PROPOSED

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

Recovery Strategy for the Dromedary Jumping-slug (*Hemphillia dromedarius*) in Canada

Dromedary Jumping-slug

2017

Government of Canada
Gouvernement du Canada
Canada

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

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

RECOVERY STRATEGY FOR THE DROMEDARY JUMPING-SLUG (*Hemphillia dromedarius*) IN CANADA

2017

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

In the spirit of cooperation of the Accord, the Government of British Columbia has given permission to the Government of Canada to adopt the *Recovery Strategy for Dromedary Jumping-slug (Hemphillia dromedarius) in British Columbia* (Part 2) under Section 44 of the *Species at Risk Act* (SARA). Parks Canada Agency has included a federal addition (Part 1) which completes the SARA requirements for this recovery strategy.

The federal recovery strategy for the Dromedary Jumping-slug in Canada consists of two parts:

Part 1 – Federal Addition to the *Recovery Strategy for Dromedary Jumping-slug (Hemphillia dromedarius) in British Columbia*, prepared by the Parks Canada Agency.

Part 2 – *Recovery Strategy for Dromedary Jumping-slug (Hemphillia dromedarius) in British Columbia,* prepared by the British Columbia Ministry of Environment.

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Part 1 – Federal Addition to the *Recovery Strategy for Dromedary Jumping-slug (Hemphillia dromedarius) in British Columbia*, prepared by the Parks Canada Agency

Preface

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

The Minister of Environment and Climate Change and the Minister responsible for the Parks Canada Agency is the competent minister for the Dromedary Jumping-slug and has prepared the federal component of this recovery strategy (Part 1), as per section 37 of SARA. To the extent possible, it has been prepared in cooperation with the Province of British Columbia and Environment and Climate Change Canada, with input from Indigenous Peoples, environmental non-governmental organizations and local industrial groups, as per section 39(1) of SARA. SARA section 44 allows the Minister to adopt all or part of an existing plan for the species if it meets the requirements under SARA for content (sub-sections 41(1) or (2)). The Province of British Columbia provided the attached recovery strategy for the Dromedary Jumping-slug (Part 2) as science advice to the jurisdictions responsible for managing the species in British Columbia. It was prepared in cooperation with the Parks Canada Agency and Environment and Climate Change Canada.

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

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

The recovery strategy sets the strategic direction to arrest or reverse the decline of the species, including identification of critical habitat to the extent possible. It provides all Canadians with information to help take action on species conservation. When critical

[2] http://registrelep-sararegistry.gc.ca/default.asp?lang=En&n=6B319869-1%20

habitat is identified, either in a recovery strategy or an action plan, SARA requires that critical habitat then be protected.

In the case of critical habitat identified for terrestrial species including migratory birds SARA requires that critical habitat identified in a federally protected area[3] be described in the *Canada Gazette* within 90 days after the recovery strategy or action plan that identified the critical habitat is included in the public registry. A prohibition against destruction of critical habitat under ss. 58(1) will apply 90 days after the description of the critical habitat is published in the *Canada Gazette*.

For critical habitat located on other federal lands, the competent minister must either make a statement on existing legal protection or make an order so that the prohibition against destruction of critical habitat applies.

If the critical habitat for a migratory bird is not within a federal protected area and is not on federal land, within the exclusive economic zone or on the continental shelf of Canada, the prohibition against destruction can only apply to those portions of the critical habitat that are habitat to which the *Migratory Birds Convention Act, 1994* applies as per SARA ss. 58(5.1) and ss. 58(5.2).

For any part of critical habitat located on non-federal lands, if the competent minister forms the opinion that any portion of critical habitat is not protected by provisions in or measures under SARA or other Acts of Parliament, or the laws of the province or territory, SARA requires that the Minister recommend that the Governor in Council make an order to prohibit destruction of critical habitat. The discretion to protect critical habitat on non-federal lands that is not otherwise protected rests with the Governor in Council.

Acknowledgments

The federal supplementary material to the Province of British Columbia's Recovery Strategy for the Dromedary Jumping-slug (*Hemphillia dromedarius*) in British Columbia was produced by the Parks Canada Agency, with support from the British Columbia Invertebrates Recovery Team and Vanessa Craig of Ecologic Research Ltd. In particular, the Parks Canada Agency would like to acknowledge the science support provided by the following recovery team members: Trudy Chatwin, Jennifer Heron, Suzie Lavallee, Kristiina Ovaska and Lennart Sopuck. Helpful comments and input were also provided by Kim Borg, Megan Harrison, Kella Sadler and Dan Shervill. The federal supplementary material was reviewed by the Province of British Columbia. Tyler Innes, Jackie Churchill and Tania Tripp of Madrone Environmental Ltd. assisted with mapping of critical habitat polygons.

[3] These federally protected areas are: a national park of Canada named and described in Schedule 1 to the *Canada National Parks Act*, The Rouge National Park established by the *Rouge National Urban Park Act*, a marine protected area under the *Oceans Act*, a migratory bird sanctuary under the *Migratory Bird Convention Act, 1994* or a national wildlife area under the *Canada Wildlife Act* see ss. 58(2) of SARA.

Additions and Modifications to the Adopted Document

The following sections have been included to address specific requirements of the federal *Species at Risk Act* (SARA) that are not addressed in the *Recovery Strategy for Dromedary Jumping-slug (Hemphillia dromedarius) in British Columbia* (Part 2 of this document, referred to henceforth as "the provincial recovery strategy") and/or to provide updated or additional information.

Under SARA, there are specific requirements and processes set out regarding the protection of critical habitat. Therefore, statements in the provincial recovery strategy referring to protection of survival/recovery habitat may not directly correspond to federal requirements. Recovery measures dealing with the protection of habitat are adopted; however, whether these measures will result in protection of critical habitat under SARA will be assessed following publication of the final federal recovery strategy.

1. COSEWIC* Species Assessment Information

This updated COSEWIC species assessment (COSEWIC 2014) replaces the COSEWIC species assessment information provided in the provincial recovery strategy.

Date of Assessment: May 2014
Common Name (Population): Dromedary Jumping-slug
Scientific Name: *Hemphillia dromedarius*
COSEWIC Status: Threatened
Reason for Designation:
This relatively large slug is a member of a small group of slugs that are found globally only in western North America. In Canada, despite a great deal of searching, this species is known from fewer than 20 sites on southern Vancouver Island. There, it is restricted to moist, older-growth (>80 years old) forests. Populations are invariably small, and are fragmented by intervening logged areas and by the species' poor dispersal ability. Threats include further loss and fragmentation from forestry and the increased frequency and severity of droughts associated with climate change.
Canadian Occurrence: British Columbia
COSEWIC Status History: Designated Threatened in May 2003. Status re-examined and confirmed in May 2014.

* COSEWIC (Committee on the Status of Endangered Wildlife in Canada)

2. Species Information

This section updates the Populations and Distribution section of the provincial recovery strategy.

The provincial recovery strategy lists 15 locations[4] and COSEWIC (2014) lists 19 locations of Dromedary Jumping-slug in British Columbia. This federal recovery strategy considers 18 locations. Two of the locations in the provincial recovery strategy and COSEWIC (2014), Rainforest A and B Trail, are considered as one location in this federal recovery strategy because a single threatening event could affect all individuals at Rainforest A and B Trail (IUCN 2012) and slug observations at Rainforest A and B Trail are less than 1 km apart (NatureServe 2011). The further discrepancy between the number of locations in the three documents is due to the discovery of four new locations (Site ID No. 11, 17, 18, 19 in Table 2 below from COSEWIC 2014) since the provincial recovery strategy was completed in 2008. This federal recovery strategy adopts the Site ID numbers used in COSEWIC (2014) which differ slightly from those presented in the provincial recovery strategy.

3. Threats Assessment from COSEWIC

This section updates the Threats section of the provincial recovery strategy by providing an updated summary of threats facing the species, as provided by COSEWIC (2014). For more detailed information on threats, see COSEWIC (2014).

Table 1. Threats calculator assessment.

Threat		Impact[a]	Scope[b]	Severity[c]	Timing[d]
1	Residential & commercial development	Low	Small	Extreme	High (Continuing)
1.1	Housing & urban areas	Low	Small	Extreme	High (Continuing)
1.3	Tourism & recreation areas	Negligible	Negligible	Serious	Moderate
3	Energy production & mining	Negligible	Negligible	Extreme	High (Continuing)
3.2	Mining & quarrying	Negligible	Negligible	Extreme	High (Continuing)
4	Transportation & service corridors	Low	Restricted-Small	Slight	High (Continuing)
4.1	Roads & railroads	Low	Restricted-Small	Slight	High (Continuing)
4.2	Utility & service lines	Negligible	Negligible	Negligible	High (Continuing)
5	Biological resource use	Medium	Restricted	Extreme	High (Continuing)
5.3	Logging & wood harvesting	Medium	Restricted	Extreme	High (Continuing)
6	Human intrusions & disturbance	Low	Restricted-Small	Slight	High (Continuing)
6.1	Recreational activities	Low	Restricted-	Slight	High (Continuing)

[4] **Location:** "a geographically distinct area where a group of individuals of a species is (or has been) found. The total population of a species may comprise a number of locations. Dispersal between sites is impossible or very rare. A single threatening event can rapidly affect all individuals in a location. Where a taxon is affected by more than one threatening event, location should be defined by considering the most serious plausible threat. (Source: adapted from IUCN 2001)" (COSEWIC 2008).

Threat		Impact[a]	Scope[b]	Severity[c]	Timing[d]
			Small		
7	Natural system modifications	Negligible	Negligible	Extreme	High (Continuing)
7.1	Fire & fire suppression	Negligible	Negligible	Extreme	Low
7.2	Dams & water management/use	Negligible	Negligible	Moderate	High (Continuing)
8	Invasive & other problematic species & genes	Medium-Low	Restricted	Moderate-Slight	High (Continuing)
8.1	Invasive non-native/alien species	Medium-Low	Restricted	Moderate-Slight	High (Continuing)
9	Pollution	Negligible	Negligible	Slight	High (Continuing)
9.3	Agricultural & forestry effluents	Negligible	Negligible	Slight	High (Continuing)
10	Geological events	Low	Small	Extreme-Serious	High-Moderate
10.2	Earthquakes/tsunamis	Low	Small	Extreme	Moderate
10.3	Avalanches/landslides	Negligible	Negligible	Extreme-Serious	High (Continuing)
11	Climate change & severe weather	Medium-Low	Pervasive	Moderate-Slight	High (Continuing)
11.1	Habitat shifting & alteration		Unknown	Unknown	Unknown
11.2	Droughts	Medium-Low	Pervasive	Moderate-Slight	High (Continuing)
11.4	Storms & flooding	Low	Small	Moderate	High (Continuing)

[a] **Impact** – The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of each threat is based on Severity and Scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. The median rate of population reduction or area decline for each combination of scope and severity corresponds to the following classes of threat impact: Very High (75% declines), High (40%), Medium (15%), and Low (3%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity are unknown); Not Calculated: impact not calculated as threat is outside the assessment timeframe (e.g., timing is insignificant/negligible or low as threat is only considered to be in the past); Negligible: when scope or severity is negligible; Not a Threat: when severity is scored as neutral or potential benefit.

[b] **Scope** – Proportion of the species that can reasonably be expected to be affected by the threat within 10 years. Usually measured as a proportion of the species' population in the area of interest. (Pervasive = 71–100%; Large = 31–70%; Restricted = 11–30%; Small = 1–10%; Negligible < 1%).

[c] **Severity** – Within the scope, the level of damage to the species from the threat that can reasonably be expected to be affected by the threat within a 10-year or three-generation timeframe. Usually measured as the degree of reduction of the species' population. (Extreme = 71–100%; Serious = 31–70%; Moderate = 11–30%; Slight = 1–10%; Negligible < 1%; Neutral or Potential Benefit ≥ 0%).

[d] **Timing** – High = continuing; Moderate = only in the future (could happen in the short term [< 10 years or 3 generations]) or now suspended (could come back in the short term); Low = only in the future (could happen in the long term) or now suspended (could come back in the long term); Insignificant/Negligible = only in the past and unlikely to return, or no direct effect but limiting.

Table 2. Updated threats assessment (adapted from COSEWIC 2014).

Site information		Threat Sub-categories											
Nº du site	**Location Name**	**1.1 Housing & urban areas**	**1.3 Tourism & recreation areas**	**4.1 Roads & railroads**	**5.3 Logging & wood harvesting**	**6.1 Recreational activities**	**6.3 Work & other activities**	**8.1 Invasive non-natives**	**9.3 Agricultural & forestry effluents**	**10.2 Earthquakes, tsunamis**	**11.1 Habitat shifting & alteration**	**11.2 Droughts**	**11.4 Storms & flooding**
1	Shawnigan Lake			X	X	X			X?		X	X	
2	Mt. Arrow-smith, Mt. Cokely			X	X	X					X	X	
3	Mt. Arrow-smith, McBey Cr			X	X						X	X	
4	Mt. Brenton				X	X		X	X?		X	X	
5	Mt. Hooper			X	X	X			X?		X	X	
6	Juan de Fuca Prov. Park, Loss Creek			X		X		X				X	X
7	Thrasher Cove					X						X	
8	Clo-oose					X		X		X		X	X
9	Keeha Beach Trail					X				X		X	X
10	Bamfield	X		X	X			X		X		X	X
11	Bamfield Marine Station	X		X		X	X?	X				X	
12	Willow-brae		X	X		X		X				X	
13	Indian Creek			X	X			X	X?			X	X
14	Goldmine Trail			X				X				X	
15 & 16	Rainforest A Trail Rainforest B Trail			X		X X		X X				X X	
17	Highway SE of Pacific Rim NPR border			X	X	X		X				X	
18	Highway right at the Pacific Rim NPR border			X		X		X				X	
19	Tyhistanis, near Pacific Rim NPR	X		X				X				X	
	Total number of sites	3	2	14	8	14	1	13	4	3	5	19	5
	% of sites	16	11	74	42	74	5	68	21	16	26	100	26

4. Population and Distribution Objectives

This section replaces the “Recovery Goal” in the provincial recovery strategy. The federal population and distribution objective for Dromedary Jumping-slug is to:

> *Ensure the survival of Dromedary Jumping-slug by maintaining the species at its current area of occupancy across its extent of occurrence in Canada.*

Rationale:

The federal population and distribution objective is designed to be consistent with the recovery goal in the provincial recovery strategy. The objective is centered on species survival to ensure no further species decline in Canada until sufficient data on species life history, population size and distribution is available to determine a quantitative population and distribution objective for species recovery.

Currently, the known extent of occurrence is estimated at 6,695 km^2 (COSEWIC 2014). This is an increase of 68% from the previous value of 3985 km^2 (COSEWIC 2003), a result of further surveys expanding the known range.

The current area of occupancy is not known with certainty. COSEWIC (2014) estimated the area of occupancy for this species to range from 72 km^2 to 2,000 km^2. The estimate of 72 km^2 is an underestimate because it assumes that the species only occurs near the known observations. COSEWIC (2014) also provided an estimate of 400 km^2. This is also an underestimate because it assumes the species only occurs on the coast of Vancouver Island when in fact several locations are known from inland areas. Given the estimated extent of occurrence in Canada of 6,695 km^2, the species’ patchy distribution and specific habitat requirements, COSEWIC (2014) concluded that the area of occupancy will likely not exceed 2,000 km^2. An activity to address this knowledge gap is included in Table 5.

5. Critical Habitat

This section replaces the Critical Habitat section in the provincial recovery strategy.

5.1. Identification of critical habitat

The *Species at Risk Act* defines critical habitat as “… the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species’ critical habitat in a recovery strategy or action plan for the species.”

The critical habitat identified in this recovery strategy for 12 Dromedary Jumping-slug locations (Table 3) is based on the best available information and is considered to be a partial identification of critical habitat because:

- Currently available information is insufficient to identify critical habitat for three locations where the slug was observed on human-made structures,
- The current critical habitat identification (201 ha) is considerably less than the estimated area of occupancy for this species of between 72 km^2 to 2,000 km^2 (COSEWIC 2014), and
- Some critical habitat has not been identified due to ongoing cooperation and consultation. The Government of Canada will continue to work cooperatively with applicable organizations to complete the identification of critical habitat.

A schedule of studies (Table 5) has been developed to provide the information necessary to complete the identification of critical habitat that will be sufficient to meet the population and distribution objective.

5.1.1. Geospatial location of areas containing critical habitat

Critical habitat is identified for 12 Dromedary Jumping-slug locations on southern Vancouver Island, British Columbia (Table 3). Three conservation principles were used to identify critical habitat:

1) The habitat included should be representative of habitat in which Dromedary Jumping-slug is known to occur,
2) Habitat areas should be large enough to maintain a Dromedary Jumping-slug population at each location, and
3) If multiple records of Dromedary Jumping-slug have been documented within the same location, they should be connected with corridors to facilitate potential movement of individuals within the location area.

See Appendix A for more detail on these principles.

The three conservation principles guided the creation and use of the following protocol to identify Dromedary Jumping-slug critical habitat:

1. Terrestrial Ecosystem Mapping, a high resolution habitat mapping method standardized for British Columbia (B.C. Ministry of Environment 2006; RIC 1998), was used to identify habitat types at and near to Dromedary Jumping-slug observation locations.
2. The primary forest ecotypes[5] and their age (age defined as per structural stages in RIC 1998) associated with each Dromedary Jumping-slug observation were identified at each location. The age-specific primary forest ecotypes documented across all locations (defined broadly across locations, not specific to individual locations) were defined as suitable habitat for the species.

[5] Primary forest ecotypes were defined as forest ecotypes (as per RIC 1998) that comprised at least 25% of the habitat composition surrounding known Dromedary Jumping-slug locations.

3. At each location, all suitable habitat (based on the age-specific primary forest ecotypes) was mapped to a radius of 500 m from the centre of each Dromedary Jumping-slug location. This radius was chosen solely to ensure sufficient data availability, even in areas with patchy habitat.
4. For each individual slug location, contiguous suitable habitat was selected until a target area of 20 ha was reached or no more contiguous suitable habitat was available. Where there was greater than 20 ha of suitable habitat within 500 m, suitable habitat was selected so as to minimize fragmentation and edge effect (i.e., to minimize the edge/volume ratio).

The target of 20 ha, used to map critical habitat, reflects the biological needs of the species (i.e., observed dispersing away from occupied areas and low densities; COSEWIC 2014) and will provide a reasonable probability of persistence for known Dromedary Jumping-slug locations. See Appendix A for further details on rationale for the target area of 20 ha.

The age of forest stands was used to map critical habitat because the species has most often been found in mature and old-growth forests (Appendix A; COSEWIC 2014; Part 2). In mapping critical habitat, efforts were made to keep all habitat contiguous (to maintain connectivity within the location) and to minimize edge effects by keeping the edge/volume ratio of the critical habitat polygon as low as possible. For this reason, suitable habitat was added from the centre (observation location) outwards, with no gaps and avoiding long or linear patches of habitat that would have a high edge/volume ratio. See Appendix A for further details on how this protocol was applied to specific locations.

Critical habitat polygons at Mount Cokely and Mount Brenton are significantly smaller than the target of 20 ha because 20 ha of contiguous suitable habitat was not available around these locations at the time critical habitat was mapped. It is unclear whether polygons with significantly less than 20 ha of critical habitat identified will be viable over the long term (Appendix A). As forests around locations with small areas of critical habitat grow older, additional habitat may become suitable and be identified as additional critical habitat.

Biophysical attributes of critical habitat

The Dromedary Jumping-slug occurs in both high elevation ‘cloud’ forests and low elevation ‘fog’ forests that share the following general biophysical attributes (COSEWIC 2014; Part 2):

- a well-developed forest canopy (provides cover, shade, and maintains moisture in the forest),
- a productive understory (e.g., understory trees, abundant moss and shrubs) that provides for moist micro-climate on the forest floor and cover for the species,

- abundant coarse woody debris, especially of a large diameter (i.e., > 50 cm diameter), that provides for moist micro-climate on the forest floor, cover for the species, and hidden travel corridors and micro-sites, and
- a structurally complex forest floor (e.g., hummocks and cavities) that provides a moist micro-climate on the forest floor, cover for the species, and hidden travel corridors and micro-sites.

The species has most often been found in mature or old forests (those > 80 years old), likely because the above attributes typically take time to develop as forests age, though has occasionally been found in younger forests (Table 3).

In addition to the above general description of the biophysical attributes of critical habitat, Terrestrial Ecosystem Mapping (RIC 1998) primary forest ecotypes and their age class (‘structural stage’ as per RIC 1998) of occupied forests were used to define the biophysical attributes of critical habitat, as outlined in Table 3.

The above biophysical attributes of critical habitat contribute to providing sufficient habitat for foraging, cover, travel, hibernation and reproduction (COSEWIC 2014; Part 2).

The areas containing critical habitat for the Dromedary Jumping-slug are presented in Figures 1-12. Within the area identified as containing critical habitat for Dromedary Jumping-slug, critical habitat is identified wherever any of the above biophysical attributes occur.

Table 3. List of locations with critical habitat identified for Dromedary Jumping-slug, the biogeoclimatic zone in which the location occurs (BEC Zone), the size of the critical habitat polygon identified for the location, and the primary forest ecotypes that define the biophysical attributes within each critical habitat polygon (ecology and age). Adapted from Churchill *et al.* (2010).

Site ID No.[1]	Location name	Figure	Elevation (m)	BEC zone[2]	Critical habitat polygon area (ha)	Primary forest ecotypes[3] in critical habitat polygons	
						Ecotype[4]	Structural Stage[5]
1	Shawnigan Lake	Figure 1	700	CWHmm2	21	HD, AP	5, 6, 7
2	Mt.Arrowsmith-Mt.Cokely	Figure 2	1200	MHmm1	3	MB	7
3	Mt.Arrowsmith-McBey Cr.	Figure 3	> 950	MHmm1	6*	MB	7
4	Mt.Brenton	Figure 4	> 1000	MHmm1	3	MB	6
5	Mt.Hooper	Figure 5	850	MHmm1	20	MB, YS, MT	7
6	Juan de Fuca Prov. Park, Loss Creek	N/A	<150	CWHvm1	TBD*	HD, AB, AD	5, 6, 7
7	Thrasher Cove	N/A	< 100	CWHvm1	TBD*	AB	7
8	Clo-oose Bay	Figure 6	10	CWHvh1	20	HS	6, 7
9	Keeha Beach Trail, PRNPR	Figure 7	20	CWHvh1	20	HS	7
10	Bamfield	Figure 8	30	CWHvh1	20	HS	4, 5, 6, 7
11	Bamfield Marine Station	N/A	< 50	CWHvh1	TBD*		
12	Willowbrae	Figure 9	30	CWHvh1	22	HS	6, 7
13	Indian Creek	Figure 10	< 50	CWHvh1	18	HS, SD	6
14	Goldmine Trail, PRNPR	Figure 11	< 30	CWHvh1	20	HS	6, 7
15 &16	Rainforest A and B Trail, PRNPR	Figure 12	< 40	CWHvh1	28	HS, SD	7
17	Hwy SE of PRNPR border	N/A	40	CWHvh1	TBD*		
18	Hwy at PRNPR border	N/A	40	CWHvh1	TBD*		
19	Ty-histanis	N/A	< 100	CWHvh1	TBD*	HS	6, 7

* Some critical habitat has not been identified due to insufficient available information or ongoing cooperation and consultation (see schedule of studies in Table 5).

[1] Location ID numbers as per COSEWIC (2014).

[2] Biogeoclimatic (BEC) zones as per Ministry of Forests and Range (2012).

[3] Primary forest ecotypes were defined as forest ecotypes (RIC 1998) that comprised at least 25% of habitat polygons in which Dromedary Jumping-slug location records were observed (see Section 5.1.1 and Appendix A for details).

[4] Listed primary forest ecotypes are: HD = Western Hemlock/Amabalis Fir-Deer Fern; AP = Western Hemlock/Amabalis Fir-Pipecleaner Moss; AB = Western Hemlock/Amabalis Fir-blueberry/Salal; AD = Amabalis Fir / Sitka Spruce - Devil's Club; HS = Western Redcedar/Western Hemlock-Salal; MB = Mountain Hemlock/Amabalis Fir-blueberry; SD = Western Redcedar/Sitka Spruce-Devil's Club; YS = Mountain Hemlock / Yellow Cedar - Sphagnum; MT = Amabalis Fir / Mountain Hemlock - Twistedstalk; (RIC 1998).

[5] Structural stages of dominant ecotype polygons, as follows: 4, forest < 40 years old; 5, forest 40-80 years old; 6, forest 80-250 years old; 7, forest >250 years old (RIC 1998).

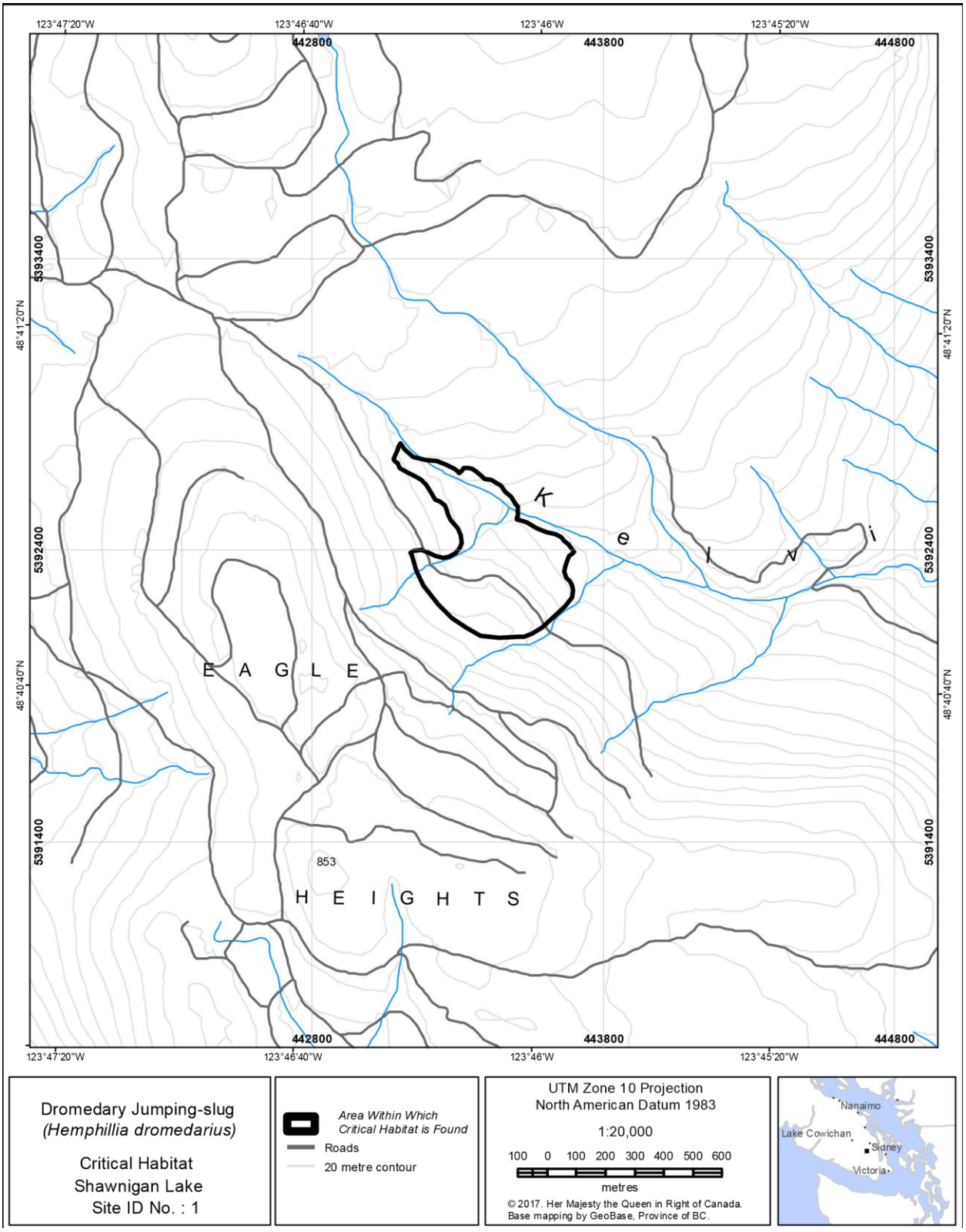

Figure 1. Critical habitat (21 ha) for Dromedary Jumping-slug at Shawnigan Lake.

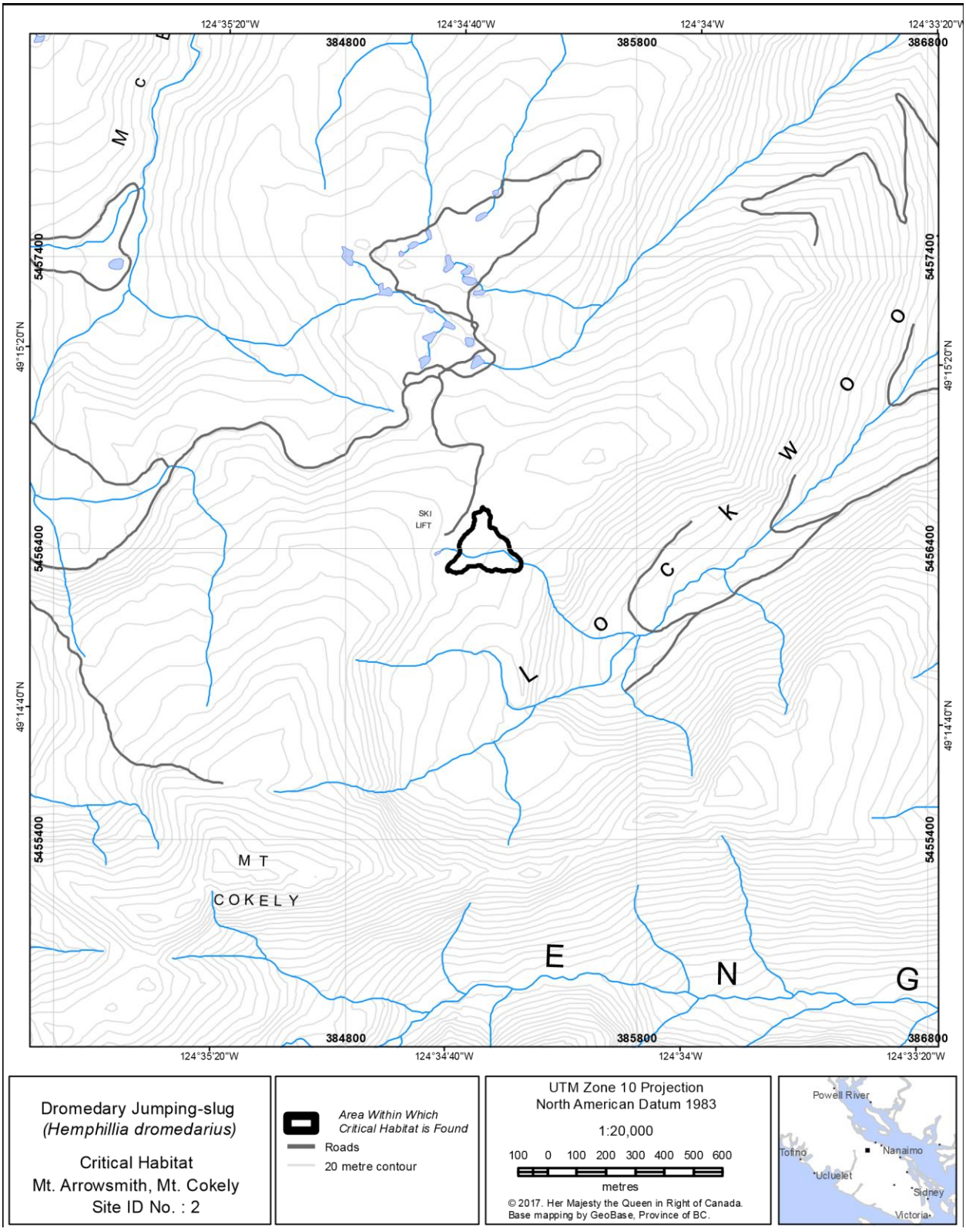

Figure 2. Critical habitat (3 ha) for Dromedary Jumping-slug at Mount Arrowsmith – Mount Cokely.

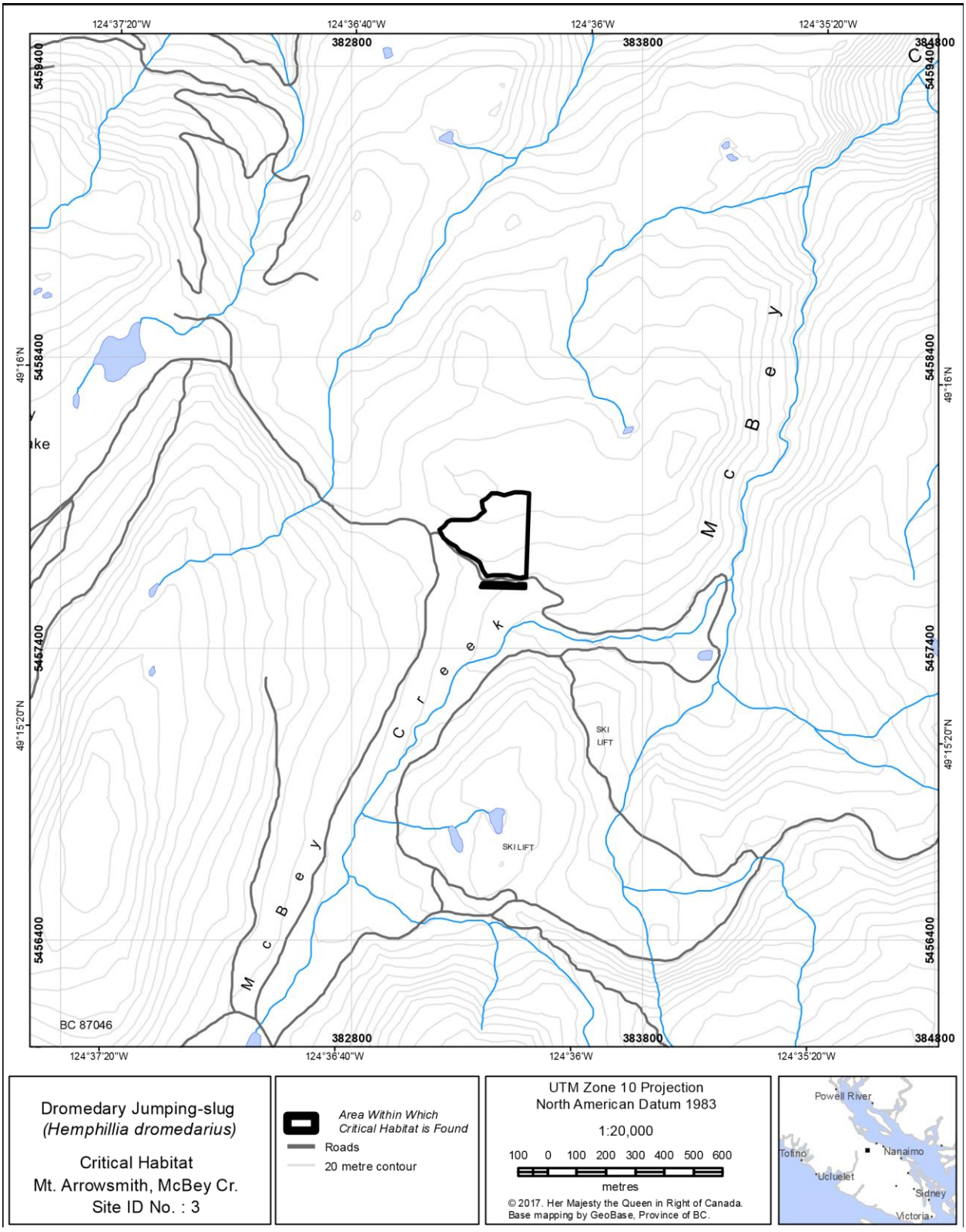

Figure 3. Critical habitat (6 ha) for Dromedary Jumping-slug at Mount Arrowsmith – McBey Creek.

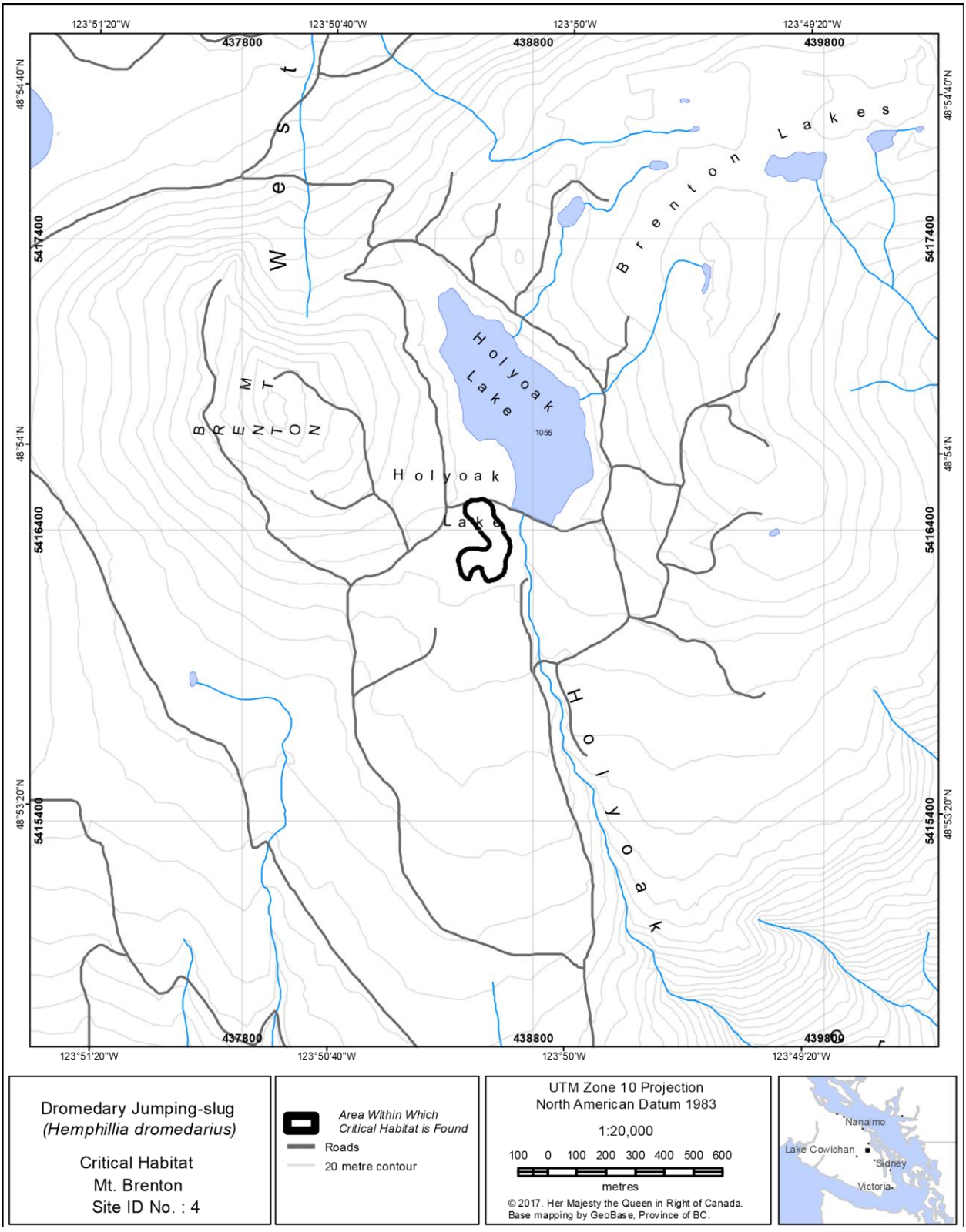

Figure 4. Critical habitat (3 ha) for Dromedary Jumping-slug at Mount Brenton.

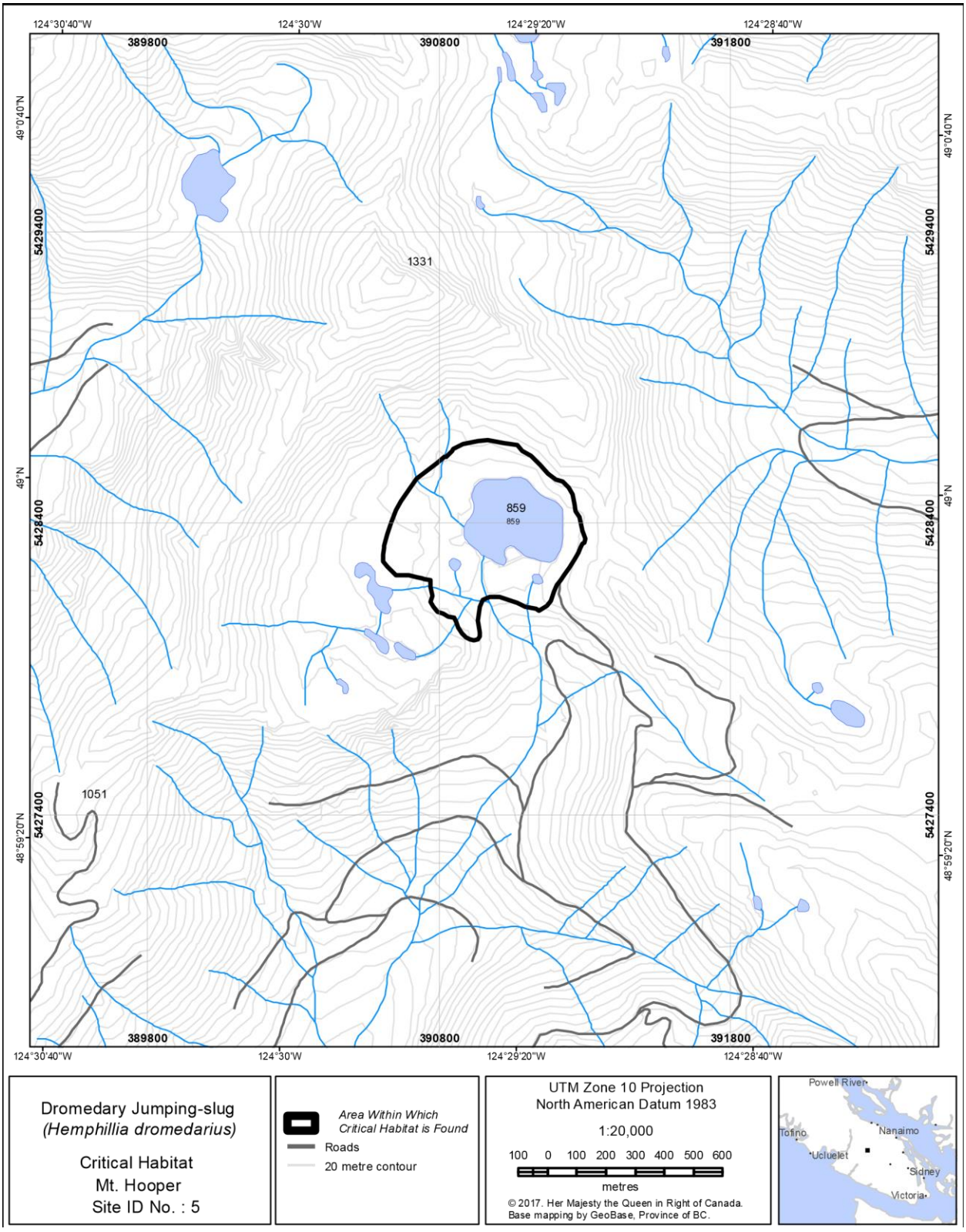

Figure 5. Critical habitat (20 ha) for Dromedary Jumping-slug at Mount Hooper.

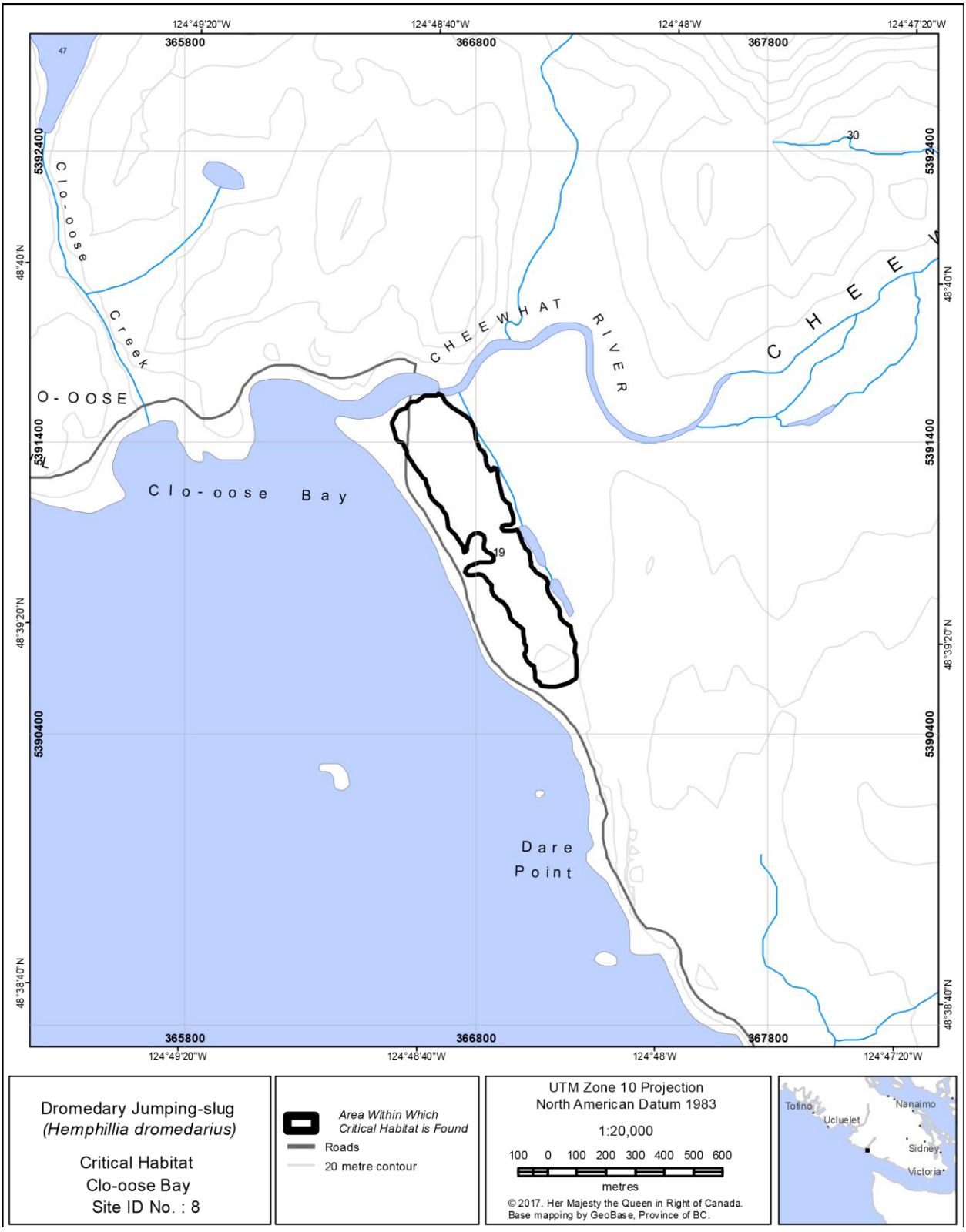

Figure 6. Critical habitat (20 ha) for Dromedary Jumping-slug at Clo-oose Bay.

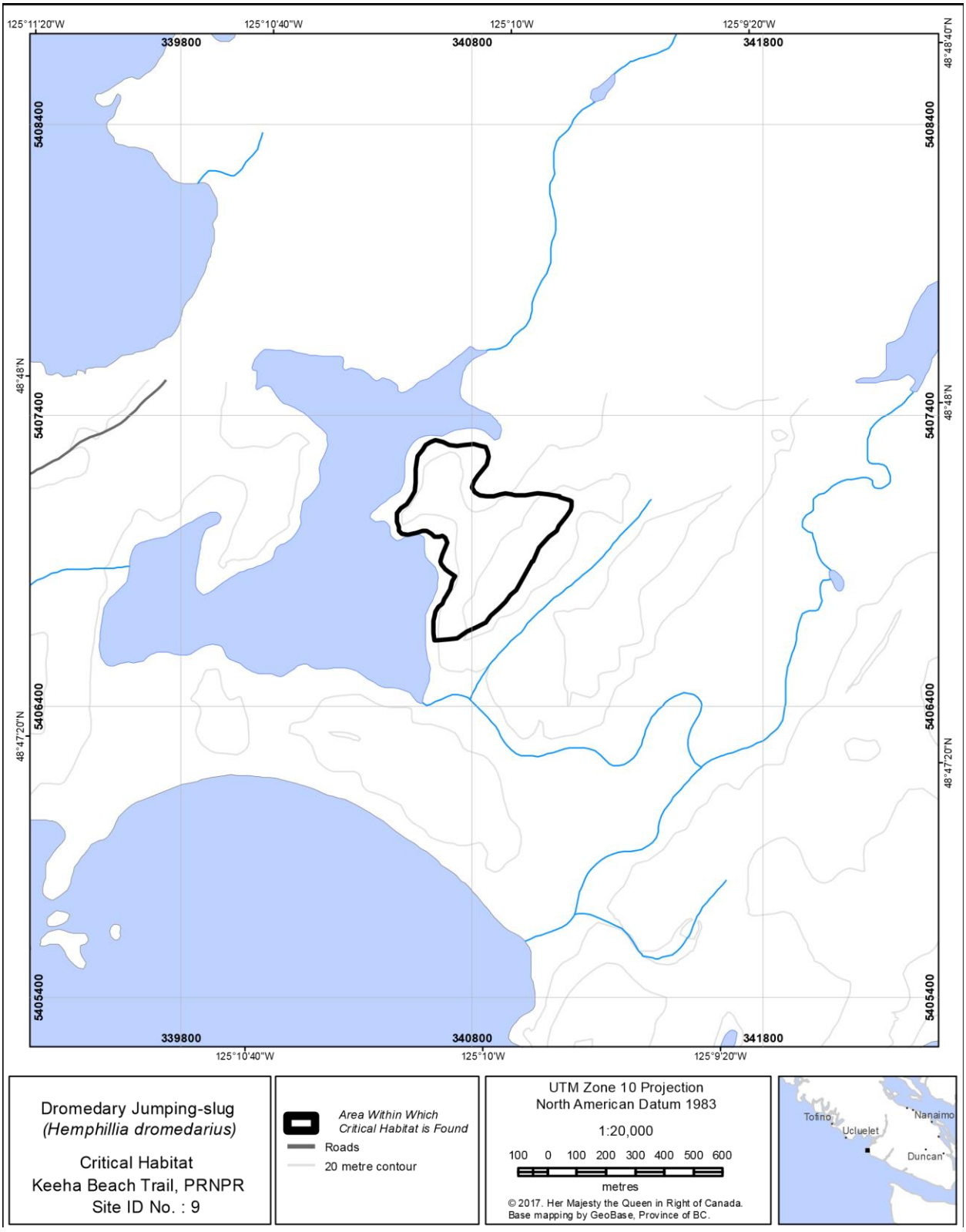

Figure 7. Critical habitat (20 ha) for Dromedary Jumping-slug at Keeha Beach Trail.

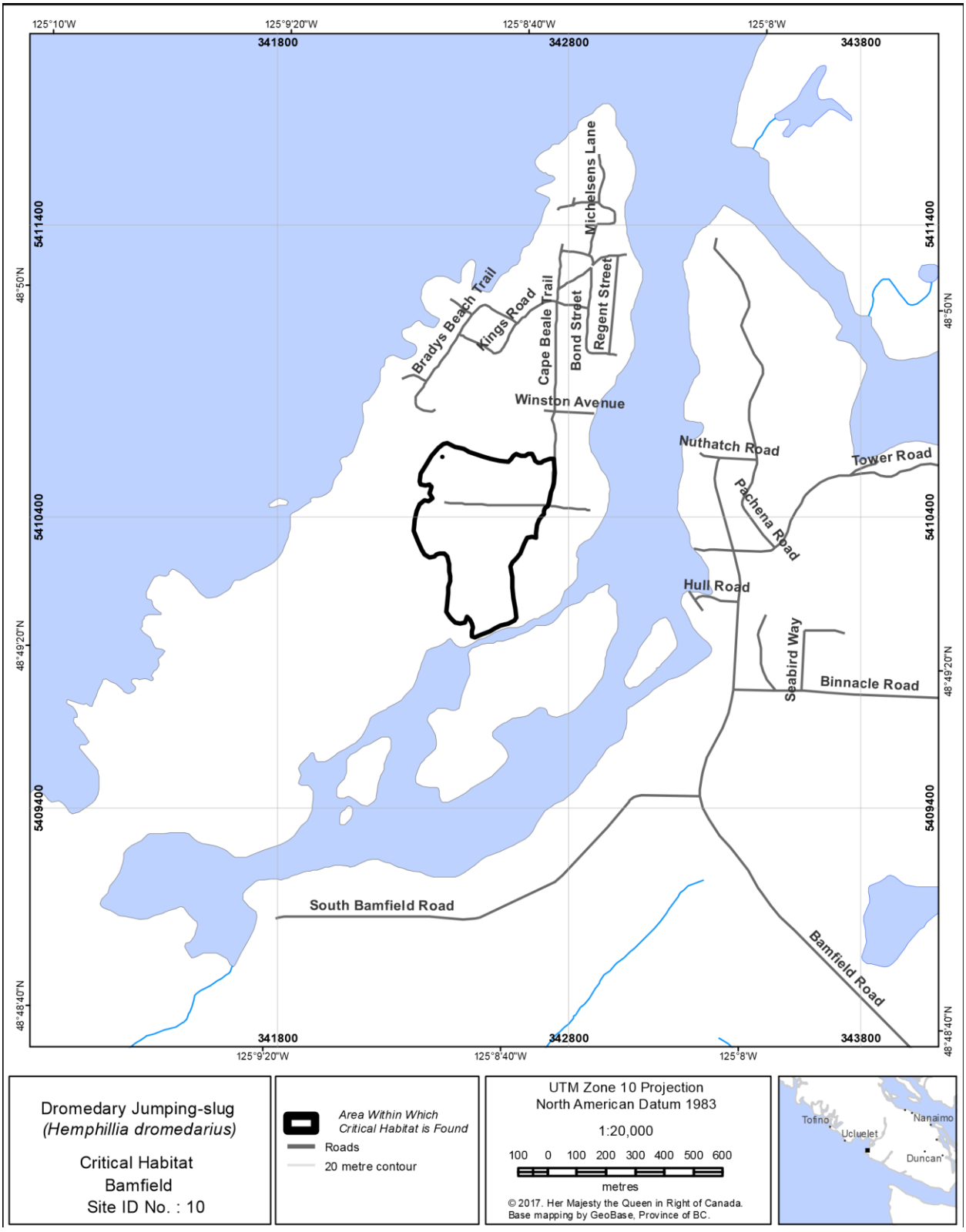

Figure 8. Critical habitat (20 ha) for Dromedary Jumping-slug at Bamfield.

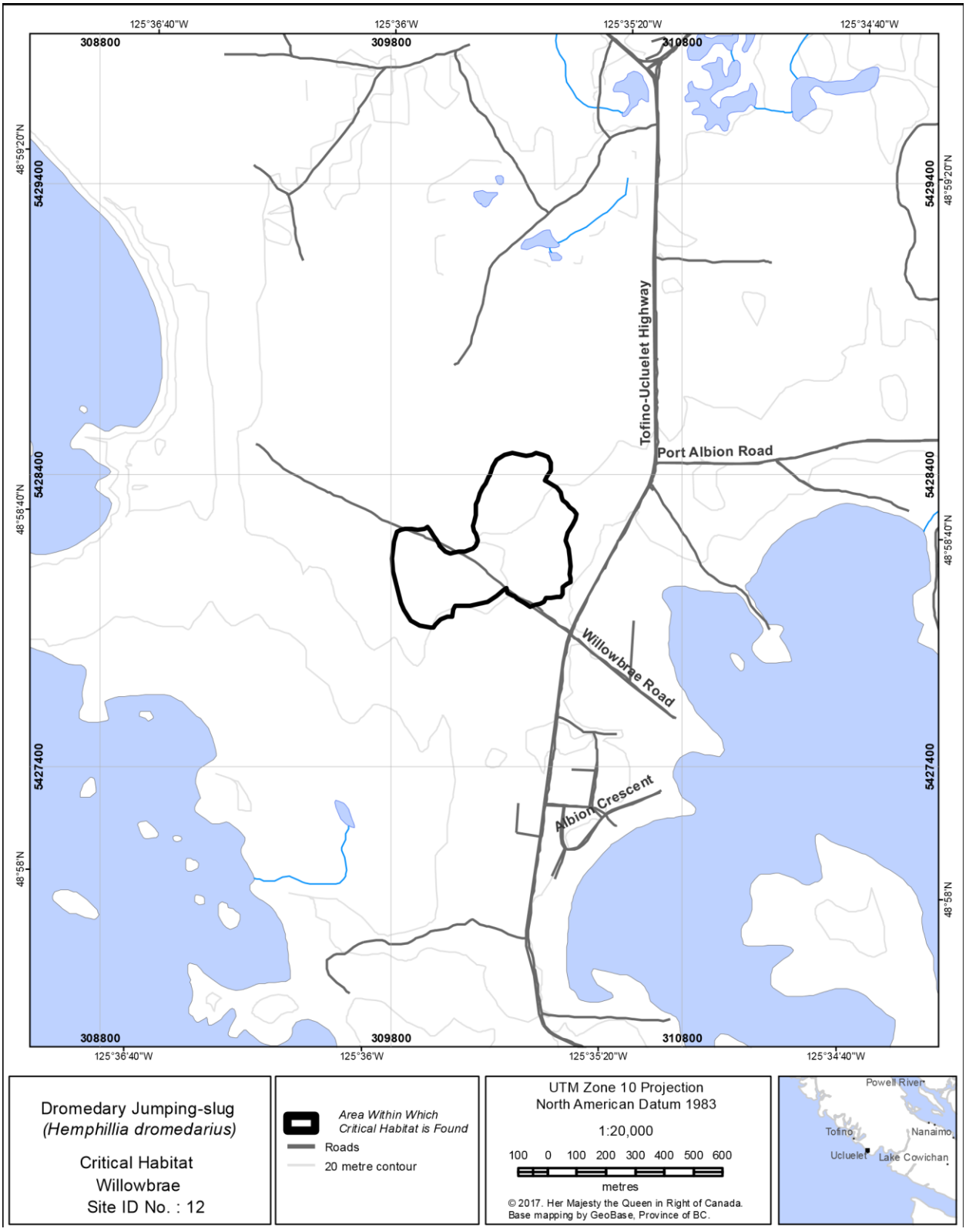

Figure 9. Critical habitat (22 ha) for Dromedary Jumping-slug at Willowbrae.

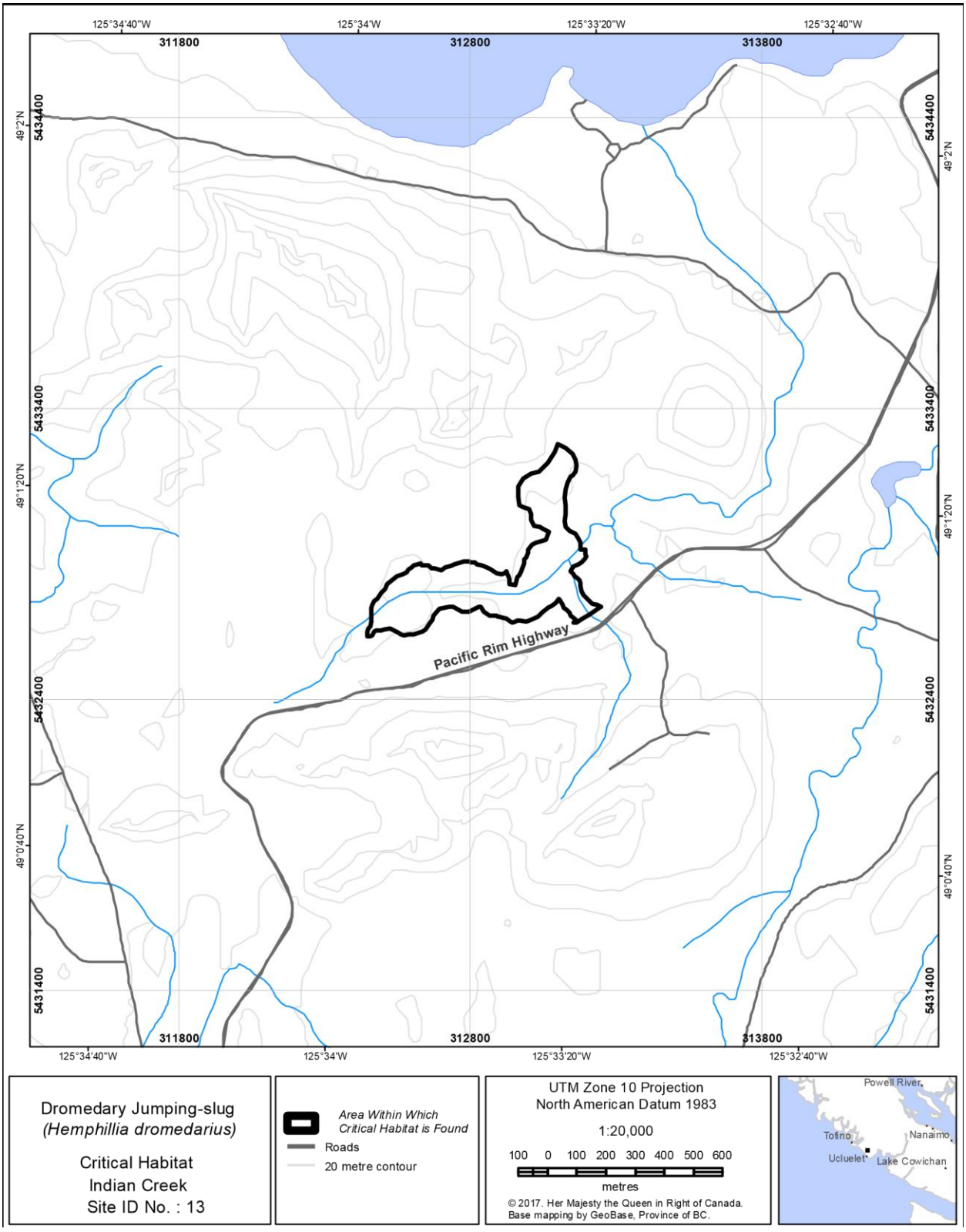

Figure 10. Critical habitat (18 ha) for Dromedary Jumping-slug at Indian Creek.

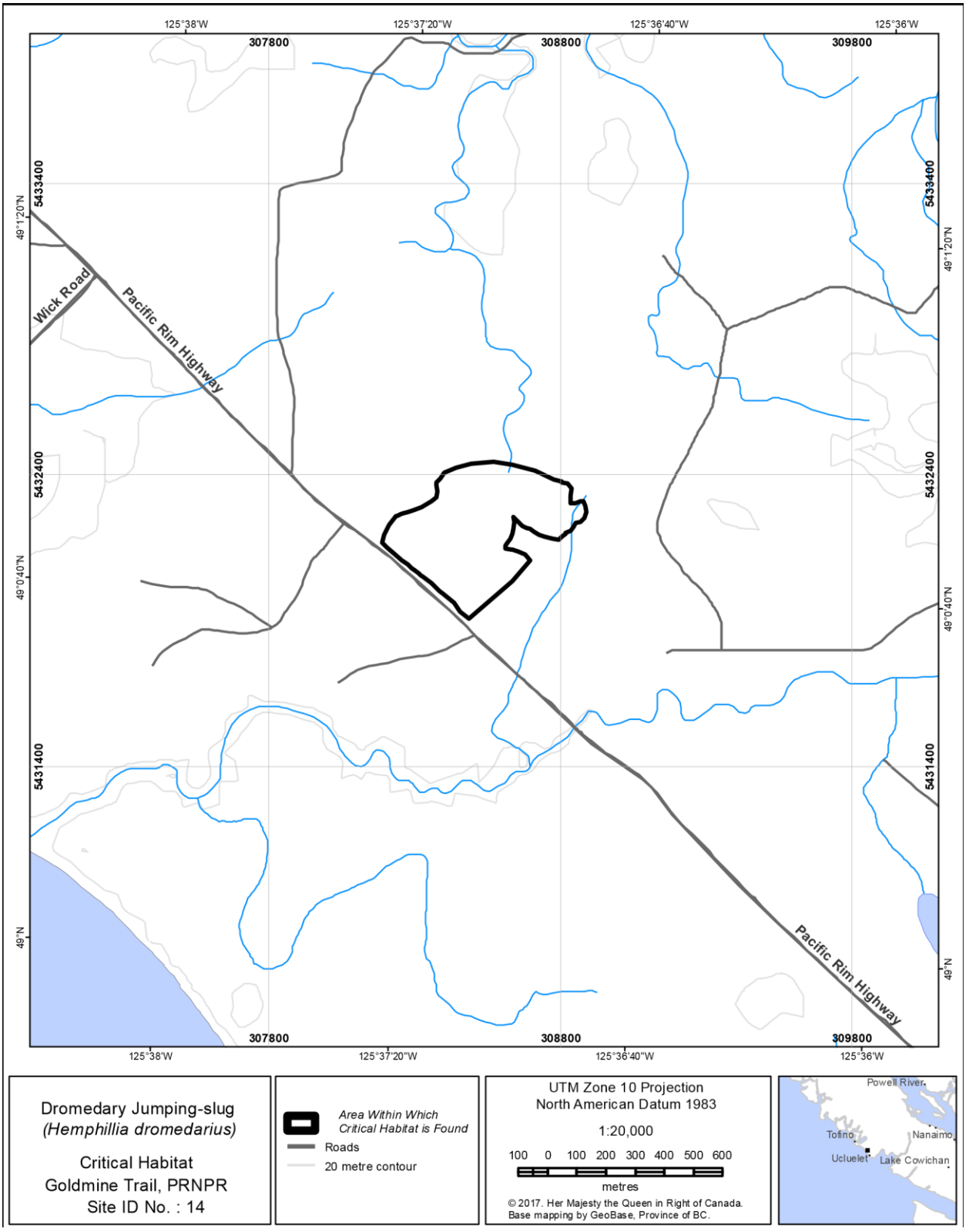

Figure 11. Critical habitat (20 ha) for Dromedary Jumping-slug at Goldmine Trail.

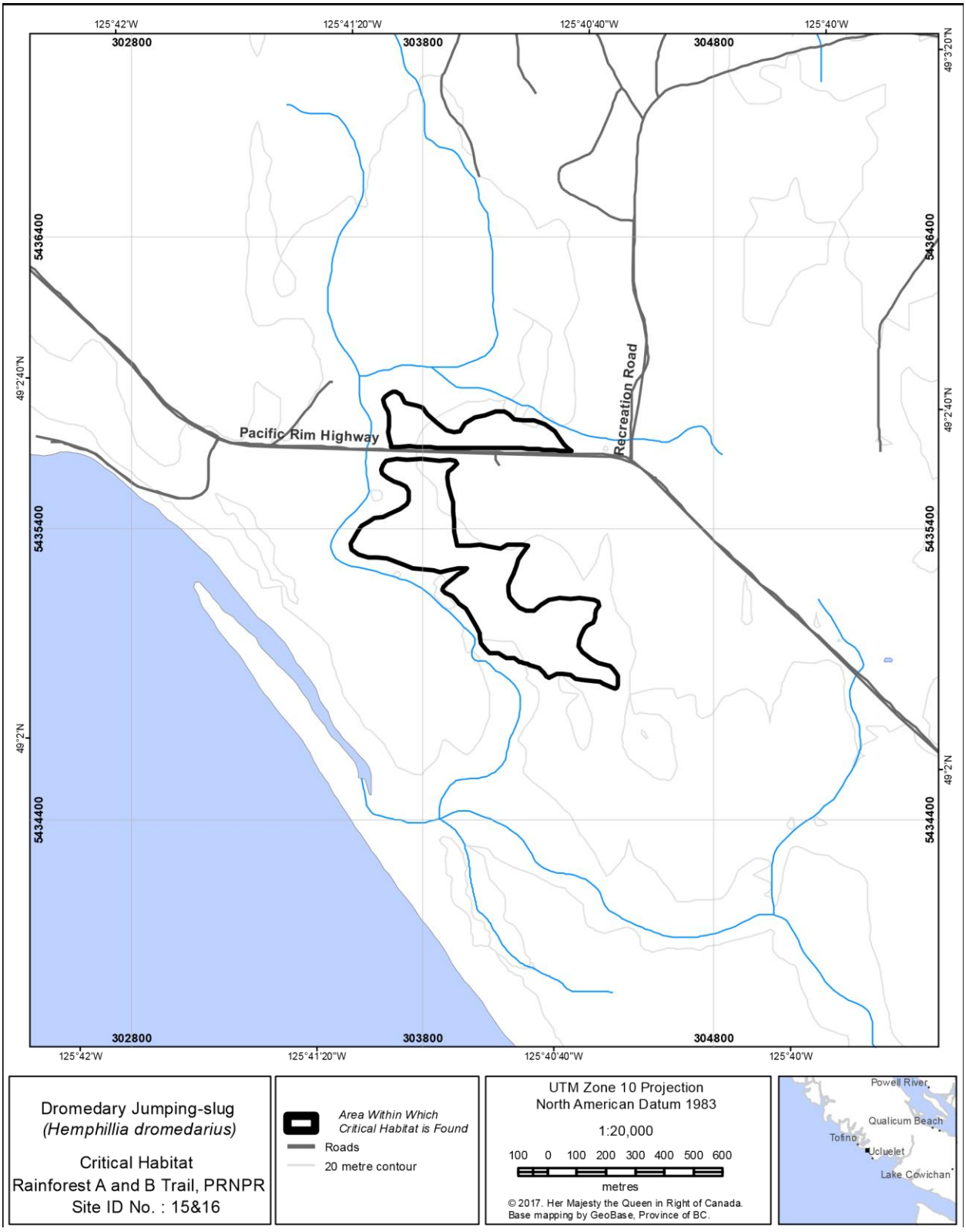

Figure 12. Critical habitat (28 ha) for Dromedary Jumping-slug at Rainforest A & B Trail.

5.2. Examples of activities likely to result in destruction of critical habitat

Understanding what constitutes destruction of critical habitat is necessary for the protection and management of critical habitat. Examples of activities likely to destroy critical habitat are provided below (Table 4); however, destructive activities are not limited to those listed. Destruction is determined on a case by case basis. Destruction would result if part of the critical habitat were degraded, either permanently or temporarily, such that it would not serve its function when needed by the species. Destruction may result from single or multiple activities at one point in time or from cumulative effects over time. It is important to note that some works or activities performed outside critical habitat have the potential to destroy critical habitat especially if they alter ecological dynamics and ecological processes (e.g., through edge effects or introduction of exotic plants or animals) such that the critical habitat attributes are no longer present to support the species.

It is recognized that existing facilities and land uses in and adjacent to critical habitat already affect critical habitat, to various degrees, and may decrease the quality of certain portions of critical habitat that remain in the area. Lower quality or sub-optimal areas are nonetheless included as critical habitat because they still serve a biological function for the species (e.g., shading). Any new, additional, or increases in activity (including the construction of new facilities) inside or outside of critical habitat polygons may cause destruction of critical habitat. Some human activities in or adjacent to critical habitat will require careful assessment for possible effects, including cumulative effects on critical habitat and the potential for destruction.

Table 4. Examples of activities likely to result in destruction of critical habitat of the Dromedary Jumping-slug.

Activity	Effect of activity on critical habitat
Works or activities within the boundaries of critical habitat	
Works or activities within critical habitat that result in loss of forest canopy cover (e.g., typically larger developments such as logging, building houses, golf courses, mineral or aggregate extraction, building roads, wide trails or transmission lines).	Forest clearing results in the loss of forest canopy cover (reducing cover, shade and moisture for the forest floor). It is also likely to result in a change to the overall age of the forest stand and may alter the ecotype of the habitat (see Table 3), making it less suitable for the species. Forest clearing may also result in the direct or indirect loss of other important biophysical attributes: such as a productive understory (e.g., small trees, shrubs, moss), abundant coarse woody debris (especially that with a large diameter), and a structurally complex forest floor (e.g., cavities, travel corridors) (COSEWIC 2014, Part 2). In addition, such activities are likely to introduce alien invasive species which can affect habitat functions (e.g., exotic plants can alter food availability; COSEWIC 2014, Part 2).

Activity	Effect of activity on critical habitat
Works or activities within critical habitat that do not affect the forest canopy but that still affect the understory, coarse woody debris, or forest floor structure (e.g., typically smaller developments such as small trails, platforms, kiosks).	Works that may not cause loss of the forest canopy may still result in the loss of important biophysical attributes: such as a productive understory (e.g., small trees, shrubs, moss), abundant coarse woody debris (especially that with a large diameter), and a structurally complex forest floor (e.g., cavities, travel corridors) (COSEWIC 2014, Part 2). These works may also alter the ecotype of the habitat (see Table 3), making the habitat less suitable for the species. In addition, such activities are likely to introduce alien invasive species which can affect habitat functions (e.g., exotic plants can alter food availability; COSEWIC 2014, Part 2).
Application of herbicides and other chemicals within the boundaries of critical habitat.	Chemical application can result in destruction of biophysical attributes such as moss or shrub cover, and food resource availability (e.g., fungus; COSEWIC 2014, Part 2).
Works or activities outside the boundaries of critical habitat	
Forest clearing within 120 m of critical habitat that results in loss of biophysical attributes within critical habitat (see above examples of works or activities resulting in a loss of forest canopy cover)	Loss of well-developed forest canopy within 120 m of critical habitat can affect critical habitat due to edge effects that reduce moisture on the forest floor for this species threatened by desiccation (COSEWIC 2014; Part 2). An edge in this context is defined as a gap in the forest that is wider than the average surrounding stand height and with a ‘hard’ edge (defined as where the average canopy height abruptly declines by at least 50%). This guideline is based on edge effects on soil moisture (Chen *et al.* 1995).

5.3. Schedule of studies to identify critical habitat

A list of studies and activities required for additional critical habitat to be identified for Dromedary Jumping-slug is included in Table 5.

Table 5. Studies and activities required for a full identification of critical habitat for Dromedary Jumping-slug.

Description of activity	Outcome/rationale	Timeline
Some critical habitat has not been identified due to ongoing cooperation and consultation. The Government of Canada will continue to work cooperatively with applicable organizations to complete the identification of critical habitat and will update this document as appropriate.	Increased amount of critical habitat.	On-going, pending progress respecting cooperation and consultation.
Conduct modelling to determine the area of occupancy for the species.	Current mapping and the geography of known locations can be used to estimate the area of occupancy. This will allow for better quantification of the amount of critical habitat required to meet the population and distribution objective.	2017-2018

Survey areas surrounding the three Dromedary Jumping-slug locations where scientific information regarding natural habitat use is lacking.	Scientific information available regarding natural habitat use; identification of critical habitat.	2017-2019
Conduct habitat modelling or mapping to allow for a range wide identification of suitable habitat for Dromedary Jumping-slug.	Habitat modelling or mapping can be used to achieve a range wide critical habitat identification that will meet the population and distribution objective.	2020-2027

6. Socio-Economic Considerations

The "Socio-economic Considerations" section of the provincial document (Part 2) is not part of the federal recovery strategy for the Dromedary Jumping-slug (*Hemphillia dromedarius*) because socio-economic factors are not a consideration in the preparation of SARA recovery strategies (see section 41(1) of SARA).

7. Action Plan

This section modifies information in the Province of British Columbia's Recovery Strategy for Dromedary Jumping-slug (*Hemphillia dromedarius*) in British Columbia (Part 2).

One or more action plans for the Dromedary Jumping-slug will be completed and posted on the Species at Risk Public Registry five years following the final posting of this recovery strategy.

8. Effects on the Environment and Other Species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*[6]. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or any of the Federal Sustainable Development Strategy's[7] (FSDS) goals and targets.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a

[6] http://www.ceaa.gc.ca/default.asp?lang=En&n=B3186435-1
[7] http://www.ec.gc.ca/dd-sd/default.asp?lang=En&n=CD30F295-1

particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below in this statement.

This recovery strategy will clearly benefit the environment by promoting the recovery of the Dromedary Jumping-slug. Activities to meet recovery objectives are unlikely to result in any important negative environmental effects, as they are limited to habitat protection, research activities, fostering stewardship, increasing public awareness, improving knowledge on habitat requirements and population threats, and conducting habitat/species mapping and inventory.

The recovery strategy identifies current threats to the Dromedary Jumping-slug and its habitat as well as current knowledge gaps. Recovery objectives clearly focus on resolving these threats and filling information gaps. Recommended activities may also benefit non-target species and the environment.

Some recovery strategy activities (e.g., surveys involving the manipulation of animals) may require project-level environmental assessment as required under the Canadian Environmental Assessment Act (CEAA). Any activities found to require project-level environmental assessments will be assessed at that time pursuant to the provisions of the Act. The SEA process has concluded that this recovery strategy will have several positive effects on the environment. No significant negative effects are expected.

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Appendix A: Critical Habitat Identification Background

Three conservation principles guided the critical habitat identification and are described below:

1. *The habitat included should be representative of habitat in which Dromedary Jumping-slug is known to occur.*

The forest ecotypes and their ages at each Dromedary Jumping-slug location were recorded (Churchill *et al.* 2010). Dromedary Jumping-slugs have been discovered at sites composed of nine different forest ecotypes (Table 3), most commonly in mature or old forests (about 40 to > 250 years old, most commonly > 80 years old). When defining critical habitat polygons, only habitats composed of primary forest ecotypes and forest ages known to be suitable (across all locations) for Dromedary Jumping-slug were included.

2. *Habitat areas should be large enough to maintain a Dromedary Jumping-slug sub-population at each location.*

Although some terrestrial gastropods have home ranges varying from about 12 m^2 to 404 m^2, no literature is available that quantifies the size of habitat areas required to maintain viable Dromedary Jumping-slug locations (Grimm and Paill 2001; Edworthy *et al.* 2012). Oregon Forestsnails (*Allogona townsendiana*) in British Columbia had a mean home range size of 117 m^2 and existed at high densities – a mean of 1.0 snail per m^2 (Steensma *et al.* 2009; Edworthy *et al.* 2012). Blue-grey Taildroppers (*Prophysaon coeruleum*) in British Columbia appear to typically exist at densities from 0.01 to 0.15 slugs per m^2 (COSEWIC 2006). In California, Dunk *et al.* (2004) concluded that entire gastropod populations may be found in a 1 ha area. Dromedary Jumping-slugs, however, appear to occur at much lower densities than the species studied by the above authors and they may have larger home ranges than other local gastropods (COSEWIC 2014).

Some useful context for the size of reserves can be drawn from studies on other ecosystems and species. Twenty hectares has been recommended as a minimum size to maintain a specific habitat type (Darnell et al 1974; as cited in Shafer 1995). Other studies regarding the habitat areas required to ensure the persistence of small organisms have been for plants: bryophytes in British Columbia have been found to persist in as little as 3.5 ha of forest (Baldwin and Bradfield 2005), while herb species in South Africa required between 4 and 15 ha to persist (Cowling and Bond 1991).

Although few studies have quantified the area required for the persistence of small organisms, many studies have concluded that larger reserves increase the probability of persistence for organisms in general and for small organisms in particular (e.g., reviewed by Saunders *et al.* 1991; Shafer 1995). Some insect species were lost from experimental reserves in Brazil that were up to 10 ha in size and it was suspected that

insect species may even be lost from reserves as large as 100 ha (Bierregaard *et al.* 1992). Similarly, in British Columbia, habitat reserves > 100 ha were found to contain a greater abundance and diversity of gastropods (though no Dromedary Jumping-slugs were found) after logging, than reserves < 2 ha (Ovaska and Sopuck, unpubl. manuscript).

To summarize, some terrestrial gastropods have small home ranges (e.g. Grimm and Paill 2001), or exist at high densities (e.g., Steensma *et al.* 2009), but these species appear to occur at much higher densities than Dromedary Jumping-slugs (COSEWIC 2014). Given that the Dromedary Jumping-slug is a mobile animal that occurs at low densities (and thus low population sizes), and has been observed dispersing away from occupied areas (COSEWIC 2014), it likely requires significantly larger areas than bryophyte and herb species that are not mobile, disperse primarily using seeds or spores and occur at relatively high densities. With this information in consideration, reserves of 15 ha or less may not provide for a strong probability of long term persistence for terrestrial gastropod populations.

To ensure that the critical habitat polygons in this recovery strategy provide a reasonable probability of persistence for known Dromedary Jumping-slug locations, a target size of 20 ha was chosen for critical habitat polygons.

A recently published recovery strategy for the Blue-grey Taildropper (another British Columbia gastropod; Environment and Climate Change Canada 2016) applied a slightly different approach to the identification of critical habitat than for the approach used here for Dromedary Jumping-slug. These approaches differ based on biological differences between the species (the Blue-grey Taildropper appears to have less dispersal capabilities and exists at higher densities than Dromedary Jumping-slug; COSEWIC 2006, COSEWIC 2014). However, both critical habitat approaches affect a similar amount of land base and protect a similar number of individuals (Parks Canada, unpubl. data). The Blue-grey Taildropper identification uses a smaller core area and a larger buffer (1.9 ha core and 240 m buffer, versus 20 ha core and 120 m buffer for Dromedary Jumping-slug), but the overall area affected is similar (estimated at 221 ha and 435 ha, respectively). Additionally, considering the different densities estimated for the two species (COSEWIC 2006, COSEWIC 2014), the core reserves (1.9 ha and 20 ha, respectively) will protect a similar number of individuals (protection estimated for 157 Blue-grey Taildroppers and 229 Dromedary Jumping-slugs; Parks Canada, unpubl. data).

For sites where 20 ha of suitable habitat is not currently available to be identified as critical habitat, adjacent areas should be restored so that sufficient suitable habitat will be available at a future date.

3. *If multiple records of Dromedary Jumping-slug have been documented within the same location, they should be connected with corridors to facilitate potential movement of individuals within the location area.*

Habitat connecting individuals in a location is important to increase the probability of persistence (Taylor *et al.* 1993; Harrison and Voller 1998). Due to the wide geographic separation of many of the Dromedary Jumping-slug locations on Vancouver Island, connectivity between locations is beyond the scope of this critical habitat identification. However, individuals within locations also require continuous habitat to allow for movement and to ensure gene flow (Harrison and Voller 1998). NatureServe (2011) considers terrestrial gastropod observations to be distinct locations if separated by at least 1 km. Therefore critical habitat includes connecting habitat for Dromedary Jumping-slug records separated by < 1 km (i.e., those within a single location).

Using the three principles, the critical habitat identification protocol was applied to identify specific critical habitat areas for Dromedary Jumping-slug as follows:

1. The forest ecotypes surrounding Dromedary Jumping-slug locations were mapped using Terrestrial Ecosystem Mapping (TEM) methodology (RIC 1998). The preferred method to define the proposed critical habitat polygons was to use mapping of habitat ecotypes on 1:10,000 to 1:20,000 scale orthophotos, supplemented with detailed ecological data collected during a site visit (Churchill et al. 2010). The TEM mapping protocol identified the forest ecotypes, areas of similar habitat based on forest structure and landform type, around each Dromedary Jumping-slug location (Churchill et al. 2010). Polygons were delineated on orthophotos and then digitized using ArcGIS software. During site visits, data were collected on forest conditions and changes in habitat within 250 m of the Dromedary Jumping-slug location. Potential barriers to slug movement, such as the presence of a recent clear-cut, highway or water, as well as changes in forest structure or landform were used to identify polygon edges. Where site access was not possible critical habitat was mapped based only on habitat types visible on 1:10,000 to 1:20,000 scale orthophotos as described above, and focused on identifying areas of similar forest structure. Potential barriers to Dromedary Jumping-slug movement and changes in forest structure visible on the orthophotos were used to identify polygon edges.

2. The forest polygon in which a Dromedary Jumping-slug was found was identified as critical habitat, and the size and attributes of the area calculated. Age-specific forest ecotypes that comprised at least 25% of forest polygons with Dromedary Jumping-slug records were defined as primary ecotypes for the purposes of this critical habitat identification and assumed to represent suitable habitat for Dromedary Jumping-slug across all locations. The forest ecotypes and structural stages of surrounding polygons up to 500 m away from the location were examined to identify other habitat polygons that contained primary ecotypes (500 m radius was selected as a methodological consideration to ensure adequate mapping to reach 20 ha at each site).

3. Where available within 500 m, contiguous polygons that contained primary ecotypes for the Dromedary Jumping-slug and addressed any outstanding deficits in the critical habitat polygon size were added one at a time until the critical habitat polygon reached or exceeded the target of 20 ha (or until there was no suitable

ecologically relevant contiguous habitat in the surrounding area available for inclusion).

4. Due to the age of much of the imagery used in producing polygon boundaries (1984 to 2005), Google Earth imagery (dated from 2005 to 2010) was used where available to help ensure that suitable habitat was still present within the critical habitat polygon boundaries. Although the most recent ortho imagery available was used to verify the status of the habitat within critical habitat polygons, further forest harvesting or natural disturbance may have occurred in the area since the last date of imagery available or since field visits occurred.

Geographic Location details

This section describes the geographic location of each Dromedary Jumping-slug location and the corresponding critical habitat polygon.

1. **Shawnigan Lake**: The site is in a high-elevation (~700 m) coniferous forest in the CWHmm2 subzone (Table 3). There is one observation record for this location, from 1999 (B.C. Conservation Data Centre 2010). The Shawnigan Lake critical habitat (Figure 1) occurs northwest of Shawnigan Lake. The critical habitat polygon is bounded to the north by forest of a younger structural stage, and to the northeast by a moist, rich ecotype not considered suitable for Dromedary Jumping-slug. Critical habitat for this location was mapped through interpretation of 1:15,000 1988 colour orthophotos and in lieu of a site visit Google Earth imagery (14 September 2012) was used to verify critical habitat was still present within the polygon.

2. **Mount Cokely, Mt. Arrowsmith**: The site is in a mature Mountain Hemlock-Amabalis Fir high elevation (~1200 m) forest in the MHmm1 subzone (Table 3). There is one observation record for this location, from 2006 (B.C. Conservation Data Centre 2010). The Mount Cokely critical habitat (Figure 2) is near Mount Arrowsmith Regional Park near a former ski area. Critical habitat for this location was mapped through interpretation of 1:16,000 1990 black and white orthophotos and in lieu of a site visit Google Earth imagery (04 August 2012) was used to verify critical habitat was still present within the polygon. No additional habitat can be included in the critical habitat polygon because no contiguous suitable and representative habitat is currently available: the critical habitat polygon is bounded to the west by highly disturbed habitat and the rest of the surrounding habitat is too dry.

3. **McBey Creek, Mt. Arrowsmith**: The site is in a mature Western Hemlock-Amabalis Fir high elevation (> 950 m) forest in the CWHmm1 subzone (Table 3). There is one observation record for this location, from 2009 (B.C. Conservation Data Centre 2010). Critical habitat (Figure 3) for this location was mapped through interpretation of 1:16,000 1990 black and white orthophotos and a detailed ecological assessment on a site visit on 01 July 2010. The Government of Canada

will continue to work cooperatively with applicable organizations to complete the identification of critical habitat and will update this document as appropriate.

4. **Mount Brenton**: The site is in a mature Western Hemlock-Amabalis Fir high elevation (> 1000 m) forest in the MHmm1 subzone (Table 3). There is one observation record for this location, from 2001 (B.C. Conservation Data Centre 2010). The Mount Brenton critical habitat (Figure 4) is near Holyoak Lake. Critical habitat for this location was mapped through interpretation of 1:15,000 1998 colour orthophotos and in lieu of a site visit Google Earth imagery (18 August 2016) was used to verify critical habitat was still present within the polygon. At Mount Brenton no other suitable habitat is currently available for inclusion in the identification. Although the ecotype of some of the surrounding forest is considered suitable for Dromedary Jumping-slug (MB ecotype; Table 3), the forest is currently too young to be considered suitable for Dromedary Jumping-slug.

5. **Mount Hooper**: The site is in high-elevation (~850 m) coniferous forest in the MHmm1 subzone (Table 3). There is one observation record for this location, from 2001 (B.C. Conservation Data Centre 2010). The Mount Hooper critical habitat (Figure 5) is 2.7 km southeast of the summit of Mount Hooper, approximately 20 km northwest of Youbou. Critical habitat for this location was mapped through photo interpretation of 1:20,000 1984 black and white orthophotos and in lieu of a site visit Google Earth imagery (16 July 2005) was used to verify critical habitat was still present within the polygon.

6. **Juan de Fuca Park, Loss Creek**: To be determined.

7. **Thrasher Cove**: To be determined.

8. **Clo-oose Bay**: The site is in mature Western Redcedar-Western Hemlock low elevation (< 100 m) forest in the CWHvh1 subzone (Table 3). There is one observation record for this location, from 2004 (B.C. Conservation Data Centre 2010). The Clo-oose critical habitat (Figure 6) occurs along the West Coast Trail near Clo-oose Bay. Critical habitat for this location was mapped through interpretation of 1:20,000 1992 colour orthophotos and a detailed ecological assessment on a site visit on 12 August 2010.

9. **Keeha Beach Trail, PRNPR**: The site is in mature Western Redcedar-Western Hemlock low elevation (< 100 m) forest in the CWHvh1 subzone (Table 3). There is one observation record for this location, from 2006 (B.C. Conservation Data Centre 2010). The Keeha Beach Trail critical habitat (Figure 7) is near Cape Beale. Critical habitat for this location was mapped through interpretation of 1:10,000 1989 colour orthophotos and a detailed ecological assessment on a site visit on 06 August 2010.

10. **Bamfield**: The site is in a low-elevation (< 30 m) old-growth/second-growth Western Redcedar-Western Hemlock forest in the CWHvm1 subzone (Table 3). There is one observation record for this location from 2000 (B.C. Conservation

Data Centre 2010). The Bamfield critical habitat (Figure 8) is within the Village of Bamfield. Critical habitat for this location was mapped through interpretation of 1:10,000 1989 colour orthophotos and in lieu of a site visit Google Earth imagery (17 June 2004) was used to verify critical habitat was still present within the polygon.

12. **Willowbrae**: The site is in an old-growth Western Redcedar-Western Hemlock low elevation (< 100 m) forest in the CWH vh1 subzone (Table 3). There is one observation record for this location, from 2006 (B.C. Conservation Data Centre 2010). The Willowbrae critical habitat (Figure 9) occurs along the Willowbrae trail in Pacific Rim National Park Reserve. Critical habitat for this location was mapped through interpretation of 1:20,000 1992 colour orthophotos and a detailed ecological assessment on a site visit on 24 August 2010.

13. **Indian Creek**: The site is in mature Western Redcedar-Western Hemlock low elevation (< 100 m) forest in the CWHvh1 subzone (Table 3). There is one observation record for this location, from 2001 (B.C. Conservation Data Centre 2010). The Indian Creek critical habitat (Figure 10) is at Kennedy Flats, near Ucluelet. Critical habitat for this location was mapped through interpretation of 1:15,000 1996 colour orthophotos and a detailed ecological assessment on a site visit on 24 June 2010. Google Earth imagery (13 August 2010) showed substantial forest harvesting after the 2010 field visit to the site. To avoid as much impacted habitat as possible, the critical habitat delineation was modified to better represent the extent/distribution of remaining suitable habitat.

14. **Goldmine Trail, PRNPR**: The site is in an old-growth Western Redcedar-Western Hemlock low elevation (< 100 m) forest in the CWHvh1 subzone (Table 3). There are two observation records for this location, from 2003 and 2004 (B.C. Conservation Data Centre 2010). The Goldmine critical habitat (Figure 11) occurs south of Goldmine trail and across the highway in Pacific Rim National Park Reserve. Critical habitat for this location was mapped through interpretation of 1:15,000 1996 colour orthophotos and a detailed ecological assessment on a site visit on 23 June 2010.

15. **Rainforest A Trail, PRNPR**: The Rainforest A (Site ID No. 15) and Rainforest B (Site ID No.16) observations are within 1 km of each other and considered one location. As the location is split by the highway that may pose a barrier (i.e., drier conditions of roads may pose as barriers to movements of slugs; COSEWIC 2014), the critical habitat has been mapped separately for each side of the highway as if they were separate locations. It has also been mapped to connect as much as possible with habitat at Rainforest B Trail, as per Principle No. 3 (see above). The site is in an old-growth Western Redcedar-Western Hemlock low elevation (< 100 m) forest in the CWHvh1 subzone (Table 3). There are five observation records for the Rainforest A Trail portion of this location (B.C. Conservation Data Centre 2010) recorded in 2003 and 2004 at an elevation of 40m. The Rainforest A Trail critical habitat (Figure 12) is along the Rainforest Trail in Pacific Rim National Park Reserve. Critical habitat was mapped through

interpretation of 1:15,000 1996 colour orthophotos and a detailed ecological assessment on a site visit on 22 June 2010. At Rainforest A Trail, no suitable representative habitat is available for inclusion to the north (the habitat is riparian and likely too wet), but across the highway suitable connecting habitat to Rainforest B Trail has been included.

16. **Rainforest B Trail, PRNPR**: The Rainforest A (Site ID No.15) and Rainforest B (Site ID No.16) observations are within 1 km of each other and considered one location. As the location is split by the highway that may pose a barrier (i.e., drier conditions of roads may pose as barriers to movements of slugs; COSEWIC 2014), the critical habitat has been mapped separately for each side of the highway as if they were separate locations. It has also been mapped to connect as much as possible with habitat at Rainforest A Trail, as per Principle No. 3 (see above). The site is in an old-growth Western Redcedar-Western Hemlock low elevation (< 100 m) forest in the CWHvh1 subzone (Table 3). There is one observation record for this portion of the location, from 2006 (B.C. Conservation Data Centre 2010). The Rainforest B Trail critical habitat (Figure 12) occurs along the Rainforest Trail in Pacific Rim National Park Reserve. Critical habitat for this location was mapped through interpretation of 1:15,000 1996 colour orthophotos and a detailed ecological assessment on a site visit on 22 June 2010. The critical habitat polygon is delineated to include connecting habitat between both sides of the highway.

19. **Ty-histanis**: To be determined.

Part 2 – *Recovery Strategy for Dromedary Jumping-Slug (*Hemphillia Dromedarius*) in British Columbia*, prepared by the British Columbia Ministry of Environment

Recovery Strategy for Dromedary Jumping-slug (*Hemphillia dromedarius*) in British Columbia

Prepared by the British Columbia Invertebrates Recovery Team

BRITISH COLUMBIA
The Best Place on Earth

Ministry of Environment

November 2008

About the British Columbia Recovery Strategy Series

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

What is recovery?

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

What is a recovery strategy?

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

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

What's next?

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

For more information

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

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

Recovery Strategy for Dromedary Jumping-slug (*Hemphillia dromedarius*) in British Columbia

Prepared by the British Columbia Invertebrates Recovery Team

November 2008

Recommended citation

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Kristiina Ovaska

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Disclaimer

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

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

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

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that may be involved in implementing the directions set out in this strategy. The Ministry of Environment encourages all British Columbians to participate in the recovery of Dromedary Jumping-slug.

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The British Columbia Ministry of Environment is responsible for producing a recovery strategy for Dromedary Jumping-slug under the *Accord for the Protection of Species at Risk in Canada*. Parks Canada Agency and Environment Canada's Canadian Wildlife Service participated in the preparation of this recovery strategy.

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EXECUTIVE SUMMARY

Dromedary Jumping-slug, *Hemphillia dromedarius,* is an old-growth coniferous forest-dwelling slug endemic to southern British Columbia (B.C.) and western Washington, with unconfirmed records in northern Oregon. The species exists at the northernmost limits of its range in south western B.C. with a known Canadian range extent of approximately 4000 km^2 confined to southern Vancouver Island. The species was located and confirmed in Canada in 1999. As of 2008, 15 locations[8] have been defined for Dromedary Jumping-slug, with eight of these locations in protected areas. Additional undocumented localities likely exist, although the range extent is not likely to expand significantly. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated Dromedary Jumping-slug as Threatened in 2003, due to the fragmentation of its coniferous forest habitats and threats to the remaining habitats, mainly from forestry activities.

The specific microhabitat requirements of Dromedary Jumping-slug are not well known. Occurrence records on Vancouver Island characterize the species as an inhabitant of mature and older temperate coniferous forests in which Western Redcedar (*Thuja plicata*) and Western Hemlock (*Tsuga heterophylla*) are the dominant tree species. Dromedary Jumping-slug requires abundant coarse woody debris and a continually moist microhabitat in which to lay eggs and take cover to minimize dehydration stress. Soil mineral content, relative humidity, a thick organic soil layer, thick understory herbaceous and shrub cover, as well as constant moisture, all contribute to optimal habitat for the species. Survey coverage and locality information for Dromedary Jumping-slug is incomplete. Much of the potential habitat within the species' range has not been surveyed.

Dromedary Jumping-slug appears vulnerable to microclimatic changes that remove both the overstory and understory, resulting in both small-scale microhabitat alteration and larger-scale stand habitat modification. Reproduction and dispersal capabilities decrease when the moist environment and abundant coarse woody debris needed to sustain populations are removed.

The main threats to Dromedary Jumping-slug are: 1) habitat loss, modification, and fragmentation including deforestation; 2) exotic species; and 3) vegetation management.

[8] **Location:** a geographically distinct area where a group of individuals of a species is (or has been) found. The total population of a species may comprise a number of locations. Dispersal between locations is impossible or very rare. A single threatening event can rapidly affect all individuals at a location. Where a taxon is affected by more than one threatening event, location should be defined by considering the most serious plausible threat. (Source: adapted from IUCN 2001) (COSEWIC 2008).

The recovery goal is to ensure the long-term survival of Dromedary Jumping-slug by maintaining a connected network[9] of protected[10] locations and habitats at the current distribution, area of occupancy, and population sizes, throughout the species' historical range in Canada.

Dromedary Jumping-slug will likely not recover naturally to occupy all of its historic range in Canada due to extensive loss of mature and old growth temperate coniferous forests within southern Vancouver Island.

Recovery objectives for Dromedary Jumping-slug are: 1) protect known locations by 2013; 2) clarify and mitigate threats to Dromedary Jumping-slug and its habitat by 2013; 3) by 2013, initiate research that addresses knowledge gaps; 4) by 2013, demonstrate an increased number of stewardship activities initiated and completed for land managers and public users of habitats occupied by Dromedary Jumping-slug.

Critical habitat cannot be identified at this time due to incomplete information on life history requirements, population sizes, distribution, area of occupancy, and specific habitat requirements at both the stand and microhabitat scale. Dromedary Jumping-slug is known to occur in older-growth coniferous forests, although the sparse records and number of observed specimens make it difficult to specifically describe critical habitat. Range wide habitat suitability modeling will likely not be possible due to a lack of knowledge of micro-habitat requirements. Soil moisture, relative humidity, coarse woody debris requirements, food requirements, soil mineral requirements, understory vegetation components, and limiting factors within a given location and habitat are not clear, and all these components are necessary to describe critical habitat. Furthermore, the small home ranges Dromedary Jumping-slug occupies are difficult to incorporate with existing GIS mapping.

An action plan will be completed by March 2013. This action plan will likely be a multi-species document, as recovery actions are similar among multiple gastropod species at risk.

[9] Dromedary Jumping-slug has a metapopulation structure within habitat patches, and unoccupied habitats need to be protected to link metapopulations. This network of patches includes known locations and potential habitats, and will link with other conservation initiatives within the species' range.
[10] Protection can be achieved through a variety of mechanisms including: regulatory changes, voluntary stewardship agreements, conservation covenants, sale by willing vendors of private lands, land use designations, and protected areas.

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BACKGROUND

Species Assessment Information from COSEWIC

Date of Assessment: April 2013
Common Name (Population): Dromedary Jumping-slug
Scientific Name: *Hemphillia dromedarius*
COSEWIC Status: Threatened
Reason for Designation: A rare mollusc found on Vancouver Island. All known sites are in old-growth forest or in forests that contain old-growth characteristics.
Canadian Occurrence: British Columbia
COSEWIC Status History: Designated Threatened in April 2003. Assessment based on a new status report.

Description of the Species

Dromedary Jumping-slug, *Hemphillia dromedarius*, is a small (~60 mm) grayish slug with cream mottling over the dorsal surface. Its morphology is briefly described in Forsyth (2004), COSEWIC status report (COSEWIC 2003) and Ovaska *et al*. (2002). The species derives its common name from its ability to actively flip and writhe back and forth when disturbed, somewhat like a fish may wiggle when out of water. This action is thought to be a form of anti-predator behaviour (K. Ovaska, pers. comm., 2008).

Dromedary Jumping-slug is secretive, primarily nocturnal (Ovaska, pers comm. 2008), and like many other slug species, is likely photophobic (Prior 1985). The complete life history, ecology, and reproductive strategy of Dromedary Jumping-slug is unstudied. The species is hermaphroditic and likely takes two years to reach maturity (COSEWIC 2003). Egg clutches contain 50 – 60 grayish/opaque eggs laid together on decaying logs (Branson 1972). No juvenile slugs have been found to date (Ovaska, pers. comm., 2008).

Classification
Class Gastropoda, Order Stylommatophora, Family Arionidae.

Populations and Distribution

Dromedary Jumping-slug is endemic to western North America and has a small global range, which extends from Vancouver Island, British Columbia (B.C.) southward to the Cascade Mountains and Olympic Peninsula in Washington State (WA) (Figure 1). Easternmost records are from the east slope of the Cascade Mountains, WA. One unconfirmed record is from Oregon State (OR).

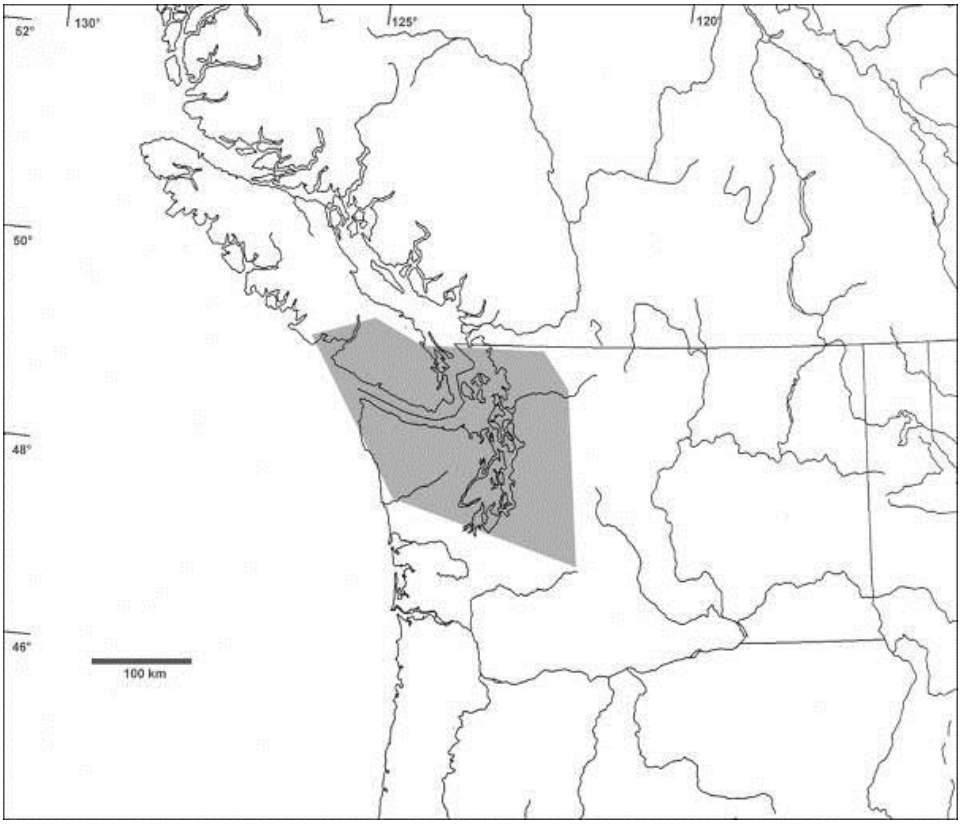

Figure 1. Global distribution of Dromedary Jumping-slug, based on Branson (1972, 1977, 1980) and Canadian records (known localities to 2008).

The Canadian range of Dromedary Jumping-slug is restricted to southern Vancouver Island, B.C. with an approximate range extent of 4000 km^2. There is no historic data for this species, as it was recently described (Branson 1972) and the first confirmed record in B.C. was from 1999 (K. Ovaska, pers. comm., 2008). An old record of a large jumping-slug exists from Vancouver Island (Hanham 1926) and most likely represents this species (COSEWIC 2003).

As of 2008, 15 locations[11] of Dromedary Jumping-slug are known in B.C. (Figure 2). Survey coverage and locality information for this species is incomplete. Much of the potential habitat within the species' range has not been surveyed although it is unlikely the range extent will extend beyond existing localities due to existing available habitat (See Habitat and biological needs section).

[11] **Location:** "a geographically distinct area where a group of individuals of a species is (or has been) found. The total population of a species may comprise a number of locations. Dispersal between sites is impossible or very rare. A single threatening event can rapidly affect all individuals in a location. Where a taxon is affected by more than one threatening event, location should be defined by considering the most serious plausible threat. (Source: adapted from IUCN 2001)" (COSEWIC 2008).

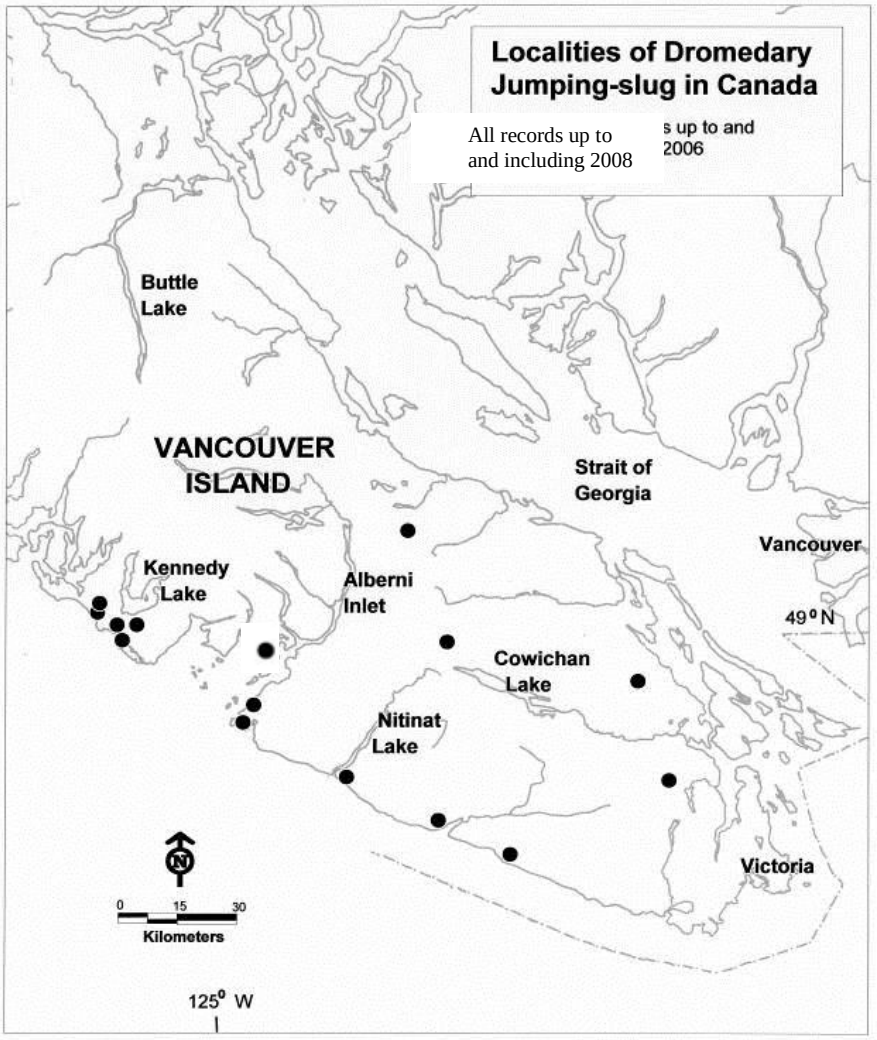

Figure 2. Canadian distribution of Dromedary Jumping-slug showing the 15 known locations for the species. Broken line: Canada–U.S. border.

Dromedary Jumping-slug is a forest dweller and appears to be associated with mature and older-growth temperate coniferous forests; all records are from within forests greater than 80 years old (K. Ovaska, pers. comm., 2008) (see Habitat and biological needs). Old-growth forest habitats on Vancouver Island have been extensively modified since the beginning of widespread European settlement in the mid-1800s. Suitable habitats for Dromedary Jumping-slug have decreased substantially over this period due to widespread habitat fragmentation caused by urbanization, logging and agricultural land practices (see Threats section).

The lack of current and historic records, combined with poor survey coverage, does not allow for an estimation of population and distribution trends. Furthermore, the species is difficult to detect and monitor due to its nocturnal habits (K. Ovaska, pers. comm., 2008) and apparently low population densities. Populations appear to survive at low densities, as observed during inventory searches (K. Ovaska, pers. comm., 2008). For example, only 1 or 2 individuals per site were found during 40 – 540 person-minutes of searching (COSEWIC 2003). Night surveys for gastropods in the Pacific Rim National Park Reserve resulted in finding two

individuals each at two sites during 80 – 240 person-minutes of searching, respectively (Ovaska and Sopuck 2003a).

Dromedary Jumping-slug has a global heritage rank of G3G4 (vulnerable) and a rank of N2 (nationally imperiled) in Canada (Natureserve 2008). Within Washington State the species is ranked N3N4 (Natureserve 2008). The species has not been assigned a conservation status rank in other US states (Natureserve 2008).

Table 1. Locations of Dromedary Jumping-slug in Canada. Results are based on surveys completed by Ovaska and Sopuck (2001; 2002a; 2002b; 2003a; 2003b; 2003c; 2003d; 2005; 2007); Ovaska *et al.* (2001); COSEWIC (2003).

Location no.	Location name	Year	Land tenure	Elev. (m)	Number of individuals observed	Description	Area (ha)**
1	Location One*	1999	Private forestland*	700	N/A	Remnant high elevation coniferous forest	1
2	Loss Creek	2000	B.C. Parks; Juan de Fuca Provincial Park	140	N/A	Old-growth coniferous forest at Loss Creek near Highway 14 (SE of Port Renfrew) in Juan de Fuca Provincial Park	2
3	Location Three*	2000	Unknown*	30	N/A	Mixed old- and second-growth cedar–hemlock coastal forest	2
4	Location Four*	2001	Private forestland*	1060	N/A	Remnant high elevation coniferous forest	5
5	Indian Creek	2001	Provincial Crown land	45	1 (COSEWIC 2003)	Old-growth cedar–hemlock coastal forest about 9 km N of Ucluelet on Kennedy Flats	20
6	Location Six*	2001	Private forestland*	850	N/A	Remnant high elevation coniferous forest	50+
7	Pacific Rim National Park Reserve	2003	Parks Canada Agency; Federal	40	15 (Ovaska and Sopuck 2005)	Old-growth cedar–hemlock coastal forest along Rainforest A Trail	15
8	Pacific Rim National Park Reserve	2003	Parks Canada Agency; Federal	25	6 (Ovaska and Sopuck 2005)	Old-growth cedar–hemlock coastal forest SE of Goldmine Trail	10
9	Pacific Rim National Park Reserve	2004	Parks Canada Agency; Federal	80	36 (Ovaska and Sopuck 2005)	Old-growth cedar–hemlock coastal forest near Thrasher Cove NW of Port Renfrew on West Coast Trail	50+
10	Pacific Rim National	2004	Parks Canada Agency;	10	1 (Ovaska and	Older second-growth cedar–hemlock coastal forest near Clo-oose on West Coast Trail	50+

Location no.	Location name	Year	Land tenure	Elev. (m)	Number of individuals observed	Description	Area (ha)**
	Park Reserve		Federal		Sopuck 2005)		
11	Location Eleven*	2006	Mixture of provincial Crown land and private* land	1200	N/A	Remnant high elevation old-growth coniferous forest	50+
12	Pacific Rim National Park Reserve	2006	Parks Canada Agency; Federal	30	N/A	Old-growth cedar–hemlock coastal forest along Rainforest B Trail	20
13	Pacific Rim National Park Reserve	2006	Parks Canada Agency; Federal	20	N/A	Old-growth cedar–hemlock coastal forest along Keeha Beach Trail near Cape Beale	50+
14	Pacific Rim National Park Reserve	2006	Parks Canada Agency; Federal	30	N/A	Old-growth cedar–hemlock coastal forest along Willowbrae Trail	5
15	Location 15*	2008	Private forestland*	approx 1200	1	Old-growth, remnant high elevation hemlock-mixed coniferous forest	

*Private land is unnamed to respect landowner privacy.
**Area refers to the approximate area of the habitat polygon where Dromedary Jumping-slug was observed, where the forest type and ecosystem attributes are similar.

Needs of Dromedary Jumping-slug

Habitat and biological needs

Dromedary Jumping-slug is associated with rich mesic mature and old growth coniferous temperate forests dominated by western hemlock (*Tsuga heterophylla*) and western redcedar (*Thuja plicata*). On Vancouver Island, the elevation of known locations is from near sea level to 1200 m. The low-elevation locations are within the wet, west coast of Vancouver Island; the remaining localities are from elevations above 700 m, in the foggy high areas within the southern interior of the island. Five of the known localities are in remnant patches of old-growth coniferous forest dominated by western hemlock and western redcedar (Figure 3). All localities appear to have high relative humidity and constant moisture.

Microhabitat conditions are a determining factor in the presence of Dromedary Jumping-slug. Understory vegetation, abundant coarse woody debris, and moss and hummock layers, all

contribute to high microhabitat humidity within a forest stand. Low elevation Dromedary Jumping-slug locations have an understory of salal (*Gaultheria shallon*), elderberry (*Sambucus racemosa*), blueberry species (*Vaccinium spp*.), deer fern (*Blechnum spicant*), and other plants associated with these forests. Higher elevation locations have abundant blueberry species yet the overall understory is less dense than lower elevation locations.

Suitable microhabitat offers protection against daily or seasonal variations in temperature and water availability (as summarized in Prior 1985). Soil moisture and understory vegetation which allows for the retention of moisture and availability of shelter, contribute to protective cover in times of drought and relative humidity at a location (numerous studies summarized in Prior 1985).

Figure 3. Western redcedar/western hemlock old-growth forest inland from Pacific Rim National Park Reserve, within provincial Crown land. The region surrounding the park is heavily logged and remnant patches of old growth are important refuges for Dromedary Jumping-slug.

Microhabitat characteristics for Dromedary Jumping-slug include abundant coarse woody debris, from large-diameter pieces to a forest floor composed of thin, compact needle litter thought to provide suitable microhabitats for shelter from predators and environmental fluctuations, egg laying, hibernation, aestivation, and feeding. Mossy areas and decaying logs retain moisture and provide essential shelter during warm and dry weather conditions. It is important for Dromedary Jumping-slug to have a suitable resting site from which moisture can be absorbed through the foot; contact re-hydration is crucial for survival (Prior 1985). As observed in other terrestrial slugs and snails, large diameter, damp rotten logs may act as

dispersal corridors and shelter during seasonal drought (Applegarth, unknown date).

Microhabitat availability is important for reproductive success. Branson (1972) observed that Dromedary Jumping-slug laid their eggs within well-decayed wood. Pale Jumping-slug (*H. camelus*), which is taxonomically related (in the same genus) to Dromedary Jumping-slug, has been found to nest communally within very large logs with sloughing-off bark in mid-stages of decay (K. Ovaska, unpubl. data, pers. comm. 2008). Dromedary Jumping-slug may have similar nesting behaviour, and thus the lack of available and suitable nest logs may limit the reproductive capabilities of these gastropods. Coarse woody debris at a range of decay stages provides shelter, egg-laying sites, and a source of moisture for Dromedary Jumping-slug

A combination of environmental factors, such as temperature, water availability, and day length affect the activity patterns of all slugs and their presence within an area. Activity patterns predominantly coincide with preventing dehydration (Prior 1985). Slugs seek shelter and microhabitat that retains water, humidity, and cool temperatures. Dehydration is known to decrease locomotor activity (Prior 1985). A well-cited gastropod quote from Wells (1944) reads "the raindrops knock on the door, and the snail comes out. Hydration follows after, when it has eaten and drunk, and may then perhaps make a secondary contribution to the great rise in metabolic rate".

The physiology and activity patterns of Dromedary Jumping-slug inherently make them susceptible to continuous water loss through dehydration. All slugs deposit a dilute mucous trail, and experience constant evaporative water loss through the lung surface and integument. Numerous ecological and physiological studies show a relationship between varying body temperature hydration on locomotor activity (Machin 1975; Peake 1978; Burton 1983; Riddle 1983; Martin 1983 as cited in Prior 1985). Within two hours, active slugs can lose 30 – 40% of their initial body weight and habitat selection by slugs is correlated with water availability (Prior 1985). Although this information pertains to other slug species, it is likely similar for Dromedary Jumping-slug.

Slugs are known to initiate 'water seeking' responses to dehydration after a short-term reduction in locomotor activity (Prior 1985). Some species exhibit group aggregations, or huddles – groups of slugs aggregate together to prevent water loss (Cook 1981a, b; Prior 1981; Prior *et al*., 1983, as cited in Prior 1985). Huddles create a high humidity microenvironment and reduce dehydration, yet appear to be non-social aggregations (Cook 1981a as cited in Prior 1985). When a slug becomes dehydrated, the animal will also assume a flattened body position over a wet surface, in order to maximize the surface area of water absorption through the foot (Prior 1985). It is likely Dromedary Jumping-slug exhibits similar huddling and flattening behaviour when dehydrated.

Prior (1985) summarizes homing behaviour in some slugs and snails. Slugs have been observed to leave their homesite or shelter site after dark, forage for several hours, and return before dawn. When slugs exhibit this homing behaviour, it ensures the animal returns to suitable shelter, minimize dehydration, and prevent exposure to drying conditions (Prior 1985). It is likely Dromedary Jumping-slug exhibits similar homing behaviour.

Diet and feeding preferences are unstudied for Dromedary Jumping-slug, although captive slugs were observed to feed sparingly upon vegetable matter (COSEWIC 2003). The species may feed specifically on a particular fungi or lichen, although this has been unstudied (COSEWIC 2003).

Ecological role

Dromedary Jumping-slug is a contributor to the natural capital (ecosystem goods and services) of a coniferous and mixed forest. Gastropods, in general, build healthy soil and contribute to the turnover of organic matter and decomposition processes on the forest floor. The species is likely a detrivore-fungivore and may disperse fungal spores including mycorrhizal species, which assist in promoting the healthy growth of trees. Slugs are also prey for various predators including birds, amphibians, carabid beetles, and small mammals.

Limiting factors

1. **Habitat availability**
   Dromedary Jumping-slug is an associate of mature and older-growth temperate coniferous forests. The slug has a scattered distribution pattern throughout its range, likely due to the isolation of suitable habitat patches and poor dispersal capabilities (see Habitat and biological needs). Large diameter, damp rotten logs may act as dispersal corridors and shelter during seasonal drought, as shown in other mollusc species (Applegarth, unknown date).

2. **Moisture, microhabitat, and soil conditions**
   Moisture and microhabitat, including soil organic matter content, coarse woody debris, understory vegetation, bryophyte layers, and relative humidity are limiting factors for slug activity, reproductive success, foraging, and persistence within a forest. Higher moisture conditions will draw a slug out of aestivation, and increase activity levels, as well as affect homing behaviour.

   When the forest floor becomes more exposed to wind and sunlight, and there is less vegetation growing throughout the understory, terrestrial molluscs are more vulnerable to dehydration (Applegarth, unknown date; Prior 1985) and experience high rates of evaporative water loss through their skin (Dainton 1954a,b; Machin 1964a,b,c; 1966; Burton 1964, 1966; Prior *et al.* 1983; as cited in Prior 1985). Brief exposure to drying conditions can have lasting cellular effects on slugs and cause intensive physiological stress. Cell volume regulatory mechanisms can tolerate some osmotic changes, although continuous expansion (from rehydration) and contraction (from dehydration) causes further stress to the slug (Hughes and Kerkut 1956; Kerkut and Tayor 1956; Treherne 1980; Prior and Pierce 1981; Prior 1981; Pierce 1982; Prior 1983b; Phifer and Prior 1982, as cited in Prior 1985).

   Soil mineral content (including magnesium and calcium) and pH may play an important

factor in slug microhabitat preference. Although unstudied in Dromedary Jumping-slug, these limiting factors have been known to affect habitat preferences in other gastropods (Wareborn 1969; Hylander *et al.* 2005).

3. **Limited dispersal ability and small home range**
   Dispersal ability of Dromedary Jumping-slug is likely poor. It is unclear how much area (hectares) is required to sustain a population within a location, especially where mature and older temperate coniferous forest habitats are fragmented. By their very nature, Dromedary Juming-slugs are predominantly sedentary animals, and their natural ability to colonize new areas is likely poor. The fragmented low-elevation coniferous forests of southern Vancouver Island may limit natural dispersal.

4. **Low population densities and reproductive potential**
   Dromedary Jumping-slug appears to be primarily nocturnal and secretive (K. Ovaska, pers. comm. 2008). All observations of Dromedary Jumping-slug have been at low densities (as shown in surveys Ovaska and Sopuck (2001; 2002a; 2002b; 2003a; 2003b; 2003c; 2003d; 2005; 2007); Ovaska *et al.* (2001); COSEWIC (2003)). Thus given the species' apparent low densities, it likely has low reproductive potential, even within optimal habitats. These factors make it difficult to detect, study, and monitor populations and gain further information on whether population density is a limiting factor.

5. **Competition and predation**
   Dromedary Jumping-slug is likely vulnerable to predation pressure, which likely increases in human-modified landscapes. Invertebrate predators known to be present at Dromedary Jumping-slug locations include the carnivorous Robust Lancetooth snail (*Haplotrema vancouverensa*) and ground beetles (e.g. *Scaphinotus angusticollis*) (K. Ovaska and L. Sopuck, unpubl. data, 2000). Both species are believed to be gastropod specialists (Thiele 1977) and will follow the slime trails of Dromedary Jumping-slug. Robust Lancetooth has been observed to attack and kill slugs (Ovaska and Sopuck, unpubl. data, 2000). These (and other) invertebrate predators are common throughout southern Vancouver Island forests; there is no known obligate association with Dromedary Jumping-slug.

   Concentration of predators in small habitat patches where little escape cover is available will potentially increase predation rates on Dromedary Jumping-slug. Competition and predation as a limiting factor may become more of a threat when combined with competition and predation from exotic species and further development pressures (see Threats section). For example, roads are known to increase the spread of exotic species and predation pressure on gastropods (Trombulak and Frissell 2000). Dromedary Jumping-slug has been observed at the roadside of the main highway through Pacific Rim Park (Table 1).

Threats

Threats to Dromedary Jumping-slug include: 1) habitat loss, fragmentation, and modification including deforestation; 2) competition from exotic species; and 3) vegetation management.

Additional threats that need further clarification and research, but which are not considered significant at this time include: 4) seasonal roadside maintenance; 5) fire and flooding; 6) recreational use of habitats; and 7) climate change. These latter threats are also discussed below.

Table 2. Threat classification table for Dromedary Jumping-slug.

1	**Habitat loss, fragmentation, and modification including deforestation**	**Threat attributes**		
Threat category	Habitat loss or degradation	**Extent**	widespread	
			Local	**Rangewide**
General threat	Habitat loss, fragmentation and degradation	**Occurrence**	high	high
		Frequency	high	high
Specific threat	Habitat conversion; fragmentation; isolation; recreational use	**Causal certainty**	high	high
		Severity	high	high
Stress	Isolation of populations; decreased resources; dispersal sinks; mortality	**Level of concern**	high	high

2	**Competition from exotic species**	**Threat attributes**		
Threat category	Changes in Ecological Dynamics or Natural Processes	**Extent**	widespread	
			Local	**Rangewide**
General threat	Exotic gastropod and plant species	**Occurrence**	high	medium
		Frequency	unknown	medium
Specific threat	Resource competition; alteration of habitat characteristics and plant communities; changes in plant species and community structure of forest ecosystems	**Causal certainty**	unknown	unknown
		Severity	unknown	unknown
Stress	Decreased microhabitat humidity from changes in forest floor vegetation; isolation of populations; dispersal sinks; reduced food availability and increased egg and larval mortality (from dehydration); increased predation and competition by exotic gastropods	**Level of concern**	medium	

3	**Vegetation management**	**Threat attributes**		
Threat category	Habitat degradation	**Extent**	widespread	
			Local	**Rangewide**
General	Roadside vegetation	**Occurrence**	medium	medium

threat	management and maintenance	**Frequency**	medium	medium
Specific threat	Errant application of roadside herbicides; chemicals that contain high concentrations of salt; vegetation removal (reducing humidity)	**Causal certainty**	high	medium
		Severity	high	medium
Stress	Increased dehydration; direct mortality from vegetation removal	**Level of concern**	low	low

Description of the threats

1. Habitat loss, fragmentation, and modification

Confining Dromedary Jumping-slug populations to smaller habitat patches likely increases their vulnerability to: predation (e.g., from natural predators such as *Scaphanotus angusticolus* (Thiele 1977)), drying of the forest floor (Applegarth unknown date; Prior 1985), flooding of the forest floor; reduced genetic diversity; competition from exotic species (Ovaska and Sopuck, pers. comm. 2007); and harmful fluctuations in microclimate (Prior 1985). Habitat loss, fragmentation and habitat modification are described below.

- *Loss of mature and old growth forest habitats*
  Continued loss of mature and old growth forest habitats as a result of logging, agricultural land conversion, urbanization, and other developments is the main threat to the species (COSEWIC 2003). Forestry activities and urban and rural land development likely contributed to habitat loss in the past. Within the Canadian range of Dromedary Jumping-slug, less than 6% of the landbase remains in old-growth forests and remaining habitats are highly fragmented (MacKinnon and Eng 1995). Incremental and cumulative habitat loss, modification, and fragmentation continue at present day throughout the species' range on southern Vancouver Island.

- *Intensive forest management*
  The Canadian range of Dromedary Jumping-slug coincides with an area of B.C. with extensive historic logging. The forest landbase continues to be intensively managed due to the high demand for forest products. Forest practices have changed substantially since the mid 1800's when widespread European settlement on Vancouver Island began, and are more intensive at present day. 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 populations of Dromedary Jumping-slug.

  Pre-commercial thinning and pruning practices reduce the quantity and/or alter the timing of leaf and branch litter that would otherwise fall to the forest floor and provide shelter for Dromedary Jumping-slug. Pruning activities that remove lateral branches reduce the overall forest canopy, which results in lower relative humidity and subsequent desiccation of the forest floor. The active removal of trees and machinery

used may compact ground cover, crush individuals of Dromedary Jumping-slug, disturb coarse woody debris and shelter sites, and cause localized impacts within a harvested area.

- *Removal of large coarse woody debris*
  Survival of Dromedary Jumping-slug within a harvested and/or second growth forest landscape may depend on the availability of old rotten logs within which the species can take cover and lay eggs. Present day intensive forest management practices will target large dead coarse woody debris for removal during the second rotation of forest harvesting. For example, a century ago Douglas-fir trees were a priority harvest species. Western redcedar trees were still cut, but often only Douglas-fir logs were removed and the large western redcedar logs remained behind. Some second-growth forests are now at harvest age, and consequently some large western redcedar logs which were left on the forest floor after the first harvest rotation can still be of merchantable value in present-day markets (e.g., for cedar shakes). Where such cedar logs are still merchantable and are accessible, it is common practice (dependent on market conditions at the time) to remove these logs during or subsequent to the second harvest. Thus, large coarse woody debris may be in short supply in intensively managed forests; these logs are likely important for maintaining stable microclimates for developing eggs, and thus suitable microhabitat for Dromedary Jumping-slug.

- *Increased roads, trails and corridors*
  Roadsides act as corridors into natural habitats and are known to facilitate the rapid spread of exotic species (e.g. plant seeds attach to car tires, and become dislodged at new locations) (Trombulak and Frissell 2000). The threats from exotic species are discussed below. Observations of Dromedary Jumping-slug within wet vegetation adjacent to the roadside just outside of boundary to Pacific Rim National Park (Ovaska, pers. comm., 2007), and adjacent to well-used trails (Ovaska and Sopuck 2003a; Ovaska, pers. comm., 2007; Sopuck, pers. comm., 2007), suggests the potential spread of exotic species along roadsides may impact local populations through competition and predation, changes to native vegetation.

2. **Competition from exotic species**
   - *Exotic gastropods*
     Exotic gastropods likely compete with Dromedary Jumping-slug as consumers of similar food sources, as well as predators of Dromedary Jumping-slug itself. Many exotic gastropods occur in habitats throughout Vancouver Island (Forsyth 2004), are widespread within urban and agricultural landscapes in southwestern B.C., and can be locally abundant (Forsyth 1999). Although most exotic species are primarily in areas of high human use and alteration, some have spread into intact coniferous forest habitats and increased their range extent (Ovaska, pers. comm. 2008). Exotic species include Chocolate Arion (also called European Black Slug) (*Arion rufus*) and Giant Gardenslug (*Limax maximus*), which may compete with native forest-dwelling species for shelter and egg-laying sites. Giant Gardenslug is known to be an aggressive competitor (Rollo and Wellington 1979) with other gastropod species. Carnivorous gastropods, such as Longneck Fieldslug (*Deroceras panormitanum*) and Wormslug

(*Boettgerilla vermiformis*), may also be of concern, although at present neither appears widely distributed within Vancouver Island forests (Ovaska, pers. comm., 2007; Sopuck, pers. comm., 2007). Within forests in Washington State, Chocolate Arion is documented from within old growth forests, and may be displacing native Banana Slugs (*Ariolimax columbianus*) (Applegarth, unknown date).

- *Exotic plants*
  Exotic plant species are known to change the forest floor vegetation and soil structure and increase the light penetrating to the forest floor. Increases in light levels lead to dryer microclimate and understory conditions and result in desiccation of the forest floor which increases dehydration stress to slugs and other species that depend upon high water and humidity levels. Exotic plant species, such as English ivy (*Hedera helix*) have the potential to spread and displace the native vegetation on forest floors. Native gastropods are not known to live within vegetation patches of English Ivy (Applegarth, unknown date). English Holly (*Ilex aquifolium*) and Himalayan Blackberry (*Rubus discolor*) are also widely spread exotic plants within native ecosystems in coastal B.C., and are known to displace native vegetation.

3. **Vegetation management**
   - *Herbicides*
     Herbicides are used in some locations to control roadside vegetation, both within private forestlands and on Crown lands. Both at present day and in the past, herbicides have been used along hiking trails, throughout recreational picnic areas within parks, and also along road and railway corridors. For example, various herbicides have been tested to control two highly invasive plants Scotch broom (*Cytisus scoparius*) and gorse (*Ulex europaeus*) along roadsides in the Duncan area on Vancouver Island (Zielke *et al.* 1992). Herbicides are used less today, however it is unclear how extensive this practice was (or is currently), within the mature forest habitats where Dromedary Jumping-Slug is known to occur on southern Vancouver Island.

     The use of roadsides by gastropods has been documented by Baur and Baur (1990) who concluded the land snail (*Arianta arbustorum*) prefers moving along road verges and avoids crossing roads, including unpaved roads of only 3m wide (as cited in Trombulak and Frissell 2000). Dromedary Jumping-slug has been observed along roadside verges (Ovaska, pers. comm. 2007), as well as crossing a trail within Pacific Rim National Park Reserve (Ovaska and Sopuck 2003a; K. Ovaska, pers. comm. 2007). Spraying herbicides to control roadside vegetation would likely harm gastropods within these roadside verges, and the cumulative and lasting effects of herbicides within these environments may lead to long-term declines in gastropod numbers (although this has not been substantiated). Further research and monitoring is needed to determine the effects of herbicides on Dromedary Jumping-slug.

Threats that require further research and are not considered significant at this time:

4. Seasonal roadside maintenance

Salt and/or a salt-sand mixture is often spread to prevent roads from becoming icy during

winter months. It is unknown what effect this has on roadside fauna (e.g. slugs or slug eggs), and how long salt may remain along a roadside.

5. **Fire and flooding**
   Applegarth (unknown date) cited fire as a threat to gastropod populations in Washington State. Coniferous forests on the west side of southern Vancouver Island forests remain moist and wet throughout the year, but the threat of forest fires is possible, particularly in July through September. Forests on the southeastern slopes of Vancouver Island are typically dry and much more susceptible to fire.

   The low elevation locations of Dromedary Jumping-slug on the west coast of Vancouver Island are also within the tsunami zone, and should a natural disaster such as this occur, extensive flooding would occur.

6. **Recreational use of habitats**
   Recreational use of forested areas for camping, hiking, foot and bicycle traffic, and the use of all terrain vehicles and trail bikes, especially off-trail bikes, can result in degradation of habitat quality through soil compaction and can also cause accidental mortality. Trail building, increased vehicle traffic, hiking, and related activities may also increase the spread of exotic species.

7. **Climate change**
   Climate change is considered a potential, but poorly understood threat to Dromedary Jumping-slug habitat. Climate change may increase possible drought and cause a shift in understory vegetation composition.

Knowledge Gaps

Distribution, inventory, and monitoring	• Population estimates for the 15 locations (as of 2007) of Dromedary Jumping-slug in Canada and quantification of the density of slugs in relation to microhabitat characteristics at each site. • Population structure within each location as well as the connectivity between isolated patches or populations. • Inventory of potential sites on Crown land and private forestland in the species' range to determine if additional locations exist, and what the threats are at each of these locations.
Life history, ecology and movements	• Dispersal ability and factors that may influence dispersal (such as coarse woody debris and humidity) and movement patterns • Life history information such as life cycle, egg laying and survival, lifespan, residence, food requirements such as fungi upon which the slug may depend, etc.
Habitat requirements	• Habitat requirements and habitat correlates (riparian vs. upland areas, associations with plant communities, and canopy coverage),

	microhabitat requirements, habitat moisture requirements, associated vegetation, soil mineral requirements, coarse woody debris requirements, stand size necessary to ensure long term survival of a localized population, etc. How do these habitat requirements compare across elevation gradients?
Clarification of threats	• Feasibility of habitat restoration of sites for Dromedary Jumping-slug. • Ability to recolonize a stand after fire, flooding, logging, etc. • Effects of herbicides and other chemicals used in forest management and roadside vegetation control. • Quantify additional threats to the species, including high intensity fires and flooding within habitats, herbicide use, roadside salt and fertilizer use in habitats adjacent to Dromedary Jumping-slug habitat

RECOVERY

Recovery Feasibility

Recovery of Dromedary Jumping-slug is biologically and technically feasible in B.C. The recovery criteria used to assess the technical and biological feasibility of recovery of Dromedary Jumping-slug are discussed below.

Criteria 1: Are individuals capable of reproduction currently available to improve the population growth rate or population abundance?

Yes. It is assumed individuals capable of reproduction are present within locations, as populations have persisted within fragmented habitats, and individuals have been observed. The nocturnal, secretive nature of the species makes it difficult to detect, study, and monitor populations within a location. Little is known about the dispersal and reproductive capabilities, ability to tolerate habitat disturbances, and survival characteristics within habitat patches.

Criteria 2: Is sufficient habitat available to support the species or could it be made available through habitat management or restoration?

Yes. Dromedary Jumping-slug has been found in mature and old growth temperate coniferous forest habitats, with a continuously moist to wet understory, an abundance of coarse woody debris, and an overstory of western hemlock and western redcedar.

Within the species' range, less than 6% of the landbase remains in old-growth forests and remaining habitats are highly fragmented (MacKinnon and Eng 1995). Dromedary Jumping-slug likely has small home ranges, and thus small (< 20 hectares) fragmented patches of

habitat throughout the southern portion of Vancouver Island will likely provide suitable habitat.

Much of southern Vancouver Island remains as immature and second-growth productive forests for the growth of future timber. These second-growth forests can theoretically grow into suitable recovery habitat for Dromedary Jumping-slug. Polygons of older second-growth forests with habitat characteristics similar to old-growth temperate coniferous forests could be retained and managed to remain standing beyond the expected rotation (harvest) age. Specific areas of second-growth adjacent to known Dromedary Jumping-slug localities, such as existing federal and provincial protected areas, can function as potential areas of expansion, dispersal, and connectivity between habitats.

Criteria 3: Can significant threats to the species or its habitat be avoided or mitigated through recovery actions?
Yes. Threats to Dromedary Jumping-slug habitat can be mitigated through changes in forest practices and the protection of known locations. If Dromedary Jumping-slug is listed as Identified Wildlife, the species can be protected on provincial Crown forest land through the establishment of wildlife habitat areas under the B.C. *Forest and Range Practices Act*.

Best management practices guidelines will assist private landowners and private forest land managers with making informed decisions regarding management of Dromedary Jumping-slug habitat and minimizing threats to the species. Within best management practices guidelines, provisions for herbicide and pesticide application, retention of coarse woody debris, and additional potential threats can also be addressed.

Further threats can be addressed at known locations and specific approach/actions can be formulated. Overall public education regarding exotic species can be incorporated into broad scale campaigns that involve multiple species and agencies (e.g. South Coast Conservation Program (www.sccp.ca) and Garry Oak Ecosystems Recovery Team (www.goert.ca), as well as initiatives at all levels of government.

Criteria 4: Do the necessary recovery techniques exist and are they known to be effective?
Yes. Techniques used to recover this species are similar to the recovery planning applied to species with similar threats, issues, and requirements, both from an ecological and social perspective. None of the proposed recovery techniques are thought to be highly experimental by the academic community, gastropod experts, or the recovery team members. Currently, captive breeding to supplement the wild populations and locations is not thought necessary for the recovery of Dromedary Jumping-slug. Captive breeding may take place to gain knowledge regarding this species' life history and reproductive capabilities.

Recovery Goal

The recovery goal is to *ensure the long-term survival of Dromedary Jumping-slug by maintaining a connected network[12] of protected[13] locations and habitats at the current distribution, area of occupancy, and population sizes, throughout the species' historical range in Canada*.

The species' range is considered to include an area of southern Vancouver Island bounded by localities with existing records. This range will be expanded as needed, if new localities are found. This species was likely not common in the landscape before 1850, when large scale European settlement, logging, and habitat change from agriculture became more widespread. Dromedary Jumping-slug will likely not recover naturally to occupy all of its historic range in Canada due to extensive loss of mature and old growth temperate coniferous forests within southern Vancouver Island.

Recovery Objectives

1. Protect[5] known locations by 2013.
2. Clarify and mitigate threats to Dromedary Jumping-slug and its habitat by 2013.
3. By 2013, initiate research that addresses knowledge gaps.
4. By 2013, demonstrate an increased number of stewardship activities initiated and completed for land managers and public users of habitats occupied by Dromedary Jumping-slug.

Approaches Recommended to Meet Recovery Objectives

1. Habitat protection
2. Population protection
3. Inventory/monitoring
4. Public education and stewardship
5. Research to address knowledge gaps

Table 3 provides a time-referenced summary of recovery planning priorities, objectives, associated steps, and anticipated effects related to meeting the objectives.

[12] Dromedary Jumping-slug has a metapopulation structure within habitat patches, and unoccupied habitats need to be protected to link metapopulations. This network of patches includes known locations and potential habitats, and will link with other conservation initiatives within the species' range.

[13] Protection can be achieved through a variety of mechanisms including: regulatory changes, voluntary stewardship agreements, conservation covenants, sale by willing vendors of private lands, land use designations, and protected areas.

Recovery planning table

Table 3. Recovery planning table for Dromedary Jumping-slug.

Priority	Objective	Specific steps	Anticipated effect
Urgent	1) Protect known locations by 2013	i. Incorporate species-specific management provisions into provincial and federal parks planning documents. ii. Develop best management practices guidelines for privately managed forestland. iii. List species as Identified Wildlife under the provincial *Forest and Range Practices Act*	Management provisions implemented for the species within protected areas that provide effective management and protection for Dromedary Jumping-slug on the ground. Protected localities within privately managed forestland. Protection of Dromedary Jumping-slug within Wildlife Habitat Areas under the *Forest and Range Practices Act*, within provincially managed forests
Urgent	1) Protect known locations by 2013; 2) Clarify and mitigate threats to the species and its habitat by 2013; 3) By 2013, initiate research that addresses knowledge gaps.	i. Map potential habitat within the Canadian range (southern Vancouver Island) using GIS applications; ii. Delineate land tenure and ownership of potential habitats.	Mapped potential habitat allows prioritization of areas for inventory (including parks and protected areas, Crown lands, etc.) using a coarse filter (not all potential lands may be suitable habitat); areas for better management within existing parks and protected areas; and priority areas for protection. Allow for additional threats to be identified within potential habitats, and allow for prioritization of sites for protection. Determine the scale of fragmentation
Urgent	1) Protect known locations by 2013; 2) Clarify and mitigate threats to the species and its habitat by 2013; 3) By 2013, initiate research that addresses knowledge gaps.	i. Develop survey schedule and land owner contact strategy to ensure all potential habitat is surveyed for Dromedary Jumping-slug ii. Develop standard protocol for gathering information during gastropod surveys, including site-specific threats within areas surveyed. iii. Survey priority habitats (identified through habitat mapping).	Provides information on undocumented populations and assists in protecting these populations. Provides information on the extent of occupied habitat, area of occupancy and microsite characteristics Clarifies range and extent to which exotic gastropods are a threat and evaluates habitat quality in protected areas.
Urgent	2) Clarify and mitigate threats to the species and its habitat by 2013; 3) By 2013, initiate research that addresses knowledge gaps.	i. Broad-scale comparisons of Dromedary Jumping-slug distribution patterns among historically logged areas, and undisturbed (control) forests stands; examine the effects of different silviculture systems on the species' management.	Evaluates the effects of logging/recreation/urban/rural land development on the species and assists in the clarification of these threats to the species. Assists in evaluating protection and mitigation requirements.

Priority	Objective	Specific steps	Anticipated effect
Urgent	1) Protect known locations by 2013; 2) Clarify and mitigate threats to the species and its habitat by 2013; 4) By 2013, demonstrate an increased number of stewardship activities initiated and completed for land managers and public users of habitats occupied by Dromedary Jumping-slug.	i. Inform forest companies and resource professionals about Dromedary Jumping-slug. Ultimately, this may further protect individuals, residences, and critical habitat by a) increasing the number of Wildlife Habitat Areas or similar reserves on Crown land and b) stewardship agreements with private forest companies. ii. Incorporate species into the existing draft best management practices guidelines for gastropods. iii. Incorporate this species into multi-species stewardship and habitat management programs.	Identifies and protects habitat through regulatory means (Crown land) or voluntary stewardship activities (private land). Collaboration on projects with local nature trusts and stewardship groups. Provides land managers with practical tools for voluntary stewardship activities. Prevents additional gastropod species from becoming at risk. Protects individual Dromedary Jumping-slugs and their residences.
Necessary	3) By 2013, initiate research that addresses knowledge gaps.	i. Explore the possibility of mark-recapture studies to obtain information on life history, movements, habitat use, and population biology. ii. Genetic studies to obtain information on isolation of subpopulations and distinctness of the Vancouver Island population. iii. Research and quantify threats to the species.	Provides information for the development of science-based decisions for management. Assists with identification of dispersal barriers and subpopulations. Confirms threats to the species with science, and allows for better decision making.
Necessary	4) By 2013, demonstrate an increased number of stewardship activities initiated and completed for land managers and public users of habitats occupied by Dromedary Jumping-slug.	i. Prepare multi-species brochures, specific best management practices guidelines for different land owners (of sites where Dromedary Jumping-slug is known to occur), and information for distribution to local governments and other potential landowners within the species' range that may have habitat for these species.	Increases public awareness and understanding of this poorly known animal group and their habitats. Encourages the public to report observations. Gains public support and appreciation for stewardship of rare ecosystems and the species they contain.

Of the strategies outlined in Table 3, **habitat mapping and population inventory at each known location are considered most urgent**. These strategies will provide detailed information on available habitats and relative abundance within the Canadian range of the species and will determine habitat protection and stewardship activities. This information is required for identifying core areas, critical habitats, areas under immediate threats from human activities, and prioritizing areas for habitat protection. Detailed habitat mapping can be used to focus survey efforts according to habitat potential, especially within areas where gaps exist in previous survey coverage.

Protection is needed for all locations of Dromedary Jumping-slug, mainly due to the small number of known locations. Protective measures on Crown lands, including the listing of Dromedary Jumping-slug as Identified Wildlife under the *Forest and Range Practices Act*, are considered urgent. Including provisions for Dromedary Jumping-slug in park management plans at all levels of government, and implementing recommendations within such plans, will ensure threats to the species are minimized within these protected areas.

Protection on private forestlands will involve voluntary stewardship initiatives, and best management practices guidelines specific to a given location. Best management practices and public education programs will help support and initiate stewardship activities that provide the main options for habitat protection in populated areas and on private lands, including those managed by forest companies.
Research into habitat use, life history, and demography of the species is also necessary and will help fill in gaps in our knowledge about Dromedary Jumping-slug, their ecological role, and their habitat requirements. Additional research is needed on the threats to the species, including fire and flood, recreational use of habitats, and climate change.

Further research into threats to Dromedary Jumping-slug is necessary. Threats from exotic species may pose problems for Dromedary Jumping-slug through habitat modification and/or predation. Further research into the threats to Dromedary Jumping-slug from recreational practices, forest management practices (such as thinning and pruning, herbicide application), fire, flooding and urban/rural developments require clarification.

Performance Measures

Table 4. Evaluation of success of Dromedary Jumping-slug recovery strategy. The recovery strategy will be reviewed within five years; therefore these performance measures will be evaluated at the same time as the recovery strategy revision.

Approach/ strategy	Performance measures
Habitat protection	• Has a detailed habitat management plan been developed for each known location? • What proportion of known populations and locations protected? • What mechanisms have been used for protection and how secure is the protection? • Have relevant national, provincial, regional, municipal, and aboriginal governments been informed and consulted?
Population protection	• Are there population size targets and does annual monitoring show that population sizes are stable/increasing? • Are threats to populations described for each location and have actions been initiated to minimize threats at each location?
Inventory and monitoring	• Has inventory of known and/or potential populations been conducted each year? Are populations comparable between years? Can population numbers be quantified at each location?

	• What proportion of potential habitats has been surveyed for Dromedary Jumping-slug? How much habitat each year and what percentage of habitat is left within the species known range that has not been surveyed?
Public Education and stewardship	• Have landowners who have occupied or potential habitat been contacted, provided with information, and consulted? • Have any conservation agreements been developed with landowners who have occupied habitat on their property? • How many and what proportion of landowners with potential habitat have been contacted? Have conservation agreements been developed with these landowners? • Have stewardship materials (best management practices guidelines, brochures, etc) been produced and how many copies have been distributed?
Research to address knowledge gaps	• Has it been possible to quantify microhabitat requirements of Dromedary Jumping-slug; at what locations and how has this been documented? • Has it been possible to document home ranges of some slugs? • Have the life history, movements, habitat use, and population biology of the species been documented? • What proportion of potential habitats have been inventoried throughout the species' range? • Have the effects of forest management on the species been documented (e.g., how do populations persist in second growth forest)? • Has genetic characterization of the species between populations and between Vancouver Island and the mainland US been completed?

Critical Habitat

Identification of the species' critical habitat

Critical habitat cannot be identified at this time due to incomplete information on life history requirements, population sizes, distribution, area of occupancy, and habitat requirements at both the stand and microhabitat scales.

Dromedary Jumping-slug is known to occur in older-growth coniferous forests, although the sparse records and number of observed specimens make it difficult to specifically describe critical habitat. Range wide habitat suitability modeling will likely not be possible; the extremely small home ranges Dromedary Jumping-slug occupies are difficult to incorporate with existing geographic information systems mapping information. Soil moisture, humidity, coarse woody debris requirements, food requirements, soil mineral requirements, understory vegetation components, and limiting factors within a location are not clear, and all these components are necessary to establish the critical habitat. Critical habitat thus will be completed based on known locations for the species, but more research is needed to determine the spatial and temporal boundaries to those locations.

Knowledge gaps preventing the identification of critical habitat will be addressed according to

the schedule of studies, and critical habitat will be proposed within a draft action plan that will be completed by March 2013. This action plan will likely be a multi-species document, as threats and proposed recovery actions are similar among multiple gastropod species at risk.

Recommended schedule of studies to identify critical habitat

Table 5. Schedule of studies needed to identify critical habitat for Dromedary Jumping-slug.

Description of activity	Outcome/rationale	Timeline
Habitat studies for Dromedary Jumping-slug	Stand characteristics and quantity of habitat required to maintain a population in a given location.	2008 – 2013
	Knowledge of the microhabitat components necessary to maintain a population in a given location.	
	Clarification of threats to the species	
Research knowledge gaps	Determine microhabitat requirements for egg laying and nesting, feeding, shelter (aestivation and hibernation sites), and cover (protection from predators)	2008 – 2013

Existing and Recommended Approaches to Habitat Protection

Dromedary Jumping-slug is protected within parks and protected areas under the provincial *Park Act* (Strathcona Provincial Park location) and the federal *Canada National Parks Act* (Pacific Rim National Park Reserve locations). Both federal and provincial parks staff are aware of the necessary habitat requirements for this species, and are working to include the species within park planning and management.

It is unknown if Dromedary Jumping-slug is within regional or municipal parks, although if the species is found within these areas, efforts will be made to incorporate the species into protective planning within these areas. For example, Capital Regional District is aware of the species and its necessary habitat requirements, as the district is also incorporating other gastropod species at risk within their regional planning (M. Fuchs, pers. comm. 2008). Other jurisdictions, such as the Department of National Defense, are proactively surveying their properties for gastropod species at risk, including Dromedary Jumping-slug (A. Robinson, pers. comm. 2008).

Dromedary Jumping-slug is recommended for listing as Identified Wildlife under the provincial *Forest and Range Practices Act*. Once listed under this act, it will be possible to protect known locations of this species within Wildlife Habitat Areas on provincial Crown land.

Further inventory of provincial lands will increase the knowledge of the species. It is unclear how much habitat is needed to protect a Dromedary Jumping-slug location, although for simplicity the habitat polygon in which the slug is located (see Table 1) is considered in its entirety as a patch of suitable habitat, and delineated as such. If further research suggests

otherwise, future decisions will incorporate these results into science-based decision making. If the habitat is private land, landowner contact should be initiated and best management practices should be made available to the landowner. If the habitat is Crown land, legislative protection measures should be implemented. If the land is regional or municipally owned, contact with these governments should be initiated and best management practices written.

For successful implementation of species at risk protection measures, there is a strong need for engaging stewardship activities on various land tenures, including private forest lands. Stewardship involves the voluntary cooperation of all members of society, including government, industry, and all Canadians, to protect species at risk and the ecosystems they rely on. The preamble to the federal *Species at Risk Act* states that "stewardship activities contributing to the conservation of wildlife species and their habitat should be supported" and that "all Canadians have a role to play in the conservation of wildlife in this country, including the prevention of wildlife species from becoming extirpated or extinct." Furthermore, the Bilateral Agreement between British Columbia and Canada on Species at Risk states that "stewardship by land and water owners and users is fundamental to preventing species from becoming at risk and in protecting and recovering species that are at risk" and that "cooperative, voluntary measures are the first approach to securing the protection and recovery of species at risk."

To successfully protect many species at risk in British Columbia, voluntary initiatives by all Canadians will be important to help maintain areas of natural ecosystems that support these species. This stewardship approach will cover many different kinds of activities, including but not limited to: following guidelines or best management practices to support species at risk; voluntarily protection of important areas of habitat; conservation covenants on property titles; and eco-gifting or sale of property (in whole or in part) to protect certain ecosystems or species at risk. Both government and non-governmental organizations have successfully conserved lands in the province. This could be aided by the B.C. Trust for Public Lands and other non-governmental organizations.

Effects on Other Species

Many plants and animals at risk occur within the range of Dromedary Jumping-slug. In total, approximately 164 plant species that are either on the provincial Red-list (highest threat category) or Blue-list (not immediately threatened but of concern because of their vulnerability to disturbances) occur within the species' range (Conservation Data Centre 2008). About 24 of these 164 species are forest inhabitants and may overlap with some of the habitat characteristics of Dromedary Jumping-slug. Integrating Dromedary Jumping-slug habitat protection into measures that protect these additional species will allow for habitat connectivity and potential future habitat.

A vertebrate species listed by COSEWIC that may jointly benefit through habitat protection and stewardship activities for Dromedary Jumping-slug is the Red-legged Frog (*Rana aurora*) (Special Concern 2002).

Survey and habitat assessments for Dromedary Jumping-slug may increase knowledge about other gastropod species at risk within similar habitats and overlapping geographic range including:

- Puget Oregonian Snail (*Cryptomastix devia*) (COSEWIC Extirpated 2002). The two species overlap in their habitat use in the United States (Pilsbry 1940).
- Blue-grey Taildropper slug (*Prophysaon coeruleum*) (COSEWIC Endangered 2006), an older forest associate, which is known from only a few localities in Canada, all on southern Vancouver Island.
- Warty Jumping-slug (*Hemphillia glandulosa*) (COSEWIC Special Concern 2003), occurs in similar habitats as Dromedary Jumping-slug.

To date, research on Dromedary Jumping-slug has focused primarily on searching for and documenting new localities. Few researchers work on terrestrial gastropods in the province, and information for these species is often coupled into multi-species surveys.

Socioeconomic Considerations

Recovery of Dromedary Jumping-slug is not expected to have extensive socioeconomic implications. A detailed review of the socioeconomic considerations will be completed in the action plan for this species. Localized economic considerations involve forest harvesting within older-growth forests within the species' range, **although small patches of habitat (< 50 hectares) may be all that is necessary to conserve Dromedary Jumping-slug locations**. Potential long-term conflicts involve habitat conservation within areas where there have been extensive logging and historic land use activities that are incompatible with protection or recovery recommendations. Yet multiple species at risk occur within similar habitats to Dromedary Jumping-slug, and this gastropod can be incorporated into existing management for species that require larger scale habitats.

Habitat protection within certain locations may impact potential recreational opportunities. Southern Vancouver Island is widely used for recreation, particularly low-elevation areas that are easily accessible by foot and automobile. Activities such as horseback riding, mountain biking, all terrain vehicle use and high traffic hiking trails, have the potential to impact localized populations of Dromedary Jumping-slug. For example, the locations within Juan de Fuca Provincial Park and Pacific Rim National Park Reserve are both areas with intensive recreational use (from hiking) within some parts of the parks. Provincial and private forestlands may have localized areas where mountain biking and all terrain vehicle use is high.

Dromedary Jumping-slug, and gastropods in general, contribute to the natural capital of an ecosystem by building and maintaining healthy soil through dispersing mycorrhizal spores and thus promote healthy tree growth. This species is not known to have any commercial value. This species is a valuable endemic species to the pacific region of North America, and is part of the unique biodiversity in southern Vancouver Island and the province.

In the short-term, there are few anticipated conflicts with species-specific inventory and research activities. Protection of habitat at known sites and management of potential habitat within the range of the species may conflict with proposed logging. Consultation, cooperation, and negotiation with First Nations, protected area planners, industry, and local stewardship groups are to be important components in the recovery of Dromedary Jumping-slug. Incorporation of Dromedary Jumping-slug management into existing park plans and best management practices guidelines (preferably through inclusion into the existing draft best management practices guidelines for gastropods) are not expected to create conflict with interest groups.

Habitat protection for Dromedary Jumping-slug within watersheds and areas adjacent to important waterways will have benefits to drinking water protection, and maintenance of water quality for salmon and other aquatic species. The efficacy of intact forests contributes to water quality.

Garnering research interest is a potential challenge as there are currently few active researchers for gastropod species at risk.

Recommended Approach for Recovery Implementation

A multi-species approach to recovery is currently recommended for Dromedary Jumping-slug. Many recovery actions (such as survey requirements, habitat protection, and public outreach) are best carried out within the context of a multi-species approach. Action planning may be best approached through action plans specific to the jurisdiction that governs the specific location, such as those management activities addressed through a park management plan.

Currently, no additional COSEWIC-listed gastropods are known to overlap entirely with the same habitat types as Dromedary Jumping-slug. However, recovery objectives, such as public education and inventory efforts can be integrated with other gastropods at risk. COSEWIC-listed gastropods with similar and partially overlapping habitat types include the Puget Oregonian Snail (*Cryptomastix devia*), which has been designated as Extirpated, but may still occur in remnant habitat patches. This species is considered an old-growth specialist, but inhabits mixed-wood and deciduous forests rather than purely coniferous forests. The Warty Jumping-slug (*Hemphillia glandulosa*) has been designated as Special Concern and overlaps in range with Dromedary Jumping-slug; the two species were found in the same habitat at two localities (Ovaska *et al.* 2001). The Endangered Oregon Forestsnail (*Allogona townsendiana)* occupies low-elevation habitats dissimilar to those of Dromedary Jumping-slug. An opportunity exists to integrate future recovery activities with the Blue-grey Taildropper slug (*Prophysaon coeruleum*), which is COSEWIC Endangered.

Inventories and threat clarification can be approached using a multi-gastropod-species strategy. Stewardship and habitat protection can be carried out through a broader multi-species or ecosystem approach that could include other older forest associates, both invertebrates and vertebrates.

Statement on Action Plans

An action plan will be completed by March 2013. The action plan will likely be a multi-species document, as recovery actions are similar among multiple gastropod species at risk.

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