations of snails or patches of high-quality habitat occur, as identified during annual surveys. These areas should be mapped and marked on the ground, so that disturbance to them can be avoided.

The objective of the following practices is intended to mitigate harm to the population of snails:

- Avoid clearing during spring-early summer (from late March to end of June) when the snails are most active on the surface and depositing eggs. Preferably work should be conducted during dry periods in summer (in July – August) or cold periods in winter (in November – February), when the snails are inactive. Mowing and management of herbaceous vegetation can be done in mid-summer, and shrub and tree trimming can be conducted in winter. (.
- For vegetation trimming and management, use hand clearing methods (e.g., cutting shears, axes) and mechanical clearing of right-of-way vegetation rather than herbicides
- When mowing, raise the level of the blades (~10-15 cm above ground) to retain cover for the snails and mitigate crushing of snails.

- Confine vehicles and machinery to the road surface itself, or to a designated trail along service right-of-ways, to minimize compacting soil and crushing snails within vegetation; avoid parking vehicles and machinery on vegetated roadsides and right-of-ways.

- If after taking the above precautions, Oregon Forestsnails are encountered in the path of routine maintenance activities, they can be moved short distances (<30 m) out of harm's way to the nearest suitable habitat. The objective is to minimize harm to the population and its habitat rather than moving every individual snail, and resources should be allocated accordingly.

- Where mortality of snails along rights-of-way or trails is a problem, use barrier fencing to deflect snail movements away from these hazardous areas; shift the location of trails away from areas with concentrations of snails or high-quality habitat patches.

- Avoid inadvertently introducing and spreading exotic gastropods and other non-native species into snail habitat; this could be accomplished by inspecting and cleaning any equipment and building materials brought into the area, such as lumber stored outside and avoiding bringing in plants or leaf litter/mulch from other areas. These measures are particularly important in areas that are free of exotic species.

7.8 BMPs for Invasive Species Management

Avoid using chemical pesticides and herbicides that are harmful to wildlife and natural ecosystems; some municipalities prohibit pesticide use in urban/rural environments and encourage the use of integrated and green pest control strategies. Check the municipal bylaws.

Establish a pesticide-free buffer zone where gardens, lawns, and agricultural fields occur adjacent to habitat occupied by Oregon Forestsnail, such as forest edges.

Use alternative measures to pesticides to control garden pests, such as exotic slugs and snails; such methods include placement of susceptible crops in driest areas of the garden; avoid over-watering; use of copper barrier fences around individual plants or groups of plants, and trapping or hand-picking pest slugs at night (for other ideas, see University of California website http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7427.html)

Introduced invasive plants, such as Himalayan Blackberry, Scotch Broom, Spurge Laurel, and English Ivy that form dense thickets on the forest floor reduce habitat quality for Oregon Forestsnail and may need to be controlled. Where needed, use mechanical clearing of vegetation and hand clearing (e.g., pruning shears, axes) rather than herbicides, which

effectively destroy cover and food sources for snails and may increase mortality through toxic effects. If invasive plant removal is deemed necessarily in habitats occupied by Oregon Forestsnail, the activity should be carried out with extreme care to avoid inadvertently stepping on snails and trampling their habitat. Removal activities by small crews during periods when the snails are inactive, such as in late fall and winter (November – February), are preferred but could also be carried out by cutting stems during dry periods in summer (July – August). Continued vigilance and follow-up removal of sprouting plants are necessary in subsequent years to ensure long-term benefits. Ideally, where invasive plant removal is specifically proposed as a measure to enhance or restore Oregon Forestsnail habitat, its effects should be monitored. Measuring abundance of snails before and after invasive plant removal is optimal (see Section **SURVEY METHODS**). It is also important to establish appropriate controls at adjacent sites where removal is not carried out to account for possible year to year fluctuations in snail population size due to weather or to factors unrelated to the treatment. However, in practice, monitoring the responses of snails to invasive plant removal is not feasible within each project, but should be undertaken as research project by universities or government institutions; the efforts should be documented in sufficient detail to allow for such monitoring at a later date, if deemed desirable.

7.9 BMPS FOR RECREATIONAL ACTIVITIES

Avoid constructing recreational facilities, such as picnic sites or new trails, through areas occupied by Oregon Forestsnail.

Prohibit high-intensity recreational activities, such as mountain biking, use of all-terrain vehicles, or other activities that compact soil, in occupied snail habitats.

Confine recreational trails in snail habitat to clearly defined paths; for example, use chip trails to encourage trail users to remain on paths.

Use fencing or barriers made from fallen branches to discourage off-trail access where concentrations of snails or patches of high-quality habitat occur; consider rerouting paths to avoid concentrations of snails.

Where feasible, construct elevated boardwalks through high quality snail habitat; boardwalks encourage people to remain on trails and reduce trampling of vegetation and compaction of soils.

Minimize removal of Stinging Nettle patches, which provide important cover and forage for Oregon Forestsnail.

During trail maintenance, avoid using herbicides and excessive removal of trailside vegetation.

Avoid inadvertently introducing and spreading exotic gastropods and other non-native species into snail habitat; this could be accomplished by inspecting and cleaning any building materials brought into the area, such lumber stored outside, and avoiding bringing in plants from other areas. These measures are particularly important in areas that are free of exotic species.

7.10 Habitat Restoration

Habitat restoration can be used to improve severely degraded habitats. In some cases, habitat restoration may be considered as a compensatory measure for mitigating damage to Oregon Forestsnail habitat as a result of disturbance from housing or infrastructure development or other human activities. The acceptability of this approach is likely to be determined on a case by case basis and should be discussed with FLNRO.

The following measures are likely beneficial to the species, but it should be noted that no robust information is available on their effectiveness in improving Oregon Forestsnail habitat. Where feasible, the effects of restoration activities should be monitored, so that lessons learned can be applied at other sites; the activities undertaken should be carefully described and their locations mapped.

- Removal of invasive introduced species, such as Himalayan Blackberry, Scotch Broom, Spurge Laurel, and English Ivy. These plants can spread rapidly, especially in disturbed habitats, and form dense thickets that crowd out native plants. While Oregon Forestsnail may continue to occupy habitats dominated by Himalayan Blackberry and other invasive plants, it is unlikely that the habitat is of high quality and provides for their needs over the long term.

- Planting or seeding areas with native understory plants or otherwise encouraging their establishment after the removal of invasive plants.

- Establishment of new Stinging Nettle patches in forest openings and along forest edges to provide forage and cover.

- Restoration of riparian vegetation along forest streams, e.g., by replanting with native vegetation and routing trails away from these areas.

- Addition of coarse woody debris is usually not required but could be used to restore an area after a temporary disturbance. Optimally, the restoration would consist of salvaging coarse woody debris from the site before the disturbance and returning it to

the same site afterwards. The advantage of adding salvaged coarse woody debris from a development site to the adjacent area is questionable, because its effects on the snail population already at the site are unknown. However, if follow-up monitoring is feasible, the addition of coarse woody could be considered in an experimental context. It is not advisable to import coarse woody debris from other areas because of the possibility of inadvertently introducing invasive and alien species.

- Decommissioning of excess trails in recreational areas is beneficial by providing more continuous habitat and reducing accidental crushing of snails.

7.11 Additional Guidelines

The land manager or developer is responsible for collecting existing information on Oregon Forestsnail occurrences and delineated Critical Habitat in the vicinity of the study area and, where suitable habitat exists, and for conducting surveys for this and other species at risk in an appropriate manner. Sections 7.3 (**Planning phase for mitigating impacts**) and 7.4 (**Survey methodology**) cover recommendations for collecting existing information and carrying out field surveys; these recommendations should be consulted and followed whenever possible. Careful records should be kept of all tasks undertaken and their outcomes. These records can be used to demonstrate that the manager or developer has shown due diligence and made every effort to follow recommended standards and procedures.

7.11 SALVAGE AND TRANSLOCATION

Measures other than or additional to the above BMPs may be used in particular situations, provided that they conform to the recovery objectives for Oregon Forestsnail. Usually, such measures are best developed in consultation with a professional biologist with expertise on terrestrial gastropods and their habitat requirements. If in doubt about particular measures or approaches, contact the BC Ministry of Environment or the BC Conservation Data Centre.

Translocations may be for conservation purposes, including the establishment of a new population to reduce the risk of extirpation due to stochastic events (conservation translocation). Alternatively, translocations may be aimed for reducing or preventing risk to individuals when their habitat is facing permanent loss or temporary disturbances (mitigation translocation or salvage). This category also includes cases when *in-situ* preservation of a unique subpopulation that faces risks from human activities cannot be accommodated within the project. This section deals mainly with mitigation translocation (referred to as translocation for brevity), although some of the methods associated with permanent habitat loss also apply to conservation translocations.

Translocation of snails from proposed development sites is never a substitute for *in situ* or compensatory habitat protection and stewardship. It is to be discouraged for two reasons: It does nothing to prevent habitat loss and fragmentation, which is the main threat facing Oregon Forestsnail, and snails introduced to new sites may not survive, either because the habitat is sub-optimal or it is already saturated and cannot support additional snails. The absence of the species at the release site suggests that the habitat might be unsuitable (although not detecting snails within suitable habitat does not necessarily mean absence). At release sites already occupied by Oregon Forestsnail, snails from another location may carry diseases or parasites that are detrimental to the resident population. The benefits and risks of translocation need careful consideration and evaluation. Currently, no information is available to assess the success of translocations as a mitigative measure for Oregon Forestsnail. Therefore, follow-up monitoring of the fate of the translocated snails is important, so that the use of translocation tools can be evaluated. Note that SARA prohibits the collection of Oregon Forestsnail without special permits on federal lands. Future provincial legislation may have similar provisions; check with ENV or FLNRO biologists before moving individuals or planning activities.

Translocation as a mitigation measure applies only in special circumstances when all other options are exhausted. These options include:

- shifting the location of the project to avoid key habitats;

- establishing reserves or riparian management zones within the development area to protect important habitats;
- where habitat disturbance is temporary, shifting the timing of activities so as to minimize harm to snails and their habitats and adopting site maintenance activities that cause the least damage;
- setting aside and formally protecting areas of at least equal quality and size adjacent to the development or elsewhere within the species' range to compensate for the loss of habitat from development;
- contributing to targeted recovery funds or habitat restoration efforts elsewhere within Oregon Forestsnail's range in British Columbia.

A translocation plan should be prepared, including alternatives considered, assessment of risks and benefits, and detailed methods, and discussed with FLNRO Species At Risk Biologists before undertaking relocations. Where the impact area is large, a plan to monitor the success of the translocation needs to be prepared and implemented.

The following definitions apply to methods described below:

- **Development Area**: the entire area where development will occur.
- **Impact Site**: areas where proposed development footprint overlaps with occupied or suitable Oregon Forestsnail habitat, which will no longer be habitable by Oregon Forestsnail following development; source area for translocated snails.
- **Reserve Area**: riparian buffers, green spaces, or areas of high suitability habitat or high concentrations of Oregon Forestsnails, as revealed by surveys, that are set aside from the development and left undisturbed.
- **Residual Impact Site**: Sites that will indirectly continue to be affected by planned development over the next ten years. Examples include 10-15 metres on either side of a roadway or trail (edge effects will continue); or where maintenance activities will continue to cause repeated habitat disturbance over the next ten years.
- **Reference Site**: Site adjacent to the impact area where Oregon Forestsnail occurs, but to where no individuals will be relocated. This area should have similar habitat characteristics to the Relocation Sites but be far enough away not to be influenced by relocation activities (i.e., beyond Oregon Forestsnail dispersal distances).
- **Relocation Site**: Site where translocated snails are released.

MITIGATION GUIDELINES FOR TRANSLOCATIONS

Before selecting translocation as a mitigation measure, all other options need to be considered, such as shifting timing of activities, shifting the location of activities, retaining reserve areas within the development, or protecting or restoring habitat elsewhere within the species' range to compensate for habitat loss. If translocation is deemed necessary, the implications depend on project type and size. Different options are presented below for projects where the activities result in permanent habitat loss or in temporary habitat disturbance.

The planning process applies for all options and includes the following steps:

1. Compile and map existing records and delineated Critical Habitat for the species; prepare a preliminary habitat map of the study area to guide survey efforts.
2. Map proposed boundaries of the following areas and calculate the size of each:
    - Development Area
    - Impact Site
    - Residual Impact Site
    - Release and reference sites, as applicable (see below)
3. Conduct baseline surveys to ground-truth the preliminary habitat map and to identify biophysical features of Critical Habitat and potential areas of high concentrations of the snails, following steps 1 – 6 as described in Section **STEPS TO MITIGATION PLANNING**.
4. Prepare a mitigation plan that includes an assessment of mitigation options alternative and/or additional to translocation.

Option A. Habitat disturbance is temporary

Examples include roadside mowing and vegetation trimming along service corridors or recreational trails, where the project results in a temporary habitat disturbance, and habitat recovery is likely within a relatively short period (e.g., within a year).

- Adjust timing of activities, so that harm to the snails is reduced; conduct activities during periods when the snails are inactive during dry periods in summer or cold periods in winter; avoid disturbing key habitats or features to the extent possible (see **BMPs for Roadside and Right-of-Way Maintenance**).
- If snails are encountered during the activities despite taking precautions, translocate them to the nearest undisturbed, suitable habitat, no more than 30 m away from their original locations.
- Marking of the snails or monitoring their survival is not necessary.

- The activities should be documented in detail, including the number of snails moved and the location and habitat in the source and release areas.

Option B. Impact area is small and habitat loss is permanent

Examples include the construction of a small single structure or infrastructure expansion with a small impact area (e.g., <500 m^2).

- Consider placing the development so that key habitats or biophysical features important for Oregon Forestsnail are not disturbed; consider shifting the location of the impact area, if needed, based on survey results.
- Conduct an assessment of the proposed release site(s), so that the risks to the existing Oregon Snail population, if present, can be assessed. Considerations include whether the surrounding area is saturated, based on existing snail densities and habitat quality, and whether the addition of translocated snails would increase competition for resources. Select the release site from the area around the impact area according to the results.
- Conduct a thorough survey of the impact site immediately prior to the construction, and, if deemed feasible and a suitable release site in the surrounding habitat has been selected, translocate snails found to no more than 30 m away.
- Marking of the snails and monitoring their survivorship can be forfeited for projects with a very small impact area. Ascertaining the continued presence of Oregon Forestsnail and habitat integrity at the release sites in the years following the disturbance is desirable.
- Any relocations should be documented in detail, including the number of snails moved and the location and habitat in the source and release areas.

Option C. Impact area is large and the project results in either permanent loss of habitat or recovery will take several years

Examples of projects with permanent impacts include development of residential subdivisions, shopping malls, large building sites, golf courses, and other land conversions, and construction of new roads. Examples of projects where habitat loss is not permanent but where recovery takes several years include construction of new service lines or their expansion into previously undisturbed habitat. Sufficient resources need to be allocated for follow-up monitoring to document whether the translocation was successful. The resulting data and evaluation are to be submitted to provincial data bases (e.g., BC Conservation Data

Centre, SPI) and the Recovery Team, so that lessons learned can be applied to future translocations and incorporated into guidelines.

- Baseline surveys for these types of projects should be thorough, e.g., using transect methods across the study area, and include both the impact and potential release areas.
- Consider what other mitigative measures, such as set-asides or shifts of the impact area could be taken, based on survey results.
- Conduct an assessment of the potential release site(s), so that the risks to the existing Oregon Snail population, if present, can be assessed. Considerations include whether the surrounding area is saturated based on existing snail densities and habitat quality, and whether the addition of translocated snails would increase competition for resources. Select a release site(s) from the surrounding area according to the results.
- Select and indicate on the map the locations of monitoring plots at reference and release sites.
- Conduct a thorough survey of the impact site immediately prior to the construction, and, if deemed feasible and a suitable release site in the surrounding habitat has been selected, translocate snails found to the selected release site(s).Marking of the snails and monitoring their survivorship is needed to investigate the effectiveness of the mitigation and so that lessons learned can be applied to other sites, and a monitoring plan should be prepared. The scope and intensity of follow-up monitoring will depend on the type of project (see Section POST-RELEASE FIELDWORK AND MONITORING for options).

Discuss the proposed mitigation and translocation plan with regional FLNRO Species At Risk Biologists and include a follow-up monitoring plan to the proposal.

SELECTION OF RELEASE SITES

From the habitat map and reconnaissance level surveys, select area polygons that are potentially suitable as release sites. Priority will be given to areas in the immediate vicinity of the impact area that are deemed highly suitable for Oregon Forestsnail, but where the species appears to be absent or occurs at low densities based on previous surveys carried out as part of mitigation planning. High-quality habitats where the species already appears to be abundant and close to carrying capacity are not to be selected for translocations, as the augmentation will serve no purpose and could have deleterious consequences to the existing population. In some cases, snails may be absent from suitable sites because of historical events (e.g., fire history) or barriers; such sites are potentially suitable as release sites.

COLLECTION, PROCESSING, AND RELEASE OF SNAILS

Collection of Oregon Forestsnails for translocation should occur during the peak activity period of the species in April – June; earlier in the season is best to give the released snails time to find refuges and acclimatize before inclement conditions in mid-summer. Collection of snails during wet periods in early fall (September) is also possible, but translocations should not be conducted after late-September or early October, which is close to the onset of hibernation, and translocations from November through mid-March is not appropriate. Survivorship of over-wintering snails moved during these periods may be affected if they are inadvertently placed in suboptimal microhabitats.

The snails should be taken to the processing site and kept at a shaded location in ventilated plastic containers with moist leaf litter and/or moss from their habitat in small groups (no more than 10 – 15 snails per 8"x 12"x 6" container). Ideally, they should be processed and released the same day. If this is not feasible, the snails should be provided with food (e.g., organic lettuce and carrots) and the substrate kept moist but not saturated for the duration of captivity, which should not exceed 2 – 3 days.

Depending on the intensity of monitoring selected, the processing of snails may consist of measuring their shell width, noting the condition of the shell, such as cracks or wear, marking them with group marks or for individual identification, and taking a photograph of the marked snails for reference. Recommended marking methods include paint marks (as described in Steensma *et al.* 2009) or gluing a small tag onto the shell (see Section **CAPTURE-MARK-RECAPTURE METHODS** for an overview and **APPENDIX 2** for details). A method using passive integrated transponders (PIT tags) shows promise and is under development (K. Ovaska, pers. comm., see Appendix 2). The tags should be durable and intended to last for several years of monitoring. More information on tagging methods can be obtained from FLNRO species at risk biologists.

Release of snails is to take place at the designated release areas when the ground is moist, preferably immediately after or during rainfall. Snails should be released in groups of ~10 individuals in sheltered microhabitats, such as base of Bigleaf Maples with accumulated leaf litter, by large decaying logs, or sword fern bases. In unoccupied habitat, the densities of released snails should not exceed 1 snail/m^2, based on average natural densities of found in a study in Langley (Steensma *et al.* 2009). An evening release is preferred, as it avoids immediate exposure of snails to diurnal predators before they have had time to acclimatize and find refuges. Release snails by gently placing them in the selected localities; simply dumping a bucket of collected snails onto the ground in one place is unacceptable.

POST-RELEASE FIELDWORK AND MONITORING

Post-release monitoring should be incorporated into large projects that include translocation. For small projects and those where the impacts are transitory and the habitat is expected to recover over the short term, monitoring may not be required; ascertaining the continued presence of Oregon Forestsnail and habitat integrity at the release sites in the years following the disturbance may be desirable in some cases. For larger projects, as described for Option C in MITIGATION GUIDELINES FOR TRANSLOCATIONS, more comprehensive follow-up is recommended, including a Capture-Mark-Recapture study. The following options are presented; the appropriate option will depend on the type and nature of the project and the extent of associated habitat disturbance.

I. Group marks (all snails receive the same mark) are given to the snails to be translocated, and their survival and distribution within the release site is monitored through repeated surveys. Separate group marks may be given to snails of different size classes or those released at different locations around the impact area.

II. Individual marks are given to each translocated snail, so that the survivorship and movements of individuals can be tracked. This allows for the use of more powerful data analysis methods than for Option (I) above but requires considerably more effort. For comparisons, it is desirable to mark a similar number of snails from the existing population at the release site.

III. Intensive monitoring study with replicated treatment (where translocated snails have been released) and reference (where snails have not been released) plots (see Appendix 3 for suggested methodology). The translocated snails and existing snails at the release sites are marked individually, and their survivorship and movements are tracked. Intensive monitoring provides the most accurate data of the success of the translocation when compared to the other options. This intensity of monitoring is not feasible for all projects but should be considered for large projects that result in extensive disturbance to Critical Habitat and/or sites with populations of Oregon Forestsnail. Intensive monitoring studies are best conducted in collaboration with provincial or federal agencies (e.g., FLNRO, CWS) and/or researchers from academia.

Populations at the release sites should be monitored multiple times in the year of release and for several years post-salvage; annual surveys for at least three years, preferably five years are recommended. It is recommended that the first survey session take place ~2 – 3 months after release and then annually during the peak period of snail activity in spring – early summer. A second survey session, in the fall following the translocation is also desirable. Surveys are to be conducted according to methods described in Section **CAPTURE-MARK-RECAPTURE METHODS**. Briefly, the observer will walk slowly along marked survey routes (e.g., from stake to stake) visually examining the ground and carefully searching key microhabitats for snails. Each survey session

may last for more than one day (e.g., 3 consecutive days), provided that habitat disturbance can be minimized.

Where individual identification of snails is possible, suitable statistical methods for data analysis include models of encounter histories using the software program MARK (White and Burnham 1999; University of Colorado, undated). Monitoring snail populations on the plots will provide information on survivorship of the translocated snails in relation to snails on reference plots, and on population trends over time.

8. Monitoring and Reporting

Land managers and developers are strongly advised to monitor the effectiveness of habitat protection and other mitigation measures they have implemented for Oregon Forestsnail and other target species. Monitoring is essential where any manipulations, such as translocations, have been conducted in conjunction with large projects. Monitoring can demonstrate that the manager or developer has followed the prescribed BMPs; it will also help improve their mitigation practices if problems are encountered. The following steps should be reviewed and followed as appropriate:

Document all measures taken during planning, construction and maintenance of the development area, including maps showing the boundaries of natural areas retained. Use the services of a qualified resource professional.

Conduct repeated surveys of the property to determine the areas occupied by Oregon Forestsnail and compare distribution patterns before and after development using methods described in this document. For translocations, monitoring should be conducted for a minimum of 3 – 5 years.

Assess the quality of retained habitats by measuring the effects of contaminants, soil compaction, changes in moisture patterns and disturbances to natural vegetation and key habitat features such as coarse woody debris; also assess whether the habitats continue to be used by Oregon Forestsnail and other target species.

Where protection measures have been found to be deficient, document what improvements were made to rectify the problems.

A monitoring plan should be part of each project to ensure that mitigation measures implemented are working as intended. Such monitoring provides valuable feedback to managers and allows activities and mitigation measures to be adjusted through adaptive management as new information becomes available. Monitoring both habitat features and populations of target organisms is often a useful approach. The results of monitoring efforts should be summarized at regular intervals, such as yearly, through a reporting schedule to ensure that the results become available to managers in a timely fashion.

Example check-list for habitat features to be monitored:

1) Soil compaction, erosion, and disturbance

- Condition of soils, especially on slopes
- Degree of erosion
- Amount of human disturbance, including various infrastructures, number of visitors, length and density of trails/roads

2) Vegetation composition and structure of different layers

- Herbaceous vegetation (type and abundance)
- Deciduous component, particularly of Bigleaf Maple (type, abundance, and age/size)

3) Canopy closure and forest edges

- Measure of canopy closure
- Size and pattern of openings in the forest
- Amount of forest edge

4) Forest floor structure

- Coarse woody debris (amount and state of decay)
- Depth and type of litter layer
- New wind-throw, particularly around edges of retained forest patches and riparian buffer zones

5) Drainage pattern

- Are natural or pre-disturbance water-flow and drainage patterns maintained? Have temporary water bodies been converted to permanent water bodies or vice versa?
- Is storm water draining into an area? Are pools forming where once they were not present?

6) Habitat Connectivity

- Measures of degree of isolation for habitat patches, e.g., distance to nearest areas with suitable habitat
- Measures of fragmentation, e.g., length of roads of different types within the study area; proportion of paved surfaces

7) Contaminants

- Presence and/or effects of contaminants

8) Prevalence of introduced, invasive species

- Introduced species of gastropods
- Invasive plants
- Other invasive species of significance to gastropods, such as new predators

Example check-list for population/distribution characteristics to be monitored over time:

- Changes in distribution patterns of Oregon Forestsnail or other target species within the study area.
- Continued presence of Oregon Forestsnail, observations of juveniles, mating, oviposition, nesting or eggs, or other target species within designated buffer zones, protected habitat areas, or other sites within the study area.
- Continued use of key habitat features by Oregon Forestsnail or other target species within the study area; such key features may be patches of Stinging Nettle for foraging or areas with suitable soils for nesting.
- Population trends (stable, increasing, declining) of Oregon Forestsnail or other target species within the study area.

The first three measures require the least effort and are often adequate. "Presence/not detected" type of data needed for these monitoring measures should be collected through surveys at optimal times of the year using appropriate methods (see Section **SURVEY METHODS**).

Information on relative abundance or population size/density over a minimum of 3 – 5 years of monitoring after translocation is needed to determine whether a population is declining, increasing, or stable. Ideally, population trend data most accurately indicate whether mitigation is successful. However, accurate information on population size is often difficult to obtain and requires much effort. The objectives of the monitoring program should be carefully examined to evaluate whether information on population trends is needed for particular purposes or projects. Where translocations are used as a mitigation measure, intensive monitoring that provide estimates of survivorship and population trends are required for large projects.

9. Compliance and Enforcement

Best management practices (BMPs) are approaches based on known science that, if followed, allows the client to meet the standard or achieve desired objectives. Clients may follow the BMPs suggested in this document, or they may opt to follow different practices with or without the advice of an appropriately qualified professional. If the objective is not met, but the client can clearly demonstrate that they have followed the prescribed BMPs, they may not be held responsible for non-compliance with the objective. If the objective is not met, the client (and the professional) can be responsible for demonstrating that the alternative practices were an appropriate choice.

10. Case Studies

At present no case studies have been completed. Opportunities exist for collaborative research to investigative effectiveness of the BMPs described in this document. More information on such collaboration can be obtained from the Ministry of Environment and Climate Change Strategy and Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

11. Glossary

Audit (noun): a single set of tests, analyses and confirmations to verify the acceptability and quality of work or data. Audits are usually comprehensive, complex and spatially/temporally discrete. Audits can be considered a type of compliance monitoring (Quayle 2003).

BC Conservation Data Centre: http://a100.gov.bc.ca/pub/eswp/

Best management practices: methods, measures, or practices designed to prevent or reduce damage to the focal population or its habitats. Includes procedures for different types and phases of human disturbances and operations and maintenance. Usually, BMPs are applied as a system of practices rather than a single practice (Dunster and Dunster 1996).

Biodiversity (biological diversity): the diversity of plants, animals, and other living organisms in all their forms and levels of organization, including genes, species, ecosystems, and the evolutionary and functional processes that link them (MOF Web Glossary; MELP 1999).

Compliance monitoring: Measures performance against some environmental standard to establish a compliance record. May include audits, assessments, and reviews. Legal Defn: measurement of performance against practices required by law (e.g. regulations under the Fish Protection Act, Wildlife Act, etc.). Practices Defn: Measurement of performance against environmental standards, policies, best management practices or plans that are recommended but not required by law. CAUTION: In some BC ministries, the term "compliance" refers exclusively to performance against legal standards (Quayle 2003).

COSEWIC: Committee on the Status of Endangered Wildlife in Canada https://www.canada.ca/en/environment-climate-change/services/committee-status-endangered-wildlife.html

Development: refers to altering the existing landscape from a natural or semi-natural state into an urban, housing, commercial, industrial, tourism infrastructure, agricultural, roadway or utility line or other purpose with a substantial foot print. The International Union for the Conservation of Nature (IUCN) threat definition: Threats from human settlements or other non-agricultural land uses with a substantial footprint.

Effectiveness monitoring: Measures environmental condition in the context of a program, policy, plan or activity to gauge progress towards its desired outcomes or effects. Different from compliance monitoring in that rather than addressing whether people are complying with

environmental standards, effectiveness monitoring attempts to uncover whether those standards are having an effect in the environment (Quayle 2003).

Goal: goals provide general purpose and direction. They are the end result of ultimate accomplishment toward which an effort is directed. They generally should reflect perceived present and future need. They must be capable of being effectively pursued. (MOF Web Glossary). An ideal; a desired endpoint; frequently defined in abstract terms. Goals are qualitative and are achieved by means of objectives (Dunster and Dunster 1996).

Guidelines: a set of recommended or suggested methods or actions that should be followed in most circumstances to assist administrative and planning decisions, and their implementation in the field. Guidelines may consist of policy statements, procedures, or checklists. They are provided as a broad framework of recommended actions to be taken and, therefore, provide some flexibility for decision making. Note that guidelines cannot, by definition, be mandatory; such actions are prescribed by regulations or rules (Dunster and Dunster 1996).

Impact assessment: A study of the potential future effects of resource development on other resources and on social, economic and/or environmental conditions (MOF Web Glossary).

Inventory: a single enumeration of an ecological system; generally carried either as a basis for estimating potential yield or to establish a benchmark. An inventory may act as one point in time in a monitoring program. Ecological inventories may be more comprehensive and spatially/temporally discrete than monitoring activities (Quayle 2003).

Mitigation: measures implemented to control, reduce or eliminate a potential adverse impact of a project, including restorative measures (EAO 2003).

Monitoring: repeated, systematic measurements done with a specific purpose in mind. Monitoring is focused on measurements over time in order to detect the change toward, or away from, a stated standard or objective. Monitoring is part of the cycle of assessment and evaluation that is linked to management activities (Quayle 2003).

Objective: a quantifiable, measurable and defined target, capable of attainment within a defined period of time. Objectives are the means by which goals are achieved and should include four main components: 1. They must state the desired outcome (i.e., what is to be accomplished.); 2. They must indicate the time period within which the expected outcome is to be achieved; 3. They must include measurement factors, such as quantity, quality, or cost, so that the fulfilment of the objective can be verified; 4. They must indicate who is responsible for achieving the indicated result. Desirable (but not absolutely essential) elements of objectives

are a description of how they will be achieved and an indication of who will determine whether the results have been achieved. Objectives are typically narrower and shorter in range than goals, and serve as milestones toward goal achievement (Dunster and Dunster 1996).

Referral: the process by which applications for permits, licences, leases, etc., made to one government agency by an individual or industry are given to another agency for review and comment (MOF Web Glossary).

Rehabilitation: the restoration of ecosystem functions and processes in a degraded system or habitat. (Dunster and Dunster 1996).

Reporting: the process of effectively communicating the results of monitoring and their potential implications to a target audience (Quayle 2003).

Restoration: a process of returning ecosystems or habitats to their original structure and species composition. Restoration requires a detailed knowledge of the (original) species, ecosystem functions, and interacting processes involved (Dunster and Dunster 1996).

Results-based performance standards: Typically define a maximum permissible disposal or impact threshold. For example, the concentration of a particular chemical in waste water discharge or a receiving environment; minimum in-stream flow levels; forest age class distribution within a defined zone. Requiring users of the environment to stay within the established threshold is presumed will achieve the environmental goal that the standard relates to. Results-based performance standards must be scientifically supported, as locally-relevant as possible, accepted by the public and stakeholders, enforceable by being capable of being measured, and affordable and feasible to implement (Brown 2002).

Risk: the probability that an undesirable event will or will not occur. It is the product of the probability of the event taking place, the probability of being exposed to the event, and the probability of certain outcomes occurring if exposure did take place. Risk can be statistically quantified in a risk assessment (Dunster and Dunster 1996).

Salvage: Type of translocation (see definition), where organisms are removed to prevent imminent harm to them from habitat loss or human activities.

Standard: quantifiable and measurable thresholds that are typically defined in law or regulation and are mandatory. A statement that outlines how well something should be done, rather than how it should be done. A standard does not necessarily imply fairness or equity, nor an absolute knowledge of cause-and-effect linkages. Standards are typically established using a

combination of best available scientific knowledge, tempered by cautious use of an established safety (caution) factor (Dunster and Dunster 1996).

Stewardship: caring for the land and associated resources so that healthy ecosystems can be passed on to future generations (Dunster and Dunster 1996).

Sustainability: the ability of an ecosystem to maintain ecological processes and functions, biological diversity, and productivity over time (Dunster and Dunster 1996).

Sustainable development: a conceptual ideal where development (in whatever form that might be) meets the needs of the present generations without compromising the ability of future generations to meet their own needs (Dunster and Dunster 1996).

Translocation: Human-mediated movement of living organisms from one area, and release into another (IUCN 2013).

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Appendix 1. Record Keeping

Good sampling practice involves the collection of detailed field notes. The documentation should include information on the site, survey crew, type, and conditions, and animals found, as indicated below. Examples of datasheets are presented in the end of this appendix.

Site information:

- Site name
- General description of the location
- Land ownership
- Geolocation (UTM easting, northing, accuracy, NAD; or latitude and longitude)
- Elevation (asl, m)
- Landscape context
    - Surrounding area and adjacent habitat uses, e.g., urban, rural, agricultural, backcountry
    - habitat connectivity to suitable adjacent habitat
    - degree of fragmentation, amount of forest edge
- Habitat description, which should be sufficiently detailed to adequately describe key features but not consume inordinate amount of the survey time.
    - habitat type, e.g., riparian shrub, deciduous forest, mixed-wood forest, meadow-forest ecotone
    - forest structural stage and age
    - visual estimation of the following within a vegetation plot placed in representative area of the survey site: canopy closure, % coverage by understory shrubs, herbs, grass, ferns, moss, and coarse woody debris (decaying logs and stumps, sloughed-off bark), moss; dominant trees and understory species
    - substrate type (e.g., leaf, needle); depth of litter layer; soil condition (e.g., rich, mesic, soft, productive, compaction); soil pH.
    - site moisture:
        - inundated, saturated, moist (mesic), dry-mesic, dry (xeric)
    - abundance of specific features important for the target species, such as Stinging Nettle patches
    - light penetration: open, partial, filtered, shade
- Disturbance
    - erosion
    - soil compaction

  - contaminants
  - trails/roads
  - invasive species
  - evidence of fire or human activities or other disturbances

Survey information:

- survey type (opportunistic time-constrained; transect survey with point searches, mark-recapture, other)
- survey crew
- area searched
- date
- start and stop time
- weather conditions:
  - air temperature
  - litter temperature (at depth of ~10 cm)
  - relative humidity
  - precipitation (e.g., no rain, drizzle, light rain, heavy rain)
  - days since rain
  - percentage cloud cover
  - wind speed category
  - index of litter and moisture

Gastropod information:

- location within study area (geoposition, grid cell, other measurement)
- species and number found
  - Target species
  - Other gastropods
- relative age (adult, juvenile)
- for mark-recapture studies: new or recapture, identification mark, shell width, activity (e.g., feeding, moving, withdrawn in shell), comments

ECOSYSTEMS FIELD SURVEY FORM (Oregon Forestsnail, *Allogona townsendiana*)

Name of recorder / reporter:

_____

Address / phone # / email:

_____

_____

Additional personnel on sampling crew:

_____

_____

Survey Date (yy/mm/dd): _____ Survey Time _____

General location: _____

Site reference ID (*circle one*):

Reference (control) / impact / relocation (unoccupied) / relocation (occupied)

GPS coordinates: Easting: _____ Northing: _____ NAD: _____

Site elevation (m): _____Slope:_____ Aspect: _____

General directions to location (*provide maps, landmarks, photographs*):

_____

_____

Land ownership (e.g., private, crown, etc): _____

Local government name: _____

SURVEY EFFORT

Survey area (m^2): _____

Length of time spent surveying (person-min): _____

Example of datasheet for Capture-Mark-Recapture studies of Oregon Forestsnail.

Date/time	Individual (Mark ID)	Recapture? (y/n)	Location (UTM/grid cell)	Microhabitat	Activity	Relative age (adult, juvenile)	Shell width (mm)	Condition of shell	Photo # (camera)	Comments

Example of datasheet for transect surveys with point searches.

Date:	Site name:	Air temp C°:	Cloud cover (start): clear, <50%, >50%, overcast	Litter moisture: wet, moist, dry
Start time:		Soil temp °C :	Cloud cover (end): clear, <50%, >50%, overcast	Vegetation moisture: wet, droplets, dry
End time:	Survey crew:	Rel. Humidity %:	Rain (start): none, drizzle, light, moderate, heavy	Wind (start): calm, light, moderate, high
Elevation:			Rain (end): none, drizzle, light, moderate, heavy	Wind (end): calm, light, moderate, high
Notes on site and survey:				

Obs. Type[1]: Point/Opp.	Way-point #	Habitat category	Canopy closure %	Dominant tree spp.[2] (20 m radius); /shrubs/ ferns/herbs (10 m radius)	Shrubs[3] (%)	Grass/ herbs[3] (%)	Moss[3] (%)	CWD[3] (%)	Duff depth[4]	OSF found (#)	Other large snails & slugs (sp & #)	Disturb. Rating[5]	Habitat suitability rating (OSF)[6]	Photo # (camera)

1-Standard point search (5 m radius area searched for 10 min or opportunistic observation along transect; 2-Use codes for dominant tree & understory species, complete list not intended; 3-approximate percentage coverage within 10 m radius; 4-shallow (<5 cm); moderate (5-10 cm); deep (>10 cm); 5-low, moderate, high based on soil compaction, erosion, introduced plants, trails, signs of human activity; 6- assessment of habitat quality based on presence of features deemed important for Oregon Forestsnail: low, moderate, high

Appendix 2. Processing and marking snails

The quality of the population parameter estimates generated from the mark-recapture study relies on persistence of markings. Tag loss can bias estimates of population parameters (Cooch and White 2012). Henry and Jarne (2007) reviewed the literature on gastropod marking techniques and found glued plastic marks (epoxy resin) are most suitable for long-term studies while paint marks (with double markings) are best for mass-markings for shorter term studies.

The following methods have been developed through several short-term trials with different marker, nail polish and site combinations and are currently considered the most effective means of marking OFS for mark-recapture studies (Lilley and Bianchini 2012). Small glued tags are expected to be longer lasting and recommended for studies lasting for more than one year; however, they have not been used for Oregon Forestsnail as yet. An additional method using passive integrated transponders (PIT tags) shows promise and is currently under development (K. Ovaska pers. comm.).

<u>Collecting and processing snails for mark-recapture studies:</u>

For each individual Oregon Forestsnail captured:

1. Record the geoposition with GPS at capture location and check accuracy from maps, and the 2 x 2 m grid cell within the study plot where the snail was found.
2. Place snails found in each grid cell or location into individually marked bags or containers for transport into the processing station.
3. At the processing station, using calipers, measure the shell width across its widest point as an index of size; shell height can also be measured, if desired, as an additional measure.
4. Note additional comments on general shell appearance, such as worn shell covering (periostracum) exposing the unpigmented shell underneath, colouration of the shell or body of the snail, holes, marks, dents, etc. on the shell.
5. Mark the snail using appropriate methods (see below for recommended methods).
6. After marking, take a photograph of each snail for reference purposes.
7. Release the snail back to its capture location, preferably within 12 h of capture.

Applying paint marks (see Figure 1 for an example):

1. Dry the shell completely prior to applying marks. Use a paper towel if necessary.
2. Mark the shell with individual mark code, use dark nail polish. Research has shown Sally Hansen "Hard as Nails" Xtreme Wear Nail Color: No.370 (4860-28 Black Out) to be durable for this purpose.
    a. Use site specific number markings (e.g., CF-001 to represent Colony Farms, first individual captured)
    b. Place the primary mark on the spire of the shell adjacent to the apex (Appendix 1 - Figure 4).
    c. Apply a secondary mark on the outer surface of the last whorl of the shell behind the apertural lip.
    d. Ensure that the shell is not punctured – snails will dry out if their shell is cracked.
8. Allow the mark to dry completely; take care not to allow marked snails to crawl over each other or escape during the drying period.
9. Apply a top coat to seal the mark using clear nail polish (Sally Hansen "Hard as Nails" Xtreme Wear Nail Color: No.100 (4860-01 Invisible). Blowing gently on the shell can help accelerate drying.
10. Recaptured individuals with worn marks may require new markings.
11. Photograph each snail immediately after marking as reference.

FIGURE 4. EXAMPLE OF PRIMARY AND SECONDARY PAINT MARKS ON OREGON FORESTSNAIL (LILLEY AND BIANCHINI 2012).

Applying glued tags (see Figure 5 as examples):

1. Dry the shell completely prior to applying marks. Use a paper towel if necessary.
2. Prepare a clean surface for the procedure; a white box or surface is preferred, as it will facilitate detection of dropped tags.
3. If using commercial tags with numbers, detach a tag; some tags, such as fish fingerling tags meant to be injected internally with an applicator, need to be cut carefully with scissors for an external application on snails.
4. Place a drop of super glue or equivalent quick-drying glue on a piece of paper, and dip the tag in the glue, holding it with fine, blunt-tipped forceps.
5. Using the forceps, place the tag with glue onto the desired location on the shell, attempting to lay it as flat as possible.
6. Once positioned, gently tap the tag with a Qtip to mop up excess glue.
7. Allow the tag to dry completely; snails can be placed on paper towel to monitor this process. Take care not to allow marked snails to crawl over each other or escape during the drying period.
8. Photograph snails immediately after marking as reference.
9. In the field, even small numbers on tags are easily read by taking a photograph and enlarging the image. The images will also serve as documentation and reduce erroneous tag recordings.

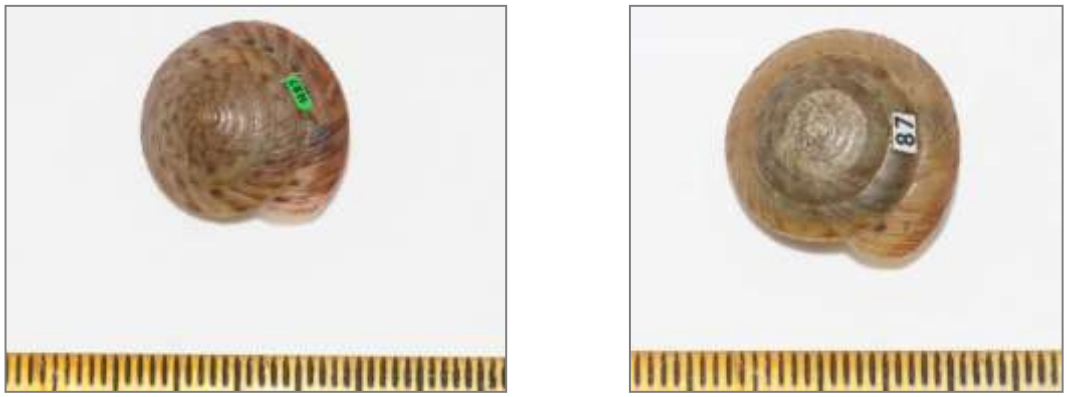

FIGURE 5. EXAMPLES OF GLUED TAGS ON LAND SNAIL SHELL (BERMUDA SNAIL, *POECILOZONITES BERMUDENSIS*); PHOTOS BY KRISTIINA OVASKA.

Other types of tags are available, for example, a suitable pit-tag for snails is an 8 mm x 1.4 mm FDX-B "Skinny" PIT Tag available here:

https://www.oregonrfid.com/index.php?main_page=product_info&cPath=14&products_id=73&zenid=e5hbc77hq7vflng13om3cuk684.

Appendix 3. Guidelines for Intensive Monitoring Associated with Translocations

Fieldwork for a capture-mark-recapture (CMR) study associated with Option C in GUIDELINES FOR TRANSLOCATIONS section includes the following steps:

1. Set up and mark CMR study plots on the ground to monitor the success of the translocation (see Section **SURVEY METHODOLOGY: CAPTURE-MARK-RECAPTURE METHODS** for details); three reference and three release plots are recommended.
2. On all above plots, conduct a survey as described in section **CAPTURE-MARK-RECAPTURE METHODS** prior to the translocation of any snails to find out whether an existing population of Oregon Forestsnails occurs at the site.
3. Collect and mark all snails from the impact sites and care for them appropriately until release.
4. Release marked snails in the centre of each release plot in small groups.
5. Monitor the establishment and survivorship of translocated snails in relation to snails on reference sites, and spatial overlap with the existing snail population, if present

Selection of release and reference sites for intensive monitoring (Option iii):

From the habitat map and reconnaissance level surveys, select area polygons that are potentially suitable as release sites. Conduct a field visit to select locations for six 24 x 24 m plots (3 reference and 3 release), which are demarcated on the ground, as described in Section **CAPTURE-MARK-RECAPTURE METHODS**. If the habitat is already occupied by Oregon Forestsnails, then one half of them will be randomly assigned as either release or reference plots. The plots should be at least 50 m apart from each other, site configuration permitting, and contain concentrations of habitat features important for the snails (see Section **HABITAT AND BIOLOGICAL NEEDS**). If the snails are to be released in unoccupied habitat, then reference plots are to be selected in similar habitat occupied by the species in the surrounding landscape.

Each plot should be surveyed using methods recommended in Section **CAPTURE-MARK-RECAPTURE METHODS**. Surveys should be conducted in April – June, which is the optimal period for detecting the species. If any Oregon Forestsnails are found on the release plots, they need to be individually marked so that they can be clearly distinguished from translocated snails on

subsequent surveys. Other large snails, both native and introduced, are to be counted and recorded, as they may affect the success of the translocation through competition for resources.

Considerations for the release site:

- It should be within close proximity, ideally within the same habitat polygon, as the occupied site, and contains biophysical features required by the species. The site should be protected from future development, e.g, by the establishment of a conservation covenant. Careful consideration should be given to where snails are translocated. Discussing ideas with other resource professionals is recommended.
- Habitat area of the release site be a minimum of 1 hectare.
- Other threats should be minimized or removed prior to translocation; e.g., remove invasive non-native vegetation, establish fencing to minimize recreational impacts, ensure garbage or other waste is removed from the site, ensure that water run-off from contaminated surfaces is minimized.
- Obtain a written permission from the landowner prior to translocation.