[PROPOSED]

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

Recovery Strategy for the Dromedary Jumping-slug in Canada

Dromedary Jumping-slug

September 2009

Parks Canada Parcs Canada

Canada

About the *Species at Risk Act* Recovery Strategy Series

What is the *Species at Risk Act* (SARA)?

SARA is the Act developed by the federal government as a key contribution to the common national effort to protect and conserve species at risk in Canada. SARA came into force in 2003, and one of its purposes is *"to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity."*

What is recovery?

In the context of species at risk conservation, 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 the species' persistence in the wild. A species will be considered recovered when its long-term persistence in the wild has been secured.

What is a recovery strategy?

A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets goals and objectives and identifies the main areas of activities to be undertaken. Detailed planning is done at the action plan stage.

Recovery strategy development is a commitment of all provinces and territories and of three federal agencies — Environment Canada, Parks Canada Agency, and Fisheries and Oceans Canada — under the Accord for the Protection of Species at Risk. Sections 37–46 of SARA (www.sararegistry.gc.ca/the_act/default_e.cfm) outline both the required content and the process for developing recovery strategies published in this series.

Depending on the status of the species and when it was assessed, a recovery strategy has to be developed within one to two years after the species is added to the List of Wildlife Species at Risk. Three to four years is allowed for those species that were automatically listed when SARA came into force.

What's next?

In most cases, one or more action plans will be developed to define and guide implementation of the recovery strategy. Nevertheless, directions set in the recovery strategy are sufficient to begin involving communities, land users, and conservationists in recovery implementation. Cost-effective measures to prevent the reduction or loss of the species should not be postponed for lack of full scientific certainty.

The series

This series presents the recovery strategies prepared or adopted by the federal government under SARA. New documents will be added regularly as species get listed and as strategies are updated.

To learn more

To learn more about the *Species at Risk Act* and recovery initiatives, please consult the SARA Public Registry (www.sararegistry.gc.ca/).

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

September 2009

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 provided the Recovery Strategy for Dromedary Jumping-slug (*Hemphillia dromedarius*) in British Columbia to the Government of Canada. The federal Minister of the Environment, as the competent minister under the *Species at Risk Act* (SARA), adopts this recovery strategy pursuant to Section 44 of SARA, with any exceptions or modifications as detailed within the body of this document.

Following the 60-day comment period starting in September 2009, and upon consideration of any comments received, the finalized recovery strategy, once included in the public registry, will be the SARA recovery strategy for this species.

The federal Minister of the Environment's recovery strategy for the Dromedary Jumping-slug consists of two parts:

1. The federal supplement to the provincial Strategy for the Dromedary Jumping-slug in Canada, and
2. The Recovery Strategy for Dromedary Jumping-slug prepared by the British Columbia Invertebrates Recovery Team for the Government of British Columbia (Appendix).

Recommended citation:

Parks Canada Agency. 2009. Recovery Strategy for Dromedary Jumping-slug (*Hemphillia dromedarius*) in Canada [Proposed]. *Species at Risk Act* Recovery Strategy Series. Parks Canada Agency. Ottawa. 8 + 39 pp.

Additional copies:

Additional copies can be downloaded from the SARA Public Registry (http://www.sararegistry.gc.ca/).

Cover illustration: Kristiina Ovaska

Également disponible en français sous le titre
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ISBN *To Come*
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DECLARATION

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. The *Species at Risk Act* (S.C. 2002, c.29) (SARA) requires that federal competent ministers prepare recovery strategies for listed Extirpated, Endangered and Threatened species. The Parks Canada Agency and Environment Canada are competent for the recovery of the Dromedary Jumping Slug.

The federal Minister of the Environment, as the competent minister under SARA, presents this document as the recovery strategy for the Dromedary Jumping-slug as required under SARA. It has been prepared in cooperation with the jurisdictions responsible for the species. The Minister invites other jurisdictions and organizations that may be involved in recovering the species to use this recovery strategy as advice to guide their actions.

The goals, objectives and recovery approaches identified in the strategy are based on the best existing knowledge and are subject to modifications resulting from new findings and revised objectives.

This recovery strategy will be the basis for one or more action plans that will provide details on specific recovery measures to be taken to support conservation and recovery of the species. Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the actions identified in this strategy. In the spirit of the *Accord for the Protection of Species at Risk*, all Canadians are invited to join in supporting and implementing this strategy for the benefit of the species and of Canadian society as a whole. The competent minister will report on progress within five years.

STRATEGIC ENVIRONMENTAL ASSESSMENT STATEMENT

A strategic environmental assessment (SEA) is conducted on all *Species at Risk Act* recovery strategies, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals* (2004). The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond their intended benefits. Environmental effects, including impacts to non-target species and the environment, were considered during recovery planning. The SEA is incorporated directly into the strategy and also summarized below.

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 (pg. 9) to the Dromedary Jumping-slug and its habitat as well as current knowledge gaps (pg. 14). Recovery objectives clearly focus on resolving these threats and filling information gaps. Recommended activities may also benefit non-target species and the environment (pg. 23).

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.

RESIDENCE

SARA defines residence as: *a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating* **[Subsection 2(1)]**.

Residence descriptions, or the rationale for why the residence concept does not apply to a given species, are posted on the SARA public registry: http://www.sararegistry.gc.ca/sar/recovery/residence_e.cfm.

CONTENT REQUIREMENTS FOR A SARA COMPLIANT RECOVERY PLANNING DOCUMENT

Socio-economic considerations

The Province of British Columbia's Recovery Strategy for Dromedary Jumping-slug (*Hemphillia dromedarius*) in British Columbia includes a section entitled, "Socio-economic Considerations." Although the strategy indicates that socio-economic impacts are not expected to be extensive, a formal evaluation of the socio-economic costs and benefits of recovery implementation has not yet been conducted, but will be included in one or more action plan(s) as required by SARA (section 49(e)).

Critical habitat

As required by SARA (section 41(1)), a recovery strategy must include an identification of the species' critical habitat, to the extent possible, based on the best available information. Examples of activities that are likely to result in its destruction must also be included. Critical habitat cannot be identified at this time due to inadequate information on life history requirements,

population sizes, distribution, area of occupancy, and specific habitat requirements at both the stand and microhabitat scale. In such cases, where available information is inadequate to identify critical habitat, SARA requires that a schedule of studies be included in the recovery strategy. A schedule of studies has been developed in the Recovery Strategy for Dromedary Jumping-slug (*Hemphillia dromedarius*) in British Columbia (see Table 5, Schedule of studies needed to identify critical habitat for Dromedary Jumping-slug; Appendix 1).

APPENDIX 1: RECOVERY STRATEGY FOR DROMEDARY JUMPING-SLUG (*HEMPHILLIA DROMEDARIUS*) IN BRITISH COLUMBIA

AS PROVIDED BY THE GOVERNMENT OF BRITISH COLUMBIA

British Columbia Invertebrates Recovery Team. 2008. Recovery strategy for Dromedary Jumping-slug (*Hemphillia dromedarius*) in British Columbia. Prepared for the B.C. Ministry of Environment, Victoria, B.C. 31 pp.

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

British Columbia Invertebrates Recovery Team. 2008. Recovery strategy for Dromedary Jumping-slug (*Hemphillia dromedarius*) in British Columbia. Prepared for the B.C. Ministry of Environment, Victoria, BC. 30 pp.

Cover illustration/photograph

Kristiina Ovaska

Additional copies

Additional copies can be downloaded from the B.C. Ministry of Environment Recovery Planning webpage at:

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

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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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RESPONSIBLE JURISDICTIONS

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.

ACKNOWLEDGEMENTS

Scientific review was completed by Kristiina Ovaska and Lennart Sopuck of Biolinx Environmental Research Ltd. Kristiina Ovaska and Lennart Sopuck have both contributed data and scientific expertise to this recovery strategy, and their collective and independent research on Dromedary Jumping-slug and other gastropods is vital to these species' recovery in British Columbia. Additional reviews were completed by Patrick Daigle, Brenda Costanzo, Jenny Feick, Jeff Brown, and Ted Lea (British Columbia Ministry of Environment, Ecosystems Branch); Conan Webb (Parks Canada Agency); Blair Hammond and Lucy Reiss (Canadian Wildlife Service, Environment Canada); Louise Blight; Robert Cannings; Robb Bennett, and Laura Byrne.

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[1] 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.

The recovery goal is to ensure the long-term survival of Dromedary Jumping-slug by maintaining a connected network[2] of protected[3] locations and habitats at the current

[1] **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).

[2] 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.

[3] 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.

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.

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BACKGROUND

Species Assessment Information from COSEWIC

Date of Assessment: April 2003
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[4] 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).

[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).

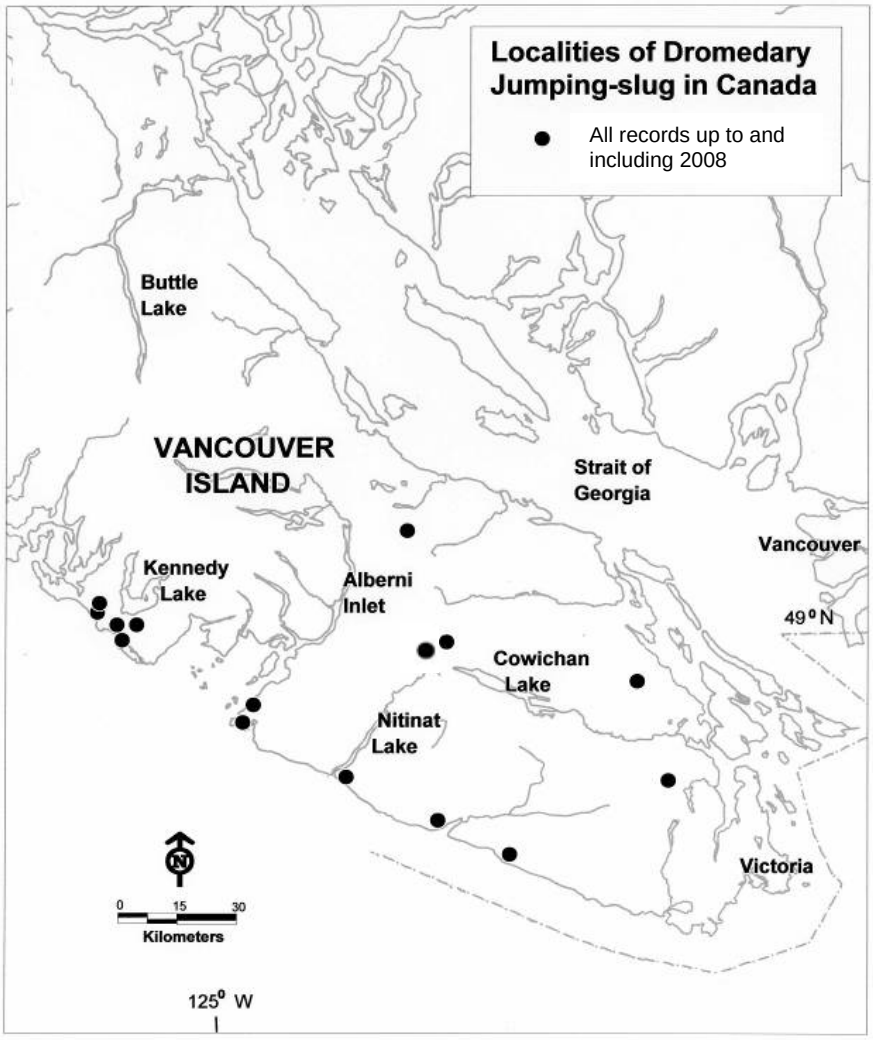

Figure 2. Canadian distribution of Dromedary Jumping-slug showing the 15 known locations for the species. Broken line: Canada–U.S. border.

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 Park Reserve	2004	Parks Canada Agency; Federal	10	1 (Ovaska and Sopuck 2005)	Older second-growth cedar–hemlock coastal forest near Clo-oose on West Coast Trail	50+
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	2006	Parks	20	N/A	Old-growth cedar–hemlock	50+

Location no.	Location name	Year	Land tenure	Elev. (m)	Number of individuals observed	Description	Area (ha)**
	National Park Reserve		Canada Agency; Federal			coastal forest along Keeha Beach Trail near Cape Beale	
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 threat	Roadside vegetation management and maintenance	**Occurrence**	medium	medium
		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[5] of protected[6] 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.

[5] 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.

[6] 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.

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.

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

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; 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.
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.

Priority	Objective	Specific steps	Anticipated effect
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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