COSEWIC
Assessment and Status Report

on the

Haida Gwaii Slug
Staala gwaii

in Canada

SPECIAL CONCERN
2013

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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For additional copies contact:

COSEWIC Secretariat
c/o Canadian Wildlife Service
Environment Canada
Ottawa, ON
K1A 0H3

Tel.: 819-953-3215
Fax: 819-994-3684
E-mail: COSEWIC/COSEPAC@ec.gc.ca
http://www.cosewic.gc.ca

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Haida Gwaii Slug — Photo by K. Ovaska.

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COSEWIC
Assessment Summary

Assessment Summary – May 2013

Common name
Haida Gwaii Slug

Scientific name
Staala gwaii

Status
Special Concern

Reason for designation
This small slug is a relict of unglaciated refugia on Haida Gwaii and on the Brooks Peninsula of northwestern Vancouver Island. It represents a recently described species and genus, and is found nowhere else in the world. It lives mostly in cool, moist microhabitats in the subalpine zone, but it has also been found in a few forested sites. Grazing and browsing by introduced deer on Haida Gwaii have greatly modified the species' habitat and have probably reduced its population; this grazing is apparently increasing at higher elevations. Climate change also threatens to reduce the extent of the slug's preferred subalpine habitat.

Occurrence
British Columbia

Status history
Designated Special Concern in May 2013.

COSEWIC
Executive Summary

Haida Gwaii Slug
Staala gwaii

Wildlife Species Description and Significance

The Haida Gwaii Slug (*Staala gwaii*) was discovered in 2003 in Haida Gwaii (Queen Charlotte Islands) and has subsequently been found also on Brooks Peninsula, Vancouver Island, British Columbia. Both areas harbour unique ecosystems and contain many rare species and subspecies as a result of the glacial history of the islands. The Haida Gwaii Slug is the only known terrestrial gastropod in western North America that is a relic of pre-glaciation times and has not expanded its range outside restricted areas. This small slug with adult size of only 1 – 2 cm has a distinctive appearance. The mantle is raised into a pronounced hump, and the entire body, including the tail, neck and mantle, is covered with small, often black-tipped projections or papillae. The colour ranges from jet black to grey or tan; darker mottling is often present on the mantle.

Distribution

The Haida Gwaii Slug is known from Moresby and Graham islands, the two main islands of the Haida Gwaii archipelago, and from Brooks Peninsula on northwestern Vancouver Island. In Haida Gwaii, there are records from 11 sites, which may represent six populations, three on each island. Much of the potentially suitable habitat on the islands, especially in alpine – subalpine areas and montane forests, has not been surveyed for gastropods, and additional sites and populations probably exist.

Habitat

The slugs are found most commonly in open, subalpine-type habitats with krummholtz formations. The habitat is characterized by scattered stunted trees, swales of low shrubs and grasses, and near-saturated ground, often with a moss cover. The slugs also occur in higher elevation forests but have been found only sporadically in lowland forests in Haida Gwaii, where most search effort has taken place. Humid microhabitat conditions, together with coarse woody debris, rocks, or a deep moss mat that provide cover from predators and harsh conditions, are thought to be important habitat features.

Biology

The life history and habits of the Haida Gwaii Slug are poorly known. Very small, recently hatched juveniles have been found from July – September, and adults appear in the samples in autumn. The generation time is probably 1 year. The slugs are poor dispersers, as shown by their extremely patchy distribution in lowland forests in Haida Gwaii. Their patchy distribution may also be indicative of their inability to persist in areas that contain a relatively high diversity of invertebrate predators and competitors, including other gastropods.

Population Sizes and Trends

Population sizes and trends are unknown. The slugs were readily found in subalpine and alpine habitats on Moresby Island, suggesting relatively high abundance. The Alpine Tundra and adjacent Mountain Hemlock biogeoclimatic zone, however, together consist of only 6% of the land area of the archipelago. In Haida Gwaii, the species has been found only rarely and in low numbers in the coastal Western Hemlock biogeoclimatic zone, which covers much of the islands.

Threats and Limiting Factors

The Haida Gwaii Slug is associated with cool, moist microhabitats and may be particularly sensitive to modifications in temperature and moisture regimes. The main threats to this species are predicted to stem from climate change and in Haida Gwaii, habitat alteration from browsing by introduced Sitka Black-tailed Deer. Logging is a threat at some sites on Graham Island. Climate change is predicted to result in habitat loss and alteration in alpine-subalpine habitats, where two-thirds of known sites for the species are located, as the tree line moves upwards. Alpine and subalpine zones in Haida Gwaii and Brooks Peninsula occur at relatively low elevations and would therefore experience rapid shrinking. Introduced deer occur throughout Haida Gwaii, including alpine-subalpine areas, and have profoundly altered understory vegetation, but their specific effects on this slug have not yet been measured. Deer browsing can decrease litter accumulation and increase exposure of the ground to sun and wind, resulting in lower humidity in micro-sites used by the slugs. Depressed abundance of terrestrial gastropods in response to ungulate browsing has been documented on small outer islands of Haida Gwaii and in northern Europe.

Protection, Status, and Ranks

As of May 2013, the Haida Gwaii Slug has no legal protection or status under the federal *Species at Risk Act*, BC *Wildlife Act*, or other legislation. In British Columbia, it is on the provincial Blue-list of species at risk.

On Vancouver Island, the Haida Gwaii Slug occurs in Brooks Peninsula Provincial Park. Haida Gwaii contains large tracts of protected areas, including Gwaii Haanas National Park Reserve and Haida Heritage Site on Moresby Island, which encompasses six of 11 known sites of the Haida Gwaii Slug on the archipelago. The remaining five sites in Haida Gwaii are on BC Crown lands on Graham Island. The Duu Guusd Heritage Site/Conservancy protects a large area in northwestern Graham Island but has not been surveyed for gastropods. Legal establishment of land use objectives through the *Haida Gwaii Land Use Objectives Order* in December 2010 includes ecosystem-based management on forestry lands. The implementation of the Order may benefit the Haida Gwaii Slug through objectives for Biodiversity and Wildlife and through objectives pertaining to riparian zone and watershed protection under Aquatic Habitat.

TECHNICAL SUMMARY

Staala gwaii
Haida Gwaii Slug Limace de Haida Gwaii
Range of occurrence in Canada (province/territory/ocean): British Columbia

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2008) is being used)	Approx. 1 year
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? -Projected decline is possible based on habitat trends and predictions.	Unknown but possible
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased? Causes for decline in habitat not reversible, not ceased but perhaps understood; unknown decline in number of mature individuals.	No
Are there extreme fluctuations in number of mature individuals?	Unknown but unlikely

Extent and Occupancy Information

Estimated extent of occurrence	16,262 km² (including ocean)
Index of area of occupancy (IAO) (Always report 2x2 grid value). The discrete IAO, based on 2 km x 2 km grid cells placed on known occurrences is 52 km², of which 8 km² (2 grid cells) are on Brooks Peninsula; however, additional suitable but unsurveyed habitat exists. If continuous stretches of alpine-subalpine areas between observations in Haida Gwaii are included, then the IAO in Haida Gwaii is 284 km² while the IAO overlapping potential habitat on the Brooks Peninsula is 96 km^2 (calculated by Jenny Wu, COSEWIC Secretariat). See text for further discussion.	52 km² (discrete) 380 km² (continuous IAO in Haida Gwaii and potential habitat on Brooks Peninsula)
Is the total population severely fragmented?	Probably not
Number of locations∗ Uncertain but likely > 10 based on the threats of climate change and grazing and browsing by introduced deer.	Likely > 10
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	Unknown

∗ See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy? -projected decline possible based on habitat trends	Unknown
Is there an [observed, inferred, or projected] continuing decline in number of populations?	Unknown
Is there an [observed, inferred, or projected] continuing decline in number of locations*?	Unknown
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat? -An observed, inferred and projected decline in area, extent and quality of habitat	Yes
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations∗?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Total	Unknown

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Not done

Threats (actual or imminent, to populations or habitats)

-Climate change and associated shifts in habitats and ecosystems, particularly those in subalpine and alpine areas
-Introduced Sitka Black-tailed Deer, which are modifying habitats, including microhabitats in the litter layer, through their browsing across Haida Gwaii
-Logging on Graham and northern Moresby islands

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? NA, endemic to Haida Gwaii	
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	NA
Is there sufficient habitat for immigrants in Canada?	Unknown
Is rescue from outside populations likely?	**No**

Data Sensitive Species

Is this a data-sensitive species?
No

Status History

Designated Special Concern in May 2013.

∗ See Definitions and Abbreviations on COSEWIC website and IUCN 2010 for more information on this term.

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Special Concern	not applicable

Reasons for designation:
This small slug is a relict of unglaciated refugia on Haida Gwaii and on the Brooks Peninsula of northwestern Vancouver Island. It represents a recently described species and genus, and is found nowhere else in the world. It lives mostly in cool, moist microhabitats in the subalpine zone, but it has also been found in a few forested sites. Grazing and browsing by introduced deer on Haida Gwaii have greatly modified the species' habitat and have probably reduced its population; this grazing is apparently increasing at higher elevations. Climate change also threatens to reduce the extent of the slug's preferred subalpine habitat.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Number of mature individuals is unknown.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. Although the EO (16,262 km^2) is below the threshold for Threatened (<20,000 km^2), the IAO (380 km^2) is below the threshold for Endangered under B2 (500 km^2) and the area, extent, and quality of habitat continues to decline, there is insufficient information to determine if the species is severely fragmented, and the actual number of locations is likely greater than 10.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Number of mature individuals is unknown.
Criterion D (Very Small or Restricted Total Population): Not applicable as number of mature individuals is unknown. Threatened D2 also is not applicable because the number of locations most likely exceeds the typical threshold of 5 or fewer and the effects of the threat from climate change will not occur within a short time frame.
Criterion E (Quantitative Analysis): Not applicable as analyses have not been done.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2013)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune
Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

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Haida Gwaii Slug
Staala gwaii

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2013

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

The Haida Gwaii Slug (*Staala gwaii*) was first documented in 2003 from Haida Gwaii (Queen Charlotte Islands). It was formally described only recently (Ovaska *et al*. 2010) but is of ancient origin and appears to have survived periods of glaciation in ice-free refugia. It is the only member of its genus. Currently, it is placed in the large, cosmopolitan family Arionidae. However, ongoing genetic studies do not support the monophyly of Arionidae as currently known (Backeljau pers. comm. 2011).

The classification of the species is as follows: Phylum Mollusca, Class Gastropoda, Subclass Orthogastropoda, Order Pulmonata, Suborder Eupulmonata, Infraorder Stylommatophora, Superfamily Arionoidea, Family Arionidae, Genus *Staala,* Species *S. gwaii*. The scientific name of the species means “island slug” in the Haida language (Xaayda kil). According to the ATK report (ATK Subcommittee 2011), spelling of “slug” would be St’aalaay or St’aall and that of “island” Gwaay. The French translation of the English common name is “limace de Haida Gwaii”

Morphological Description

The Haida Gwaii Slug is a small slug with adult body size 8 – 17 mm in length when the animal is extended (Ovaska *et al*. 2010). The large mantle extends over approximately two-thirds of the body length and covers the visceral pouch, which is elevated into a pronounced hump (Figure 1). There is a dome-shaped calcareous shell-plate that is completely covered by the mantle. The pneumostome (opening to the lung) is slightly anterior to the mid-line of the mantle and near the mantle margin. The tail is flattened and lacks a keel. The entire body of the slug, including head, tail, and mantle, is covered with numerous papillae, which are often black-tipped. The overall colour ranges from jet black to grey or tan; darker mottling on the mantle is often present on lighter individuals. The sole of the foot is undivided.

Figure 1. Haida Gwaii Slug; adults ca. 15 mm in length. Photos by K. Ovaska.

The Haida Gwaii Slug can be distinguished easily from the Meadow Slug (*Deroceras laeve*), another dark, small slug that occurs in Haida Gwaii, by the presence of a mantle hump and papillae, lack of a “fingerprint” pattern of concentric circles on the mantle, and pneumostome that is anterior rather than posterior to the mid-line of the mantle. The Haida Gwaii Slug superficially resembles small jumping-slugs (*Hemphillia glandulosa* = Warty Jumping-slug and *H. burringtoni* = Keeled Jumping-slug, not recorded from Haida Gwaii), but can be distinguished by lack of a slit in the mantle through which the shell plate is visible in all jumping-slugs and papillae that cover the entire body, not just the mantle.

Population Spatial Structure and Variability

The Haida Gwaii Slug is known from 11 sites on two islands (Graham and Moresby) of the Haida Gwaii archipelago, representing at least six populations (see **Canadian Range**). An additional, isolated population is on Brooks Peninsula, Vancouver Island. Poor dispersal ability of the slugs, coupled with fragmented habitat, suggests isolation of populations both between and within islands, but few data are available. Genetic structure of populations is unknown, but preliminary mitochondrial DNA analysis of a small number of specimens suggests that slugs from Graham and Moresby islands may have diverged (Wilke pers. comm. 2005).

Designatable Units

Presently, there is no evidence for more than only one designatable unit. There are no significant morphological or anatomical differences of the slugs from Graham and Moresby islands, although preliminary data suggest some genetic differentiation. Slugs from Brooks Peninsula, Vancouver Island, are similar to those from Haida Gwaii in appearance, but dissections or genetic analyses to compare them with slugs from Haida Gwaii have not been performed.

Special Significance

The Haida Gwaii Slug is part of the unique fauna and flora of the Haida Gwaii archipelago, which contains many endemic species and subspecies. It is one of only a few molluscs endemic to northern areas, and its entire distribution is within Canada. It is the only terrestrial gastropod in western North America that is a relic of pre-glaciation times and has not expanded its range outside restricted areas. The slug is of scientific interest for the study of glacial history, as it probably survived glacial periods in ice-free refugia, and of the phylogeography and origin of western North American slugs.

An Aboriginal Traditional Knowledge (ATK) Source Report was prepared for the species (ATK Subcommittee 2011). No cultural significance was identified, no other ATK was found for the species, and habitat trends were not addressed.

DISTRIBUTION

Global Range

The global distribution of the Haida Gwaii Slug is confined to British Columbia, where the species is known only from the Haida Gwaii archipelago (Queen Charlotte Islands) and from northwest Vancouver Island (Figure 2).

Figure 2. Global and Canadian distribution of the Haida Gwaii Slug.

Canadian Range

In Haida Gwaii, the species occurs on Graham and Moresby islands, the two largest islands of the archipelago (Figure 3). There are records from five sites on Graham Island and six sites on Moresby Island (Table 1). These sites are deemed to represent six populations, based on habitat connectivity and distance, with Sites 1, 2 – 3, Sites 4 – 5, Sites 6 – 9, Site 10, and Site 11 in Figure 3 each representing a separate population (Table 1). Habitat connectivity was the criterion used to group most of the sites; the subalpine populations were separated from other sites by expanses of lowland. Two sites within approximately 2 km from each other and on the same mountain but in different habitats were grouped together as one population (Sites 4 and 5). The two lowland forest sites were on separate islands, and also considered different populations. Undocumented sites probably exist, as survey coverage is incomplete and the slugs can easily be overlooked.

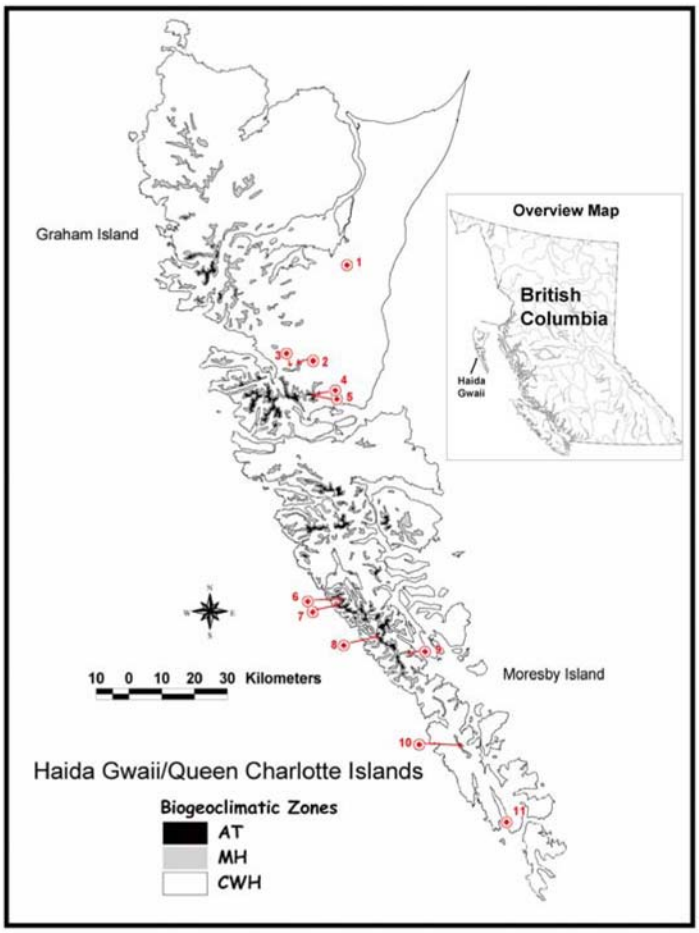

Figure 3. Global distribution of the Haida Gwaii Slug in Haida Gwaii, British Columbia. Red symbols indicate sites where the species has been found with site numbers corresponding to those in Table 1. AT – Alpine Tundra; MH – Mountain Hemlock; CWH – Coastal Western Hemlock. Mapping by Lennart Sopuck on basemap prepared by Alvin Cober.

Table 1. Records of Haida Gwaii Slug from British Columbia, including assignments to sites and putative populations. Rows for sites assigned to the same population are similarly shaded.

Population	Site #	Site name	Elev. (m)	Date(s)	# slugs	Habitat	Survey method and effort	Collector/ observer
Queen Charlotte Lowlands	1	Experimental forestry site (Hoodoo site; Plots a - e), South of Port Clements, Graham Island	65 – 80	27 July - 8 Oct 2002	8	Mature second-growth coniferous forest (naturally regenerated with patches of old growth); pre-logging: found in 6 plots, including 2 plots slated for logging.	Cardboard cover-object inspections (20 plots; 800 covers inspected 4 times)	K. Ovaska, L. Sopuck, L. Hyatt, J. Gray, C. Engelstoft
Queen Charlotte Lowlands	1	As above	65 – 80	28 Sept - 1 Nov 2006	7	As above; post-logging; found in 4 plots: uncut control (1 plot) and tree retention patches (3 plots), but not in clearcut plots.	Cardboard cover-object inspections (20 plots; 800 covers inspected 3 times)	K. Ovaska, L. Sopuck, L. Hyatt, J. Gray, C. Engelstoft
Rennell Ridge	2	Rennell Sound (Site 3), Graham Island	260	17-Nov-03	3	Old growth forest with Western Redcedar and Western Hemlock and an understory of Huckleberry	Cardboard cover-object inspection (20 covers)	J. Gray
Rennell Ridge	3	Rennell Sound (Site 4), Graham Island	260	17-Nov-03	2	Old growth forest with Sitka Spruce and Western Hemlock and an understory of Huckleberry	Cardboard cover-object inspection (20 covers)	J. Gray
Mt. Genevieve	4	Mt. Genevieve (mid-slope, start of trail), Graham Island	340	29-Oct-03	4	Old growth forest with Western Hemlock and Western Redcedar and an understory of Huckleberry	Cardboard cover-object inspection (20 covers inspected twice)	J. Gray
Mt. Genevieve	4	As above	340	22-Sep-04	6	Old growth forest with Western Hemlock and Western Redcedar and an understory of Huckleberry	Cardboard cover-object inspection (20 covers); 30 min search of forest floor	K. Ovaska, L. Sopuck, B. Wijdeven
Mt. Genevieve	5	Mt. Genevieve (near top), Graham Island	853	16-Oct-02	1	Alpine meadow with ground cover of heather, grass, and moss	Cardboard cover-object inspection	L. Hyatt
San Christoval	6	Mt. Oliver, Moresby Island	650	14-Sep-04	3	Subalpine habitat with stunted trees and swales of grasses, heather, crowberry; very moist; slugs found under stick, in grass on krummholtz under junipers & on dead herbaceous plant.	Time-constrained search (118 person-min)	K. Ovaska, L. Sopuck

Population	Site #	Site name	Elev. (m)	Date(s)	# slugs	Habitat	Survey method and effort	Collector/ observer
San Christoval	7	Mt. De La Touche, Moresby Island	700	14-Sep-04	1	Subalpine habitat with stunted trees and swales of grasses, heather, crowberry; very moist; found under rock on grassy slope	Time-constrained search (68 person-min)	K. Ovaska, L. Sopuck
San Christoval	8	Unnamed mountain near Sunday Inlet, Moresby Island	475	14-Sep-04	3	Subalpine habitat with stunted trees, swales of grasses, heather, crowberry; very moist; slugs found within crowberry/grass mat on krummholtz and under rock	Time-constrained search (64 person-min)	K. Ovaska, L. Sopuck
San Christoval	9	Unnamed mountain near Kostan Inlet, Moresby Island	285	14-Sep-04	1	Subalpine habitat with stunted trees and swales of grasses, heather, crowberry; very moist; slug found under rock on seepage slope	Time-constrained search (118 person-min)	K. Ovaska, L. Sopuck
Mt. Yatza	10a	Mt. Yatza (Site 1), Moresby Island	170	14-Sep-03	5	Subalpine meadow; scattered stunted trees (Shorepine, Mountain Hemlock, Red Cedar); most slugs found under rocks but a small juvenile within moss	Time-constrained search (60 person-min)	K. Ovaska, L. Sopuck
Mt. Yatza	10b	Mt. Yatza (Site 2), Moresby Island	210	14-Sep-03	2	Subalpine meadow; scattered stunted trees (Shorepine, Mountain Hemlock, Red Cedar); grass & moss ground cover; slugs found under rocks.	Time-constrained search (40 person-min)	K. Ovaska, L. Sopuck
Louscoone Inlet	11	Louscoone Inlet, Moresby Island	<50	17-Sep-04	1	Transition zone coniferous forest with Sitka Spruce, Yellow Cedar, Western Redcedar, Western Hemlock, and Shore Pine; understory of Huckleberry (red) and False Azalea (ca. 30% coverage) and scattered Deer Fern; slug found on underside of fallen salal leaf along bank of small creek.	Time-constrained search (2 plots; 148 person-min)	K. Ovaska, L. Sopuck

Population	Site #	Site name	Elev. (m)	Date(s)	# slugs	Habitat	Survey method and effort	Collector/ observer
Brooks Peninsula	12	Brooks Peninsula (SW ridge)	300-450	26-27-Aug-12	9	Windswept ridge with krummholtz formations; moist depressions with stunted Mountain Hemlock and Yellow Cedar (from <1 m to 5 m tall), shrubs (Salal, False Azalea, Salmonberry, Blueberry); decomposing wood (Hemlock branches) and moss.	Time-constrained search (4 plots; 534 person-min)	K. Ovaska and L. Sopuck with assistance from J. Heron and E. McClaren

In August 2012, as part of fieldwork for the preparation of this report, the Haida Gwaii Slug was searched for and found at four sites on Brooks Peninsula on northwestern Vancouver Island (Figure 4; Appendix 1). These sites are on the same ridge system and deemed to represent one population.

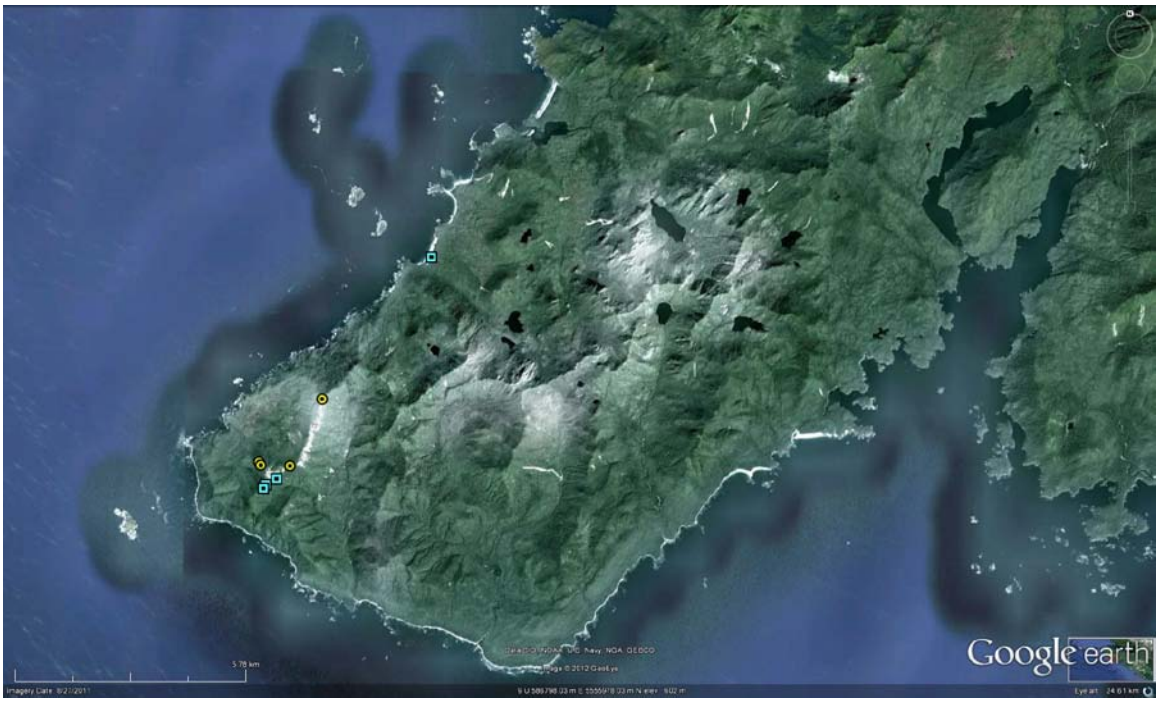

Figure 4. Sites where the Haida Gwaii Slug was found (yellow circles) and sites searched where it was not found (blue squares) on Brooks Peninsula, Vancouver Island, in August 2012. Note that the ridge on Brooks Peninsula was targeted for surveys, because of presumed glacial refugia there.

In subalpine habitats, the Haida Gwaii Slug co-occurs with several species of rare vascular plants that have disjunct or endemic distributions on the Pacific Northwest coast (Ovaska *et al.* 2010). Some plants that were initially thought to be endemic to Haida Gwaii have subsequently been found in isolated localities elsewhere on the outer coast, including Brooks Peninsula on Vancouver Island, suggesting survival in scattered glacial refugia on the northwest coast (Ogilvie 1989, 1994). Nine of 13 taxa of vascular plants previously considered to be endemic to Haida Gwaii have been found on the Brooks Peninsula and two of these, *Geum schofieldii* (red-listed in BC) and *Viola biflora* c*arlottae* (blue-listed), do not occur elsewhere in BC (Ogilvie 1997).

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EO) of the Haida Gwaii Slug is 16,262 km^2, based on the minimum polygon method including the area of Pacific Ocean between Haida Gwaii and the Brooks Peninsula. The EO excluding the ocean is 3,453 km^2. The index of area of Occupancy is 52 km^2, based on 11 occupied 2 km x 2 km grid cells in Haida Gwaii and two cells on Brooks Peninsula (discrete IAO). Many areas of potentially suitable habitat, particularly in subalpine and alpine zones that are logistically difficult to access, have not been surveyed for the species. These habitats are most continuous in northern Moresby Island, but smaller patches are scattered elsewhere on both Moresby and Graham islands. If continuous stretches of alpine-subalpine areas between observations are included, then the IAO in Haida Gwaii is 284 km^2 (continuous IAO; calculated by Jenny Wu, COSEWIC Secretariat). Similarly, an additional 96 km^2 (24, 2 km x 2 km grid cells) of suitable habitat occurs on the Brooks Peninsula along the ridge where the slug was found. If it is assumed that the entire Alpine Tundra (101 km^2) and Mountain Hemlock (503 km^2) biogeoclimatic zones present in the Haida Gwaii archipelago are occupied by the species (see **Habitat Requirements**), which is almost certainly an over-estimate, then the IAO would be 612 km^2 (604 km^2 + 8 km^2 representing 2 known sites in Coastal Western Hemlock biogeoclimatic zone). It is also possible that other scattered sites exist in the Coastal Western Hemlock zone. However, the total actual IAO is unlikely to exceed 2000 km^2.

Search Effort

In British Columbia, surveys targeting terrestrial gastropods have focused largely to the southwest, including Vancouver Island; the central and north coast have received less survey effort (Appendix 2). On the mainland, R. Forsyth (pers. comm. 2011) carried out surveys in the Stikine – Kitimat and Skeena regional districts within the Pacific Maritime ecozone, as well as farther inland in the Montane Cordillera ecozone. Ovaska (unpubl. data) surveyed coastal sites in northern British Columbia and southeast Alaska, including Prince of Wales Island located immediately to the north of Haida Gwaii. Haida Gwaii and Prince of Wales Island and its associated outer islands have been considered the same biogeographic sub-region based on genetic relationships between some mammals from the two areas (Cook *et al.* 2006).

In Haida Gwaii, survey effort specifically targeting terrestrial gastropods includes surveys by R. and T. Forsyth (1995 – 2008) and those by Ovaska, Sopuck, and coworkers from Biolinx Environmental Research Ltd. (2000 – 2006) (Figure 5; Table 2). Most sites surveyed in 2003 and 2004 by Ovaska and Sopuck (2005) specifically targeted habitats deemed suitable for the Haida Gwaii Slug. Other workers have collected terrestrial gastropods as part of invertebrate surveys, including Heron and Copley (pers. comm. 2010, 2011), Allombert (Allombert *et al*. 2005), and Johnston (records in R. Forsyth's personal files). Most sites were visited only once. Two sites were surveyed intensively and repeatedly by Biolinx Environmental Research Ltd., including an approximately 100 ha experimental forestry site near Port Clements, where the species was found (see **Sampling Effort and Methods**), and a Department of National Defence property near Masset, where the species was not found.

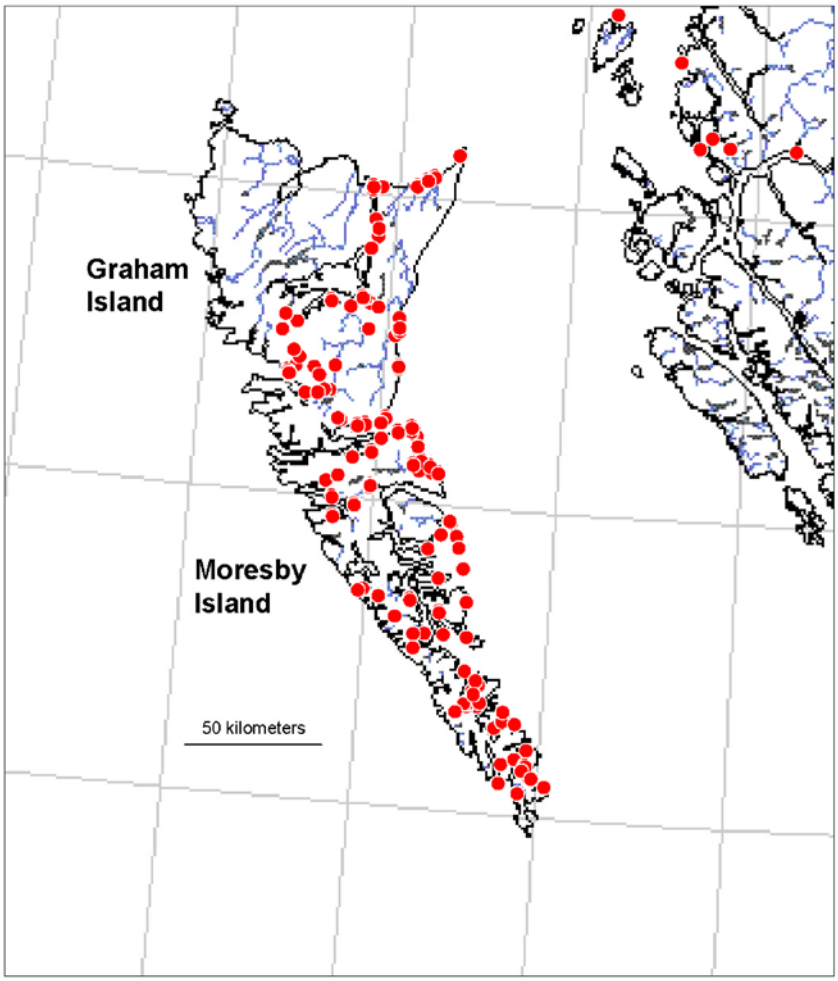

Figure 5. Search effort (red dots) for terrestrial gastropods in Haida Gwaii. Mapping by L. Sopuck based on data from surveys conducted by R. and T. Forsyth (1995 – 2008), K. Ovaska, L. Sopuck, and coworkers from Biolinx Environmental Research Ltd. (2000 – 2006), C. Copley (pers. comm. 2010, 2011), S. Allombert (Allombert *et al*. 2005), and B. Johnston (records in R. Forsyth's personal files).

Table 2. Summary of survey effort in Haida Gwaii, 1995 - 2010.

Year(s)	Month(s)	Island	No. of sites searched	Collection method	Index of search effort	Observer/ collector	Source
2006	July	Moresby	5		Unknown	Barb Johnston	R. Forsyth data files
1997 - 2008	May, June, Sept	Moresby	18	Hand	Unknown	Robert/Tammy Forsyth	R. Forsyth data files
1995 - 2008	May, June	Graham	22	Hand	Unknown	Robert/Tammy Forsyth	R. Forsyth data files
1999 - 2001	?	Islands in Laskeek Bay	6*	Pitfall trapping	Unknown	Sylvain Allombert	Allombert *et al*. (2005); Ovaska and Sopuck (2005)
2000 - 2004	Apr, Sept	Moresby	22**	Hand; cardboard cover-objects	32 person-hours; 20 cover-objects on 1 plot checked once	Biolinx Environmental Research Ltd.	Ovaska and Sopuck (2005); RBCM (2010)
2000 - 2006	Apr, July, Aug, Sept, Oct, Nov	Graham	20**	Hand; cardboard cover-objects	24 person-hours; 1052 cover-objects on 35 plots checked repeatedly.	Biolinx Environmental Research Ltd.	Ovaska and Sopuck (2005); RBCM (2010)
2003 - 2004	Sept	11 small islands adjacent to Moresby: Lyell, Kunghit, Burnaby, Tanu, Huxley, SGang Gwaay, Kat, Bischofs, Hotspring, Ellen, and Slug Islet	14**	Hand	28 person-hours	Biolinx Environmental Research Ltd.	Ovaska and Sopuck (2005); RBCM (2010)
2010	July	Graham & Moresby	16	Hand & pitfall traps	Unknown	Claudia Copley, Jennifer Heron & co-workers	Copley pers. comm. 2010

*Number of small offshore islands surveyed (Allombert *et al.* 2005)

**Several sites included two or more sub-sites (see RBCM 2010 for details of the sites). Survey plots that were within < 2 km from each other were considered the same site, unless they were in different habitats, in which case they were counted as separate sites.

Much of Haida Gwaii is rugged and logistically difficult to access. As a result, most surveys have focused on areas accessible by vehicle or boat. Montane areas and the remote west coast of both Graham and Moresby islands have received limited survey effort. With assistance from Parks Canada, Ovaska and Sopuck (2005) were able to access several mountain-top sites on Moresby Island by helicopter on 14 September 2004; many of the Moresby Island sites for the Haida Gwaii Slug in Table 1 were found during that survey.

During the preparation of this status report, with generous support from BC Ministry of Environment, BC Parks and Royal BC Museum, an expedition was mounted to Brooks Peninsula on northwestern Vancouver Island, where a glacial refuge exists. One of the target species was the Haida Gwaii Slug, which was found at four of seven sites surveyed along a ridge in krummholtz habitats. It was not found at four sites in lowland forest during the same surveys; nor was it found at other forested sites on northern Vancouver Island during previous surveys, including an intensively monitored experimental forestry site near Port McNeill.

HABITAT

Habitat Requirements

The Haida Gwaii Slug has been found in shaded, moist forests and in open-canopy subalpine-type habitats and krummholtz formations. Limited surveys at higher elevations suggest that the slugs are most common in open, subalpine-type habitats, characterized by scattered, stunted trees, swales of low shrubs and grasses, and near-saturated ground often with a moss cover. In Haida Gwaii, these habitats can occur as low as approximately 200 m asl (above sea-level), as on Yatza Mountain where the species has been found (Ovaska and Sopuck 2005), but more typically occur at elevations of 600 – 800 m asl (Haida Gwaii/Queen Charlotte Islands Land Use Plan 2003). In forested habitats, the slugs have been found in higher elevation forests with Yellow Cedar (*Cupressus nootkatensis*) and Mountain Hemlock (*Tsuga mertensiana*), as well as in lowland coastal forests dominated by Western Hemlock (*Tsuga heterophylla*), Sitka Spruce (*Picea sitchensis*), and Western Redcedar (*Thuja plicata*). However, the species has been found only rarely in lowland forests, where survey effort has been most extensive (Figure 6). More survey effort is needed especially in mid- to high-elevation forests to assess the relative use of these habitats by the species.

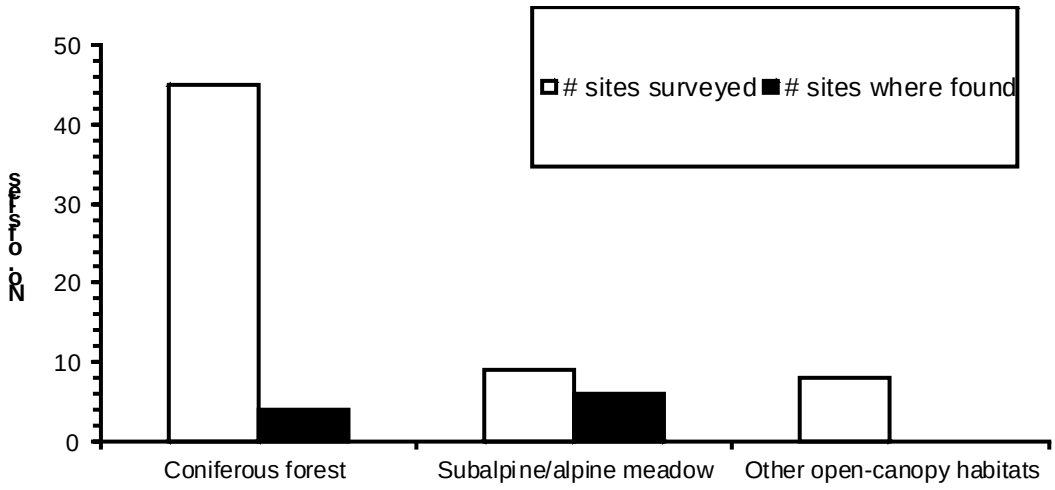

Figure 6. Frequency of detection of Haida Gwaii Slug in conifer stands, subalpine meadows, and other open canopy habitats based on surveys by Ovaska and Sopuck (2005) in Haida Gwaii from 2000 – 2006. Other open canopy habitats consisted of thermal meadows, old-field, bog forest, and grassy bluff.

In Haida Gwaii, the slug has been found at elevations from approximately 50 m to 850 m asl and in all three biogeoclimatic zones (Meidinger and Pojar 1991) present on the islands: Coastal Western Hemlock (CWH) in the lowlands, Mountain Hemlock (MH) at higher elevations, and non-forested Alpine Tundra (AT) at highest elevations. However, only two of 11 sites (Sites 1 and 11) are within the CWH zone, which covers 94% of the islands and where most surveys have been carried out, while the remaining sites are in the MH and AT zones, which cover approximately 5% and 1% of the islands, respectively (percentages from Haida Gwaii/Queen Charlotte Islands Land Use Plan 2003). Thus, the area of the MH and AT zones, respectively, is 503 km^2 and 101 km^2 of a total land area of the archipelago of 1,005,056 ha.

On Vancouver Island, the Haida Gwaii Slug was found at elevations of 300 – 450 m on a rugged ridge top on Brooks Peninsula in krummholtz habitat. The habitat is similar to subalpine habitats of the species in Haida Gwaii.

Very moist microhabitat conditions, together with cover from predators and elements, are probably important habitat requirements for the species. Suitable cover appears to consist of abundant, layered coarse woody debris at forested sites and partially embedded rocks at subalpine sites. The slugs have been found also within moss mats at several sites.

Habitat Trends

Since European settlement, natural vegetation of Haida Gwaii has been greatly modified by three main factors (Pojar 2008): post-industrial human population expansion, forestry, and browsing by the introduced Sitka Black-tailed Deer (*Odocoileus hemionus sitkensis*). Climate change is another factor that is predicted to alter habitats and ecosystems. The factors of greatest consequence for Haida Gwaii Slug habitats are browsing by deer and climate change, as both modify subalpine habitats occupied by the species.

The current human population of the islands is low and on the decline. It consists of approximately 5,000 residents, according to the Canada 2006 census, mostly concentrated in six communities on Graham Island and one on northern Moresby Island (Council of the Haida Nation, undated). There was no appreciable change in number of residents since the previous census in 2001. From 1981 – 2001, the total human population declined by approximately 12% (Haida Gwaii / Queen Charlotte Islands Land Use Plan 2003).

Forestry

Industrial logging, which began approximately 70 years ago, has had a major influence on forest habitats on Graham Island and northern Moresby Island by converting old-growth forest into structurally simpler younger forest stands, facilitating erosion and mass wasting of mountain slopes, and by fragmenting habitats (Haida Gwaii / Queen Charlotte Islands Land Use Plan 2003). Initially, logging focused on easily accessible lowlands, such as the Skidegate Plateau, but as larger trees were depleted, forestry operations shifted increasingly to steeper slopes, a trend that continues today. Harvesting of naturally regenerated second-growth and planned short rotations (60 – 80 years) are retarding recovery of old-growth conditions with unknown long-term effects on ecosystems. By the early 2000s, 17% of the total forested land base of 690,814 ha was at an early seral stage, 4% at a mid-seral stage or early mature forest, 15% mature forest, and 63% old growth forest (data current up to 1995 – 2001 for different tree farm licences; Table 32 in Haida Gwaii / Queen Charlotte Islands Land Use Plan 2003). Corresponding values, from young to old forest, were 4%, <1%, 16%, and 78% for the MH biogeoclimatic zone, and 25%, 2%, 12%, and 17% for the CWH zone. The MH zone still contains a significant amount of old growth forest, but the greatest potential for further logging is also in this zone. The annual rate of logging across the islands peaked in the 1980s but had slowed to about 60% of the peak values by 2004 (Gowgaia Institute 2007). The proportion of cedar taken has increased substantially as a result of selective targeting by the forest industry, and large cedars are rapidly being depleted from forestry lands (Gowgaia Institute 2007). The proportion of cedar (Western Redcedar and Yellow Cedar) taken from cutblocks will be regulated under Cultural Objectives of the *Haida Gwaii Land Use Objectives Order*, which was signed in December 2010 and came into effect in 2011 (Haida Gwaii Land Use Objectives Order 2010).

Significant areas of old growth forest are protected from logging, notably within the large Gwaii Haanas National Park Reserve and Haida Heritage Site on south Moresby Island. Duu Guusd Heritage Site/Conservancy protects a large area of land (143,596 ha) in northwestern Graham Island, including higher elevation habitats (elevation range: 0 – 865 m) (Council of the Haida Nation and BC Parks 2011).

Ecosystem Based Management, as per *Haida Gwaii Land Use Objectives Order* (2010) will guide the management of forest lands on the archipelago and is expected to increase protection and restore sustainable use of forest resources (see **Habitat Protection and Ownership**).

Introduced Deer

Repeated introductions of Sitka Black-tailed Deer to the islands took place from 1878 to 1925, and the species is now ubiquitous throughout the archipelago (Haida Gwaii / Queen Charlotte Islands Land Use Plan 2003; Golumbia *et al.* 2008). Through selective browsing, deer have greatly reduced understory density, altered understory composition, virtually eliminated some shrub and herbaceous plants, and retarded tree recruitment, particularly that of the Western Redcedar and Yellow Cedar (Pojar 2008). The depletion of understory vegetation has undoubtedly altered microclimates and food resources on the forest floor and potentially reduced available moist microsites for the Haida Gwaii Slug but the specific effects of the browsing and grazing on this slug have not yet been measured. Ungulate grazing has been shown to decrease gastropod abundance and diversity in northern Europe (Suominen 1999) and coastal forests in Haida Gwaii (Allombert *et al*. 2005; see **THREATS AND LIMITING FACTORS**).

Logging and the resulting increase in forage for deer in early seral stages has facilitated expansion of deer populations. Pojar (2008) noted that to date deer browsing appeared to have had lesser effects at higher elevations than in low elevation forests on the islands. However, he noted that adverse effects on vegetation in subalpine and alpine habitats seem to be increasing, probably as a result of expanding deer population or diminishing food supply at lower elevations. There is increasing pressure for deer to expand to higher elevations as forest in earlier logged-over areas matures and ceases to produce suitable forage. Deer browsing has been identified as a threat for endemic and rare plants at several higher elevation sites (Ogilvie 1994).

Climate Change

Climate change is predicted to profoundly alter ecosystems in BC by the end of the 21st century; some effects consistent with climate change have already been documented (Gayton 2008). Predicted changes in climate relevant to the Haida Gwaii Slug include: increase in average annual temperature by 1 – 4°C by the year 2100 with greatest and most rapid change in northern BC and in winter; increased annual precipitation, largely concentrated to winter months; decreased summer soil moisture; and substantial changes to hydrology (Gayton 2008).

Alpine ecosystems are deemed particularly at risk from climate change as the tree line shifts upwards (Hebda 1997; Krannitz and Kesting 1997; Gayton 2008). Predicted upward movement of the boundaries of the subalpine and alpine zones by 330 m – 660 m by the end of the 21st century would virtually eliminate some coastal alpine zones (Krannitz and Kesting 1997). Alpine and subalpine zones in Haida Gwaii occur at relatively low elevations and would therefore experience rapid shrinking. Conversely, other factors, such as possibly shorter snow-free growing period as a result of increased precipitation in winter and increased fire frequency in summer, could retard tree-line movement (Krannitz and Kesting 1997). However, regardless of the rate of tree-line shifts, changes are predicted to tree and ground cover plant species composition; in alpine areas, shrubs will become more dominant, whereas herbaceous plants will suffer (Krannitz and Kesting 1997). The Haida Gwaii Slug is most abundant and its distribution is most continuous in subalpine and alpine habitats, and it will probably be adversely affected both by predicted habitat shifts and increased competition and predation as ranges of forest invertebrates extend upwards. The Mountain Hemlock biogeoclimatic zone, also inhabited by the Haida Gwaii Slug, will similarly shrink as Western Hemlock stands expand upslope (Hebda 1997). Populations may decrease in size and become more isolated, if the slugs are forced to retreat to remaining suitable habitats in higher elevations.

BIOLOGY

Life Cycle and Reproduction

The life history of the Haida Gwaii Slug is poorly known. The species is hermaphroditic and presumably lays eggs, but no eggs have been found. There are records of a total of 47 specimens from Haida Gwaii, of which only six are less than 8 mm in length and almost certainly juveniles. On Brooks Peninsula, all slugs found were 9 – 10 mm in extended length when alive, and were probably maturing young. Very small slugs, 2 – 3 mm long, have been found from 27 July to 26 September, and presumably had hatched recently. At a forestry site in Haida Gwaii that was sampled repeatedly from end of July to late October – early November over two years, adults started to appear in the samples in September. The only records from before September were of two hatchlings found on 27 – 28 July.

Generation time is probably 1 year. The sudden appearance of adults in the autumn samples suggests that individuals might mature in their first year of life; small juveniles found late in the season might overwinter before reaching sexual maturity. Whether mature individuals survive to reproduce in more than one year is unknown.

Diet

The slugs probably feed on live and dead vegetation and fungi, but no data are available. In captivity, the slugs readily ate lettuce and carrots (Ovaska unpubl. data).

Physiology and Adaptability

Historically, the Haida Gwaii Slug probably survived glacial periods in nunataks, mountain top habitats that remained ice-free, and appears to be adapted to harsh conditions and short growing seasons that prevailed in such habitats (Ovaska *et al.* 2010). Presently, the species is associated with cool, moist microhabitats and may be particularly sensitive to modified temperature and moisture regimes associated with resource extraction activities and climate change.

Dispersal and Migration

Virtually nothing is known of movements by this species. The small global distribution and patchy distribution suggest poor dispersal ability. At a forestry site on Graham Island, the slugs were patchily distributed, and the species was repeatedly found within the same small areas, usually at the same or adjacent sampling stations (10 m apart), both within and between years, suggesting limited movements (see **Abundance and Fragmentation**).

In general, land snails (including slugs) have poor dispersal abilities unless transported by humans or animals or passively moved by wind or water (reviewed in Cordeiro 2004). No passive means of transport are known or suspected for the Haida Gwaii Slug, but transport in the fur of bears or other mammals is conceivable.

Interspecific Interactions

No interspecific interactions are known. The Haida Gwaii Slug might function as a dispersal agent for fungal spores, similar to other coastal species of native slugs (*Prophysaon* species*:* McGraw *et al*. 2002). Several species of introduced terrestrial gastropods that could compete with or prey on the Haida Gwaii Slug are present in Haida Gwaii but have not been found in the same sites as this species (Ovaska and Sopuck 2005). The Haida Gwaii Slug appears to be most abundant in habitats where few other gastropods are found and is encountered only rarely in productive low-elevation forests. This pattern may be indicative of an inability to persist in areas with high diversity and abundance of gastropod and other invertebrate predators and competitors.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

To date, most surveys have focused on detecting the Haida Gwaii Slug, rather than obtaining abundance estimates (see **DISTRIBUTION: Search Effort**). The surveys have consisted of visual searches of the forest floor, including coarse woody debris, rocks, moss, and mushrooms. Artificial cover-objects constructed of corrugated cardboard were deployed by Biolinx Environmental Research Ltd. at five sites where the species has been found (Table 1). Intensive, repeated surveys were carried out at an experimental forestry site near Port Clements, Graham Island, where 20 plots were sampled with cardboard cover-objects both in 2002 before logging and in 2006 after logging treatments had been applied (Ovaska and Sopuck 2007). Each plot consisted of an array of 10 sampling stations placed 10 m apart along two perpendicular transects. Each sampling station had four cardboard cover-objects, which were checked for gastropods from the end of July to mid-November three times in 2002 and four times in 2006. In both years, there were 800 cover-objects in total, resulting in a sampling effort of 3,200 cover-object flips in 2002 and 2,400 cover-object flips in 2006 (Table 1).

Abundance and Fragmentation

In coniferous lowland forests in Haida Gwaii, the species occurs at apparently low densities, and its distribution is extremely patchy (Figure 6). On Graham Island and northern Moresby Island, extensive logging may have further isolated populations. At the most intensively sampled site near Port Clements (see **Sampling Effort and Methods**), the species comprised only 3.8% of the total captures of four native species of slugs found (Table 3). It occurred at a much lower abundance than the Pacific Banana Slug (*Ariolimax columbianus*) and Yellow-bordered Taildropper (*Prophysaon foliolatum*), both of which were widely distributed across the site, and at a similar abundance as the Scarletback Taildropper (*P. vanattae*), which was also rarely found. At this site, the Haida Gwaii Slug was found at six of the 20 sampling plots; within each plot it was found at only a few sampling stations. Interestingly, the species tended to occur at the same or immediately adjacent (10 m away) sampling station both between sampling sessions within one year and between years; this pattern suggests an extremely patchy distribution and possible structuring of populations into semi-isolated demes. Unfortunately, however, the numbers of Haida Gwaii Slugs caught were too low (15 slugs in total) to permit meaningful analysis.

Table 3. Relative abundance (percentage of captures and occupied sampling stations and plots) of four species of slugs found during intensive surveys at an experimental forestry site sampled repeatedly with artificial cover-objects in Haida Gwaii in 2002 (4 surveys) and 2006 (3 surveys).

	Ariolimax columbianus	Prophysaon foliolatum	Prophysaon vanattae	Staala gwaii	Total
Individual slugs	15.6%	78.3%	2.3%	3.8%	397
Sampling stations[1]	24.5%	58.0%	4.5%	5.0%	200
Sampling plots[2]	90%	100%	35%	30%	20

[1]Each station consisted of 4 cardboard cover-objects.

[2]Each plot consisted of 10 stations, placed 10 m apart along two perpendicular transects in a cross-pattern.

In Haida Gwaii, the distribution of the species is probably more continuous in subalpine and alpine habitats, which occur in the MH and AT biogeoclimatic zones concentrated in the southwest of Graham Island and in the northern half of Moresby Island (Figure 3). Scattered patches of alpine-subalpine habitats occur elsewhere on the islands, including Site 10 in Figure 3. The slugs were readily found in these habitats on Moresby Island during brief visits (Ovaska and Sopuck 2005), suggesting relatively high abundance. These two zones together, however, comprise only 6% of the land area of the islands and are naturally patchily distributed. That the slugs are found in lowland forests suggests that barriers between different mountains are not insurmountable, especially where forests are largely intact, such as on the southern half of Moresby Island.

On Brooks Peninsula, a total of eight slugs were found at four sites within a 2 km wide area. The habitat is naturally patchy, and the slugs were concentrated in sheltered microhabitats in depressions or moist patches of protective vegetation.

Current viability of populations is unknown. Whereas lowland populations in Haida Gwaii may be very small, mountain populations in both Haida Gwaii and Brooks Peninsula may be more robust judging from their more continuous distribution and apparently higher abundance of slugs. It is unlikely that severe fragmentation applies (>50% of individuals or habitats in isolated patches that may not support viable populations).

Fluctuations and Trends

Nothing is known of population fluctuations or trends. A decline in population size is projected if alpine and subalpine habitats shrink as a result of climate change (see **Habitat Trends**).

Rescue Effect

There is no possibility for rescue, as the species is only found in Canada and on isolated islands.

THREATS AND LIMITING FACTORS

Assessment of Threats

The IUCN threats calculator (Master *et al*. 2009) was applied by the report writers to assess the significance of threats to the Haida Gwaii Slug from different, standardized threat categories (Table 4); results were reviewed by the Molluscs SSC. The scope of threats was based on known occurrences of the species in relation to the spatial extent of the threat. Existing habitat disturbance, as evidenced at each known site, was assessed from Google Earth® maps (Appendix 3), and threats were predicted for the future based on habitat trends and climate change projections (see **Habitat Trends**). The results from the threats calculator showed an overall, calculated threat impact of "high" (Table 4). Important threats are discussed individually below, in order of importance.

Table 4. Threats calculator results for the Haida Gwaii Slug.

Assessed by K. Ovaska and L. Sopuck, 21 Dec 2011, and reviewed by Molluscs SSC 9 Sept 2012. Cells for threats deemed not applicable for the species are left blank. See text (**THREATS AND LIMITING FACTORS**) for explanation for most important threats.

		Level 1 Threat Impact Counts	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	0	0
C	Medium	2	1
D	Low	3	4
	Calculated Overall Threat Impact:	High	High

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**
1	Residential & commercial development					
1.1	Housing & urban areas					
1.2	Commercial & industrial areas					
1.3	Tourism & recreation areas					
2	Agriculture & aquaculture					
2.1	Annual & perennial non-timber crops					
2.2	Wood & pulp plantations					
2.3	Livestock farming & ranching					
2.4	Marine & freshwater aquaculture					
3	Energy production & mining		Negligible	Negligible (<1%)	Extreme - Serious (31-100%)	High (Continuing)
3.1	Oil & gas drilling					
3.2	Mining & quarrying		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)
3.3	Renewable energy					
4	Transportation & service corridors	D	Low	Small (1-10%)	Moderate - Slight (1-30%)	High (Continuing)
4.1	Roads & railroads	D	Low	Small (1-10%)	Moderate -	High (Continuing)

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing
					Slight (1-30%)	
4.2	Utility & service lines		Negligible	Negligible (<1%)	Slight (1-10%)	Unknown
4.3	Shipping lanes					
4.4	Flight paths					
5	Biological resource use	D	Low	Restricted (11-30%)	Moderate (11-30%)	High (Continuing)
5.1	Hunting & collecting terrestrial animals					
5.2	Gathering terrestrial plants					
5.3	Logging & wood harvesting	D	Low	Restricted (11-30%)	Moderate (11-30%)	High (Continuing)
5.4	Fishing & harvesting aquatic resources					
6	Human intrusions & disturbance		Negligible	Restricted (11-30%)	Negligible (<1%)	High (Continuing)
6.1	Recreational activities		Negligible	Restricted (11-30%)	Negligible (<1%)	High (Continuing)
6.2	War, civil unrest & military exercises					
6.3	Work & other activities					
7	Natural system modifications					
7.1	Fire & fire suppression					
7.2	Dams & water management/use					
7.3	Other ecosystem modifications					
8	Invasive & other problematic species & genes	C D	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)
8.1	Invasive non-native/alien species	C D	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)
8.2	Problematic native species					
8.3	Introduced genetic material					
9	Pollution					
9.1	Household sewage & urban waste water					
9.2	Industrial & military effluents					
9.3	Agricultural & forestry effluents		Unknown	Unknown		
9.4	Garbage & solid waste					
9.5	Air-borne pollutants					
9.6	Excess energy					
10	Geological events	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)
10.1	Volcanoes					
10.2	Earthquakes/tsunamis					
10.3	Avalanches/landslides	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)
11	Climate change & severe weather	C	Medium	Large (31-70%)	Moderate (11-30%)	High (Continuing)
11.1	Habitat shifting & alteration	C	Medium	Large (31-70%)	Moderate (11-30%)	High (Continuing)
11.2	Droughts	C D	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)
11.3	Temperature extremes	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)
11.4	Storms & flooding	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)

Classification of Threats adopted from IUCN-CMP, Salafsky *et al*. (2008).

Climate Change and Severe Weather (impact medium; scope: large; severity: moderate)

In his review of climate change impacts on BC's biodiversity, Gayton (p. 10, 2008) concluded that the species most vulnerable to climate change are those "with small populations, slow rates of dispersal, restrictive elevation, climate requirements, and/or those whose habitat is limited or occurs in patches" with endemism posing an additional risk. Most of the above apply to the Haida Gwaii Slug. Historically, the Haida Gwaii Slug has experienced enormous fluctuations in climate and associated shifts in habitats, including Pleistocene glaciations and interglacial warming periods. However, the predicted climate change is much more rapid than in the past (decades versus 1000s of years), and in the face of the current warming trend, the presumed adaptations of the species to harsh conditions and low productivity habitats, such as may have prevailed in glacial refugia, confer no advantage. The effects of climate change on the Haida Gwaii Slug will probably be mainly through habitat shifting and alteration, expected to be most severe in alpine-subalpine habitats where two-thirds of known sites for the species are located (Table 5). Expansion of tree cover into higher elevations results in profound changes to alpine - subalpine ecosystems, including changes in ground cover composition and structure and in competition and predation regimes. Complex and largely unpredictable changes to ecosystems are plausible as each species responds individually to shifting conditions and interacts with each other within the new assemblages. However, increased tree cover and productivity associated with climate change are probably deleterious to the Haida Gwaii Slug both through direct changes to micro-habitats and through increased competition and predation pressures, as forest invertebrates, including other gastropods, expand their distributions. Increased incidence of droughts, temperature extremes, and storms and flooding also contribute to this threat.

Table 5. Number of individual Haida Gwaii Slugs in relation to habitat category and search effort in Haida Gwaii based on data by Biolinx Environmental Research Ltd., 2000-2004.

TCS - Time-constrained search; ACO: Artificial cover-object search

Broad habitat type	TCS: # person-minutes	ACO: # cover-board checks	TCS: # of slugs found	TCS:# slugs /60 min	ACO: # slugs found	ACO: # slugs/ cover-object
Low-elevation forest	4265	5780	1	0.014	15	0.003
Mid-elevation forest	134	84	0	0	5	0.060
Subalpine - alpine	638	8	15	1.411	1	0.125
Other open habitat	70	0	0	0	NA	0
Total	5107	5872	16	NA	21	NA

The literature contains some examples of vulnerability of higher-elevation species of gastropods to climate change. Müller *et al.* (2009) used a modelling approach based on survey data to predict responses of gastropods in Bavaria, central Europe, to climate change. Overall, terrestrial gastropod diversity in high elevation sites was predicted to increase as a result of climate change, but ranges of higher-elevation inhabitants, such as the snail *Semilimax kotulae* (family Vitrinidae), were predicted to shrink, resulting in eventual extirpation.

Invasive and Other Problematic Species and Genes (impact: medium – low; scope pervasive; severity: moderate – slight)

Introduced Sitka Black-tailed Deer are widespread throughout Graham and Moresby islands, and are also present on many small outer islands. Apart from the now-extirpated Dawson Caribou (*Rangifer tarandus dawsoni*), which had a more restricted distribution and probably was never abundant, there are no native ungulates in the archipelago (McTaggart-Cowan 1989). Through browsing on understory and ground vegetation, deer are profoundly modifying ecosystems across the islands (see **Habitat Trends**). Deer or their sign were noted at all sites where the Haida Gwaii Slug was found, including subalpine and alpine areas (Ovaska and Sopuck unpubl. data). Potential, but so far unmeasured, deleterious effects on the Haida Gwaii Slug accrue from decreased accumulation of shrub leaves in the litter layer and increased exposure of the ground to sun and wind, resulting in lower humidity in micro-sites used by the slugs; such effects of deer browsing on the litter layer have been documented in New Zealand (Wardle *et al*. 2001).

In Haida Gwaii, Allombert *et al*. (2005) studied long- and short-term effects of deer on a variety of invertebrates by comparing faunas among small outer islands where deer were either absent, had been present over 50 years, or had been present under 20 years. Of litter-dwelling invertebrates, terrestrial gastropods were the only group that showed a significant change: gastropod abundance decreased on islands subjected to long-term (> 50 year) presence of deer. Species diversity of gastropods was also depressed on these islands, but the difference was not statistically significant. The study was carried out in coastal forest on islands in Laskeek Bay (east coast of Haida Gwaii); the Haida Gwaii Slug was not documented from the study sites and occurs only rarely in coastal forests. Nevertheless, the study illustrates potential sensitivity of gastropods as a group to habitat changes caused by deer browsing. Similar negative effects of ungulate browsing on terrestrial gastropods were found in northern Europe. Suominen (1999) compared gastropod abundance and species richness from fenced ungulate exclusion plots with similar unfenced plots browsed by either Moose (*Alces alces*) in central Sweden and southern Finland or Reindeer (*Rangifer tarandus*) in Finnish Lapland. The abundance of gastropods as a group and many individual species was greater in the plots protected from grazing; the increase was greater on the Reindeer exclusion plots (24%) than on the Moose exclusion plots (17%). Species richness of gastropods as a group was also higher in the exclusion plots but was only marginally statistically significant. The author concluded that ungulates depressed gastropod populations indirectly by modifying the physical condition of microhabitats that gastropods depend on.

Introduced gastropods that might compete with or prey on the Haida Gwaii Slug occur sporadically in Haida Gwaii and are primarily associated with human habitations and other human use areas. However, their distributions are likely to expand with increased logging and recreational activities. Ovaska and Sopuck (2005) noted that Gwaii Haanas National Park Reserve and Haida Heritage site were remarkably free of introduced gastropods with concentrations only around some human use areas. No introduced gastropods were found on the ridge in Brooks Peninsula, where the species occurs on Vancouver Island (Appendix 1).

Biological Resource Use (impact: low; scope restricted; severity: moderate)

Logging and wood harvesting affect 25% of the known sites (Appendix 4), while most sites, including all sites on Moresby Island, are within a protected area. One site (Site 1 in Figure 3) was logged in 2003 – 2004, and residual effects on the species will mostly remain into the future. Brooks Peninsula is a provincial park and not subject to logging. However, extensive logging has occurred east of the peninsula outside the park boundary, including higher elevation forests.

Opening of the canopy alters microclimates on the forest floor by exposing the ground to wind and sun. Logging also drastically alters habitat structure at ground level, including distribution and replenishment of coarse woody debris. Movements of slugs among subpopulations are probably curtailed, leading to population isolation.

The responses of gastropods and other forest floor invertebrates to logging depend on various factors such as size of cut area and the amount and distribution of tree retention, in addition to forest type and requirements of individual species. In general, higher levels of tree retention have been found to better maintain pre-harvesting patterns of abundance (Huggard and Vyse 2002; Matveinen-Huju *et al*. 2006). In Ontario, Prezio *et al*. (1999) observed a 50 – 60% decline in the abundance of terrestrial gastropods 2 – 3 years after the application of conifer-release treatments, while there were no immediate effects in the first year after harvest (Hawkins *et al.* 1997). Ovaska and Sopuck (2008) examined the responses of terrestrial gastropods to various spatial patterns of logging at experimental forestry sites in western BC; one of the sites was on Graham Island, while the rest were on Vancouver Island and the Sunshine Coast on the mainland. The treatments consisted of clearcutting and the retention of trees either in small patches or in a dispersed pattern. Individual species showed a wide range of responses to the treatments 2 – 4 years after logging, but none of the logged treatments were equivalent to the adjacent, uncut control areas in maintaining the abundance of sensitive species when compared to pre-logging conditions. The Haida Gwaii Slug was found at the Graham Island experimental site in small numbers (14 slugs) at a subset of the sampling plots (6 of 20 plots) (Ovaska and Sopuck 2007). The numbers are too small for a meaningful analysis, but some inferences of short-term persistence can be made. After 2 years from logging, the slugs persisted within the three tree-retention patches (approximately 0.5 ha) and the single sampling plot in the control area where they were previously found; they were not found in the two survey plots in the clearcut where they occurred before logging. Longer-term persistence of the populations is unknown, but the cut areas probably curtail movements and connectivity among subpopulations.

Transportation and Service Corridors (impact low; scope small; severity moderate – slight)

Construction of new logging roads on Graham and northern Moresby islands is probable as logging expands to new areas. Road building can result in habitat loss and degradation, where it occurs in Haida Gwaii Slug habitats. Both existing and new roads pose potential barriers to movements, increasing habitat fragmentation and isolation of subpopulations. The scope of this threat is predicted to be small, reflecting the low number of occurrences of the species that are on forest lands as opposed to alpine – subalpine areas or protected areas.

Geological Events (impact low; scope restricted; severity slight)

Avalanches and landslides are frequent in the mountain habitats favoured by the species and probably result in a temporary loss of habitat. Landslides or avalanche chutes were visible in satellite imagery in the vicinity of most sites where the species has been found (Appendix 3). Populations will probably recover relatively rapidly from local, small-scale perturbations. Increased intensity and frequency of storms and extreme events associated with climate change, as well as logging on mountain slopes, could accentuate the natural frequency and size of these disturbances, resulting in more serious habitat loss.

Human Intrusions and Disturbance (impact negligible; scope: restricted; severity negligible)

Recreational activities occur at approximately 15% of the known sites, and hiking trails are present. In particular, the Sleeping Beauty Trail on Mt. Genevieve is a popular hiking trail in the vicinity of Queen Charlotte City. The trail is rugged and not conducive to motorized traffic. Hiking is considered to result in no or minimal impact on the Haida Gwaii Slug or its habitat at its current or predicted level.

Number of Locations

A checklist of the main threats by known site, as indicated by the threats calculator assessment, was used to estimate the number of locations (Appendix 4). The most important threats to the species are deer browsing, especially in Haida Gwaii, and climate change. If browsing by introduced deer is considered the most important plausible threat, then the number of locations is at least three but is likely higher: one each for Moresby and Graham islands and the third for Brooks Peninsula, where deer are expected to have a more limited impact as they are native to Vancouver Island. Deer densities and population processes may be different on Moresby and Graham islands, although movement of deer is likely through a narrow connecting channel. If climate change is considered the most important plausible threat, then the number of locations is at least seven, but is likely higher: all sites in subalpine and alpine sites on each island were considered one location, and the remaining sites were assigned to locations based on common predicted threat events from other sources (Appendix 4). There is much uncertainty associated with both the deer browsing and climate change threats with regards to the type, magnitude, and speed of habitat change, as well as the responses of the slugs to the changes. Hence the actual number of locations is most likely greater than 10.

Limiting Factors

The present distribution of the Haida Gwaii Slug is probably relictual, reflecting survival and expansion from glacial refugia. The species' expansion to low elevation forests in Haida Gwaii might be limited by higher predation and competition regimes in these more productive ecosystems. Geographic isolation of the archipelago and poor dispersal ability of the species limits its expansion to other areas.

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

As of May 2013, the Haida Gwaii Slug has no legal protection or status under the federal *Species at Risk Act*, BC *Wildlife Act*, or other legislation.

Non-Legal Status and Ranks

BC Conservation Data Centre (2011) has tentatively ranked the Haida Gwaii Slug as "special concern, vulnerable to extirpation or extinction" both provincially ("S3?") and G3 globally ("G3?"). The species is on the provincial Blue-list of species at risk. NatureServe (2013) has assigned the following ranks for this species: G3? (date: 12 May 2010, rounded to vulnerable), N3? (date: 10 Sept 2011).

Habitat Protection and Ownership

On Vancouver Island, the Haida Gwaii Slug occurs in Brooks Peninsula Provincial Park. In Haida Gwaii, all six known occupied sites on Moresby Island are within Gwaii Haanas National Park Reserve and Haida Heritage Site. The remaining five sites are on Graham Island on BC Crown lands used for forestry; two of these sites (Sites 4 and 5 in Figure 3) are within a recreational trail system. One site (Site 1 in Figure 3) was logged in 2003 – 2004.

Much of Haida Gwaii is protected from industrial resource extraction and development. Approximately 47.9% of the total landbase of 1,005,750 ha is or will be within protected areas: Conservancies under *Strategic Land-use Agreement* – 25.4% (existing and proposed; see below); Ecological Reserves or Class A provincial parks – 7.9% (existing); federal protected areas: 15.5% (existing) (DataBC Geographic Services 2012). The four largest protected areas are Gwaii Haanas National Park Reserve and Haida Heritage Site on Moresby Island (147,000 ha); Duu Guusd Heritage Site/Conservancy (143,600), Naikoon Provincial Park (68,600 ha), and Vladimir J. Krajina Ecological Reserve (7,800 ha) on Graham Island.

A *Strategic Land-use Agreement* between the BC provincial government and the Council of the Haida Nation was signed in 2007, leading to the legal establishment of Conservancies as new protected areas and the development of the Haida Gwaii *Land Use Objectives Order* under the *Land Act* in December 2010. The *Land Use Objectives Order* is intended to set new standards for forest practitioners and to establish a network of reserves to protect a range of cultural and ecological values (Haida Gwaii Land Use Objectives Order 2010).

Once fully implemented, almost half of the land base of Haida Gwaii will be in protected areas (BC Ministry of Natural Resource Operations 2011). The land use objectives that might be relevant for the Haida Gwaii Slug are under Biodiversity and Wildlife objectives and under Aquatic Habitats, which include protection of riparian forest in fish habitats and restricts logging in sensitive watersheds. Relevant Biodiversity objectives include those for forest swamps, ecological representation, and red- and blue-listed ecological communities. These objectives specify parameters for required habitat protection, such as minimum size, and set limits for the removal of old-growth and mature forest. The Haida Gwaii Slug might also benefit from objectives for other "umbrella" species, such as the Marbled Murrelet (*Brachyramphus marmoratus*) and Northern Goshawk (*Accipiter gentilis*), for which protection is specified under Wildlife objectives of the Order.

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Robert Forsyth, Research Associate, Royal BC Museum, Victoria
Berry Wijdeven, FIA Species at Risk Recovery Coordinator (Haida Gwaii), Queen Charlotte City

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Kristiina Ovaska, Ph.D., M.Sc., received her doctoral degree in biology from the University of Victoria, after which she completed two post-doctoral studies in animal behaviour and population biology with McGill University and University of British Columbia, respectively. Presently, she is a partner in Biolinx Environmental Research Ltd. and research associate at the Department of Forest Sciences, University of British Columbia. Her experience with terrestrial gastropods includes research into effects of forestry practices, studies on patterns of abundance and distribution of species at risk, and numerous surveys in different parts of British Columbia, including Haida Gwaii. Surveys in Haida Gwaii resulted in the discovery and description of the Haida Gwaii Slug. She has prepared status reports, recovery strategies, a multi-species action plan, and best management practices guidelines for terrestrial gastropods. Her photographs of gastropods appeared in the Royal British Columbia Museum Handbook "Land Snails of British Columbia" by R. Forsyth. She is the author of more than 40 publications in the refereed scientific literature, including several papers on terrestrial gastropods.

Lennart Sopuck, M.Sc., RPBio, has studied a wide variety of wildlife species over the past 25 years. His expertise includes assessing and mitigating effects of various human activities on wildlife, including species at risk. Together with Dr. Ovaska, he is a partner of Biolinx Environmental Research Ltd. and has conducted numerous survey and research projects on terrestrial gastropods of British Columbia, including searches for the Haida Gwaii Slug. He is co-author of several status reports, recovery strategies, a multi-species action plan, and management documents for terrestrial gastropod species.

COLLECTIONS EXAMINED

No collections were examined for this report. The following collections contain specimens of Haida Gwaii Slug (Ovaska *et al*. 2010):

Royal British Columbia Museum:
RBCM 009-00035-001 (holotype); RBCM 009-00036-001 and RBCM 009-00038-001 (paratypes); RBCM 009-00037-001, RBCM009-00039-001, RBCM 009-00041-001, RBCM009-00040-001, RBCM009-00042-001

Carnegie Museum of Natural History:
CM97971 (paratype)

Appendix 1. Summary of surveys for terrestrial gastropods on Brooks Peninsula and vicinity on Vancouver Island, August 2012, with funding and logistical support from BC Ministry of Environment and BC Parks (courtesy of Jennifer Heron and Erica McClaren), Royal BC Museum, and Environment Canada.

Surveys conducted by Kristiina Ovaska and Lennart Sopuck with assistance from Jennifer Heron, Erica McClaren, Claudia Copley, and Darren Copley.

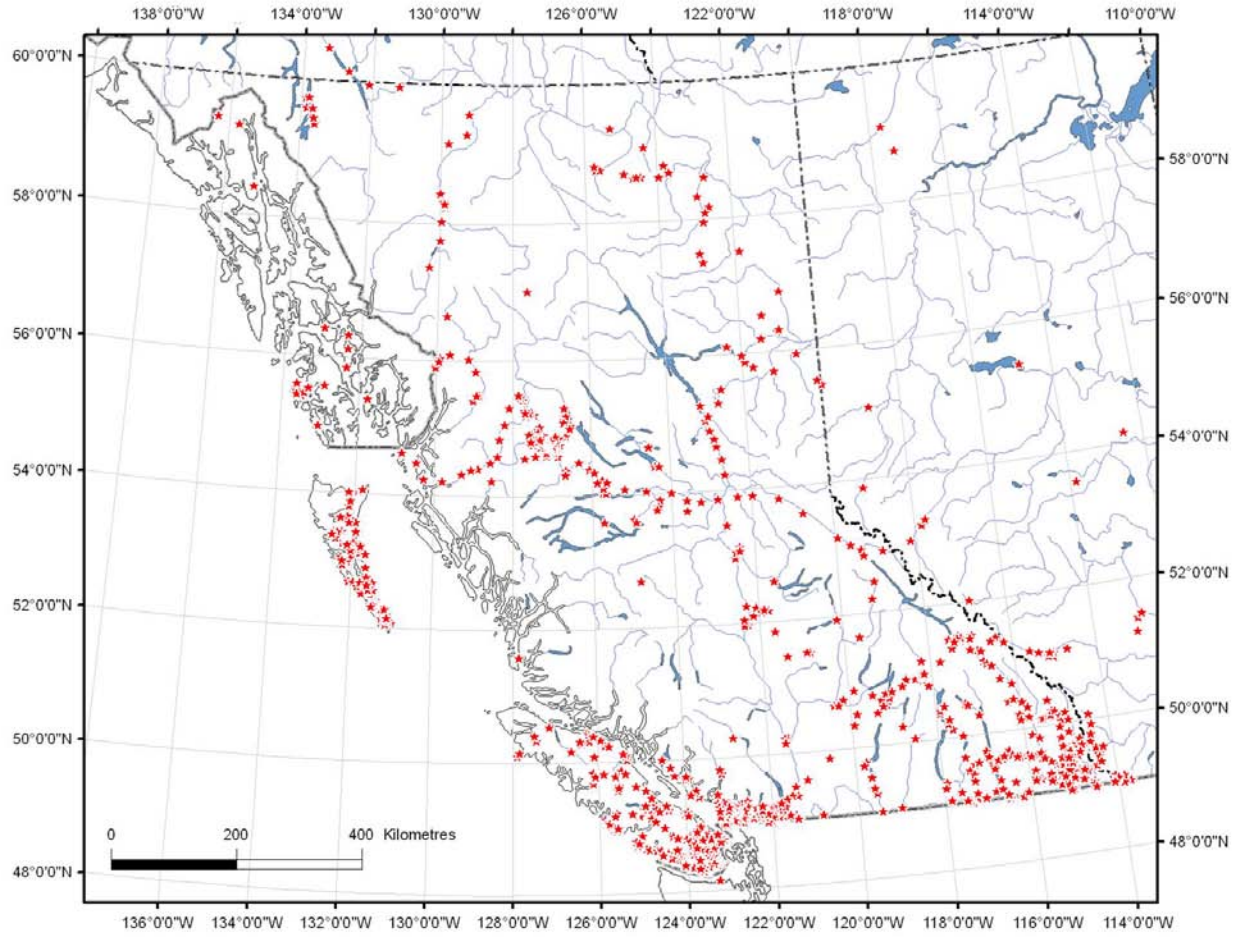
UTM zone: 09U; NAD83. Nomenclature for plant species (common names) follows Pojar and MacKinnon (1994).

Site ID	Site description	Elev. (m)	UTM Easting	UTM Northing	Habitat	Date	Search effort (person hours)	Gastropods spp. found (# of individuals)
0	Brooks Peninsula, ridge (basecamp)	371	579179	5552571	Ridgetop with krummholtz vegetation; patches of stunted trees (<2 m tall Mountain Hemlock, Yellow Cedar and Shorepine), shrubs (Salal), and ground vegetation (Crowberry, Blueberry)	25 & 29 Aug-12	Opportunistic & cardboard cover-objects	*Ancotrema sportella* (1), *Ariolimax columbianus* (6), *Prophysaon foliolatum* (3)
1	Brooks Peninsula, ridge (Site 1)	381	579230	5552654	Moist depression with krummholtz vegetation; stunted trees (<1 m tall Yellow Cedar and Shorepine), low shrubs (Salal), and ground vegetation (Deer Cabbage, Crowberry, Arnica sp.)	26-Aug-12	1.6	*Ancotrema* sp.(1), *Ariolimax columbianus* (2), *Haplotrema vancouverense* (1), *Microphysula cookie* (1), *Vespericola columbiana* (1)
2	Brooks Peninsula, ridge (Site 2)	363	579490	5552806	Riparian area by intermittent creek with steep sides on ridgetop with krummholtz vegetation; stunted trees (<1 m tall Yellow Cedar and Shorepine), low shrubs, and ground vegetation (Deer cabbage, 5-leaved Bramble, Chocolate Tip, Crowberry)	26-Aug-12	2.2	*Haplotrema vancouverense* (2), *Prophysaon foliolatum* (4), *Vespericola columbiana* (2)
3	Brooks Peninsula, ridge (Site 3)	433	579835	5553129	North slope of wooded moist gully with krummholtz vegetation; dense thicket of stunted Mountain Hemlock and Yellow Cedar (< 5 m tall), shrubs (Salal, False Azalea, Salmonberry, Vaccinium sp.) and varied ground vegetation (Bunchberry, Twisted Stalk, Arnica sp., False Lily-of-valley, grass tufts); abundant decomposing wood (Hemlock branches)	26-Aug-12	2.0	*Ancotrema* sp.(4), *Microphysula cookie* (1), *Prophysaon vanattae* (1), *Pristiloma stearnsii* (1), *Staala gwaii* (3), *Vespericola columbiana* (3)
4	Brooks Peninsula, ridge (Site 4)	450	580592	5554760	Open seepage area with moss and small pools and krummholtz vegetation; stunted trees (<1 m tall Mountain Hemlock, Yellow Cedar and Shorepine), shrubs (Salal), and ground vegetation (Blueberry, Crowberry, Deer Cabbage Bog Orchid); rushes in moist depressions	26-Aug-12	1.5	*Haplotrema vancouverense*(2), *Prophysaon foliolatum* (2), *Prophysaon vanattae* (1), *Pristiloma stearnsii* (1), *Staala gwaii* (1), *Vespericola columbiana* (1)

Site ID	Site description	Elev. (m)	UTM Easting	UTM Northing	Habitat	Date	Search effort (person hours)	Gastropods spp. found (# of individuals)
5	Brooks Peninsula, ridge (Site 5)	327	579084	5553141	Depression on ridge in dense patch of stunted trees (<2 m tall Mountain Hemlock, Yellow Cedar, Shorepine); ground cover of Crowberry, Deer Cabbage, Blueberry, and moss including patches of sphagnum	27-Aug-12	1.7	*Ancotrema sp.(1), Haplotrema vancouverense*(3), *Pristiloma stearnsii* (1), *Staala gwaii* (1)
6	Brooks Peninsula, ridge (Site 6)	301	579037	5553199	Moist, steep slope in seepage area with dense patch of stunted trees (2-5 m tall Mountain Hemlock, Yellow Cedar), dense shrub layer (Salal, False Azalea, Vaccinium sp), ground vegetation (Bunchberry, Twisted Stalk, 5-leaved Bramble, False Lily-of-valley, Deer Fern, sedges), and a deep moss mat; numerous decomposing Hemlock branches	27-Aug-12	3.7	*Haplotrema vancouverense*(2), *Prophysaon foliolatum* (1), *Pristiloma stearnsii* (1), *Staala gwaii* (3), *Vespericola columbiana* (2)
7	Brooks Peninsula, beach (Site 7)	10	583119	5558276	Old (150+ years old) Sitka Spruce fringe along sandy beach, ca. 50 m from ocean, with Salal and Salmonberry understorey	29-Aug-12	0.3	*Carychium occidentale* (3), *Striatura pugetensis* (1)
8	Mahata estuary, near Port Alice (Site1)	<50	610868	5577995	Moist, moss-covered cliff-face (step moss, pipe-cleaning moss) with stunted Douglas-fir and Western Redcedar and Deer Fern	29-Aug-12	0.8	*Ariolimax columbianus* (4), *Vespericola columbiana* (1)
9	Mahata estuary, near Port Alice (Site 2)	<50	610381	5578806	Patch of maturing (80-90 year old) Western Hemlock forest with sparse understory (Salal, Red Huckleberry, False Azalea, Deer Fern) and compact, thin litter layer and with small creek amidst logged landscape.	29-Aug-12	1.5	*Ariolimax columbianus* (3), *Prophysaon foliolatum* (1), *Vespericola columbiana* (1)
10	Port Alice (recreational area)	150	607350	5587380	Patch of maturing (80-90 year old) Western Hemlock forest with sparse understory (Salal, Red Huckleberry, False Azalea, Deer Fern) and compact, thin litter layer.	28-Aug-12	Opportunistic	*Ariolimax columbianus* (5), *Prophysaon foliolatum* (1)

Appendix 2. Distribution of searches (red stars) for terrestrial molluscs in British Columbia and neighbouring provinces and territories from 1984 - 2012.

Each star represents a locality where a search for terrestrial snails and slugs has occurred; methodology includes visual searches with or without substrate manipulation as well as forest floor litter samples. This compilation only includes records from Cameron 1986, Biolinx Environmental Research Ltd., R. and T. Forsyth, and Wildlife Systems Research; some of these records have been included in reports and publications while other records are unpublished (map prepared by L. Sopuck).



Appendix 3. Habitat disturbance at sites where the Haida Gwaii Slug has been found.

Rows for sites assigned to the same population are similarly shaded.

% refers to approximate percentage of land subjected to different land uses within about 1 km and 10 km radius area around slug records, as visually estimated from GoogleEarth® orthophotos (online version accessed in 2011); area covered by water (not habitat) omitted. Images for the Graham Island sites date from 2008 – 2009 and those for the Moresby Island sites from 2005 – 2006 (as per digital globe coverage option in GoogleEarth®).

Site #	SIte name	Logging (%)		Agricultural/ residential (%)		Recreational dev. (%)		Major roads & railways		Other		Comments
		1 km radius	10 km radius	1 km radius	10 km radius	1 km radius	10 km radius	1 km radius	10 km radius	1 km radius	10 km radius	
1	Experimental forestry site (Hoodoo site; Plots a - e), South of Port Clements, Graham Island	30-50	30-40	0	2	0	0	No	Trace	Logging roads	Logging roads	Logging mostly to the west; entire western half fragmented; less logging to the east (boggy)
2	Rennell Sound (Site 3), Graham Island	25	50	0	0	0	0	Rennell Sound road, gravel	Central logging road & Rennell Sound road, gravel	10 (landslides); logging roads	5 (landslides); logging roads	
3	Rennell Sound (Site 4), Graham Island	5	50	0	TR	0	TR	Rennell Sound road, gravel	Rennell Sound road, gravel	10 (landslides); logging roads	5 (landslides); logging roads	
4	Mt. Genevieve (mid-slope, start of trail), Graham Island	50	30	0	5	TR	TR	0	Major gravel road; paved roads through city	logging roads	logging roads; landslides 1%	Recreational trail up the mountain; network of logging roads at lower elevations; Queen Charlotte City within 10 km radius
5	Mt. Genevieve (near top), Graham Island	5	25	0	3	TR	TR	0	Major gravel road; paved roads through city	Landslides: trace	logging roads; landslides 1%	Recreational trail up the mountain; network of logging roads at lower elevations; Queen Charlotte City within 10 km radius
6	Mt. Oliver, Moresby Island	0	5	0	0	0	0	0	0	Landslides: 5%	Mine: 2%; Landslides: 2%	Old open pit mine 5 km north; few logging roads on periphery

Site #	SIte name	Logging (%)		Agricultural/ residential (%)		Recreational dev. (%)		Major roads & railways		Other		Comments
		1 km radius	10 km radius	1 km radius	10 km radius	1 km radius	10 km radius	1 km radius	10 km radius	1 km radius	10 km radius	
7	Mt. De La Touche, Moresby Island	0	1	0	0	0	0	0	0	Landslides: 2%	Mine: 2%; Landslides: 2%	Old open pit mine 6 km north
8	Unnamed mountain near Sunday Inlet, Moresby Island	0	1	0	0	0	0	0	0	Landslides: 2%	Landslides: 5%	Old logging along east shore within 10 km; no roads of any kind
9	Unnamed mountain near Kostan Inlet, Moresby Island	0	1	0	0	0	0	0	0	Landslides: 1%	Landslides: 2%	Old logging along east shore within 10 km; no roads of any kind
10	Mt. Yatza (Sites 1 & 2), Moresby Island	0	1	0	0	0	0	0	0	NA	Landslides: 5%	Old logging along east shore within 10 km; no roads of any kind
11	Louscoone Inlet, Moresby Island	0	TR	0	TR	0	TR	0	0	Landslides: 1%	Landslides: 1%	SGang Gwaay old village & watchmen cabin; Rose Harbour within 10 km
12	Brooks Peninsula	0	0	0	0	0	0	0	0			Extensive logging to east of park boundary

Appendix 4. Main threats, as assessed through the Threats Calculator, and determination of the minimum number of locations for the Haida Gwaii Slug. Due to uncertainties, the actual number of locations is likely greater than 10.

Rows for sites assigned to the same population are similarly shaded.

Site #	Site name	Logging	Deer browsing	Climate change	Locations*: deer as Threat 1	Locations*: climate as Threat 1	Residual locations*: climate as Threat 1
1	Experimental forestry site (Hoodoo site; Plots a - e), South of Port Clements, Graham Island	Yes	Yes	Maybe	1		5 (logging, deer)
2	Rennell Sound (Site 3), Graham Island	Yes	Yes	Maybe	1		6 (logging, deer)
3	Rennell Sound (Site 4), Graham Island	Yes	Yes	Maybe	1		6 (logging, deer)
4	Mt. Genevieve (mid-slope, start of trail), Graham Island	Yes	Yes	Maybe	1	1	
5	Mt. Genevieve (near top), Graham Island	No	Yes	Yes	1	1	
6	Mt. Oliver, Moresby Island	No	Yes	Yes	2	2	
7	Mt. De La Touche, Moresby Island	No	Yes	Yes	2	2	
8	Unnamed mountain near Sunday Inlet, Moresby Island	No	Yes	Yes	2	2	
9	Unnamed mountain near Kostan Inlet, Moresby Island	No	Yes	Yes	2	2	
10a	Mt. Yatza (Site 1), Moresby Island	No	Yes	Yes	2	3	
10b	Mt. Yatza (Site 2), Moresby Island	No	Yes	Yes	2	3	
11	Louscoone Inlet, Moresby Island	No	Yes	Maybe	2		7 (deer)
12	Brooks Peninsula	No	Maybe	Yes	3	4	

*Sites with the same number are considered a single location.