COSEWIC
Assessment and Status Report

on the

Sheathed Slug
Zacoleus idahoensis

in Canada

SPECIAL CONCERN
2016

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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For additional copies contact:

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

Tel.: 819-938-4125
Fax: 819-938-3984
E-mail: ec.cosepac-cosewic.ec@canada.ca
http://www.cosewic.gc.ca

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Sheathed Slug — Photograph by K. Ovaska.

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COSEWIC
Assessment Summary

Assessment Summary – May 2016

Common name
Sheathed Slug

Scientific name
Zacoleus idahoensis

Status
Special Concern

Reason for designation
In Canada, this slug is confined to a small area in the Kootenay region of southeastern British Columbia, generally within 25 km of the Canada-U.S. border. Most records are from older shady coniferous forest stands ranging from approximately 50 to >200 years. The species often inhabits riparian areas and other very moist microsites. Threats include logging and wood harvesting, and projected consequences of climate change including an increase in drought condition and wildfires. A decline is projected in the area, extent, and quality of habitat. The low number of scattered subpopulations makes the species vulnerable to both natural and human disturbances.

Occurrence
British Columbia

Status history
Designated Special Concern in April 2016.

COSEWIC
Executive Summary

Sheathed Slug
Zacoleus idahoensis

Wildlife Species Description and Significance

Sheathed Slug is a small (20 – 24 mm long), slender slug with a keeled tail and longitudinal and oblique grooves on the sides and tail. The colour is solid grey or brownish grey. Small light flecks on the mantle and tail give the slug a bluish tint. Sheathed Slug is a regional endemic to moist forests of the northern Columbia Basin, an area that contains many unique plants and animals.

Distribution

The global distribution of Sheathed Slug includes northern Idaho, northwestern Montana, and southeastern British Columbia. In British Columbia, Sheathed Slug occurs in scattered localities in the Kootenay region, south of 49°22'N within approximately 25 km of the Canada-United States border. Since the early 1990s, over 700 sites have been surveyed for terrestrial gastropods in the Kootenay region; recent surveys specifically targeted this species and other native slugs. There are records for the species from nine sites. The estimated range (extent of occurrence) of the species in Canada is 1,892 km^2 based on these occurrences.

Habitat

In British Columbia, Sheathed Slug has been found in mainly coniferous forest stands of varying ages, ranging from 40 – 50 years to old growth (>200 years old); most records are from shady, older forests. The slugs often inhabit riparian areas and gullies associated with small, fast-flowing tributary streams, seepage areas, or other very moist microsites. Moist microhabitats and refuges provided by decaying logs appear to be important.

Biology

The natural history of Sheathed Slug is poorly known. It is hermaphroditic (possessing both male and female reproductive organs) and lays eggs. Juveniles presumably overwinter, but the proportion of adults that do so is unknown. The generation time is probably 1 year or slightly more, based on the small body size of the adults and relatively short life spans of arionid slugs in general. The slugs feed on fungi and liverworts, and probably also on other live and decaying vegetation. Movement capabilities of Sheathed

Slug are presumed to be low. Slugs in general are poor dispersers if not aided by humans, wind or water; no such passive means of dispersal are known for this species, exacerbating the effects of habitat fragmentation on its distribution within the landscape.

Population Sizes and Trends

Population sizes and trends of Sheathed Slug are unknown. Survey efforts have focused on elucidating the distribution of the species rather than on obtaining abundance estimates. Records for the species from British Columbia are from 2009 – 2014, precluding information on population trends. Ongoing declines are suspected, as habitats continue to be degraded by forestry and other causes. In the United States, Sheathed Slug is thought to be declining due to habitat loss.

Threats and Limiting Factors

The greatest threats to Sheathed Slug populations in British Columbia are deemed to be logging, which continues to alter and fragment habitats, and droughts and flood events, the frequency and severity of which are predicted to continue to increase under climate change scenarios. Other threats include introduced invasive species, fire and fire suppression, roads, and livestock farming and ranching. Climate change and severe weather, fire and fire suppression, and forestry are likely to interact in a cumulative manner. Increased frequency and severity of prolonged summer droughts is expected to exacerbate the effects of logging (both recent and planned) and wildfires on the slug's habitat, resulting in declines in both quantity and quality of habitat.

Protection, Status and Ranks

Most of the distribution and records of Sheathed Slug are on unprotected provincial forestry lands. Only about the 3% of the Canadian range of the species is protected within parks or conservation lands, but it is unknown whether the species occurs in these areas.

Sheathed Slug has no official protection or status under the federal *Species at Risk Act*, B.C. *Wildlife Act*, or other legislation. It is ranked by NatureServe as follows: Global status – G3G4 (vulnerable-apparently secure); United States – N3N4 (vulnerable to apparently secure); Canada – N1N3 (critically imperilled to vulnerable); Idaho: S2 (imperilled); Montana – S2S3 (critically imperilled to vulnerable); BC – S1S3 (critically imperilled to vulnerable). In British Columbia, the species is on the provincial red list of species at risk.

TECHNICAL SUMMARY

Zacoleus idahoensis

Sheathed Slug

Limace gainée

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(2011) is being used)	ca. 1 year
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown
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 a.clearly reversible and b.understood and c. ceased?	a. Partially reversible b. Partially understood c. Not ceased
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence	2,295 km² (polygon extended to the Canada-US border beyond known occurrences)
Index of area of occupancy (IAO) (Always report 2x2 grid value).	36 km² (discrete value based on known occurrences; the actual IAO is probably somewhat larger but most likely <500 km^2
Is the population “severely fragmented” ie. is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. Possible (see **Population Fragmentation**) b. Yes

Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	Minimum of 8 – 9 based on known sites with severe droughts and logging as primary threats; 10 – 20 locations is plausible and more likely, given survey coverage and detection probability
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Unknown
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of "locations"*?	Unknown
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, inferred and projected decline in area, extent and quality of habitat
Are there extreme fluctuations in number of subpopulations?	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 subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
Total	Unknown; probably < 10,000

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 due to lack of data

* See Definitions and Abbreviations on COSEWIC website and IUCN (Feb 2014) for more information on this term.

Threats (actual or imminent, to populations or habitats)

Was a threats calculator completed for this species? Yes

i. Livestock farming & ranching (2.3)
ii. Roads & railroads (4.1)
iii. Logging and wood harvesting (5.3)
iv. Fire & fire suppression (7.1)
v. Invasive non-native species (8.1)
vi. Climate change and severe weather: Droughts (11.2), Storms & flooding (11.3)

What additional limiting factors are relevant?
Low dispersal capabilities; dependence on moist micro-habitats

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Unknown
Is immigration known or possible?	Possible, but unlikely in the short term
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada?[+]	Yes
Are conditions for the source population deteriorating?[+]	Yes
Is the Canadian population considered to be a sink?[+]	No
Is rescue from outside populations likely?	Possible over long term, but at very low rate

Data Sensitive Species

Is this a data sensitive species? No

Status History

COSEWIC: Not previously assessed.

Status and Reasons for Designation:

Current Status:	**Alpha-numeric codes:**
Special Concern	Not applicable

Reasons for designation:
In Canada, this slug is confined to a small area in the Kootenay region of southeastern British Columbia, generally within 25 km of the Canada - U.S. border. Most records are from older shady coniferous forest stands ranging in age from approximately 50 to >200 years. The species often inhabits riparian areas and other very moist microsites. Threats include logging and wood harvesting, and projected consequences of climate change including an increase in drought condition and wildfires. A decline is projected in the area, extent, and quality of habitat. The low number of scattered populations makes the species vulnerable to both natural and human disturbances.

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect) .

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. The number of mature individuals is unknown.
Criterion B (Small Distribution Range and Decline or Fluctuation): EOO (2,295 km^2) meets threshold for Endangered (<5,000 km^2) and IAO meets the threshold for Endangered (<500 km^2), with an inferred and projected decline in area, extent, and quality of habitat. However, the number of plausible locations (10 – 20) exceeds the threshold for Threatened. The species' distribution is not considered to be severely fragmented, and there is not enough information to support extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. There are no estimates of population size, and the number of mature individuals is unknown.
Criterion D (Very Small or Restricted Population): Not applicable. There are no estimates of population sizes and D2 for Threatened does not apply as both the IAO and number of locations exceed the thresholds.
Criterion E (Quantitative Analysis): Not applicable as no estimates of population size or trends are available and no quantitative analyses have been performed.

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 (2016)

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 and Climate Change Canada
Canadian Wildlife Service
Environnement et Changement climatique Canada
Service canadien de la faune
Canada

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

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Sheathed Slug
Zacoleus idahoensis

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Sheathed Slug, *Zacoleus idahoensis* Pilsbry, was described based on specimens from Idaho (type locality: Meadows, Washington County, Idaho; Pilsbry 1903). The genus *Zacoleus* is placed within the large cosmopolitan family Arionidae (Pilsbry 1903, 1948). An alternative classification by Bouchet and Rocroi (2005) raises all arionid subfamilies to full family status. Neither of these classifications is satisfactory, because current genetic studies do not support the monophyly of the more inclusive Arionidae or its subfamilies that have been investigated (Backeljau pers. comm. 2011).

The current classification is as follows:

Phylum Mollusca
Class Gastropoda
Subclass Pulmonata
Order Stylommatophora
Suborder Arionoidea
Family Arionidae
Subfamily Ariolimacinae
Genus *Zacoleus*
Species *Z. idahoensis*

The genus *Zacoleus* has been considered monotypic until recently. Burke (2013) casually described a second species, *Zacoleus leonardi*, from Ryan Lake, Washington State, based on genetic (Wilke and Ziegltrum 2004 and unpubl. data *cited in* Burke 2013), morphological, and distributional data (details of genetic, morphological data were not presented). This form has been found in Washington Cascade Mountains, Olympic Peninsula, and northwestern Oregon.

Morphological Description

Sheathed Slug is a small, slender slug with adult length of live specimens 20 – 24 mm when extended (Figure 1; Burke 2013). In British Columbia, live specimens have measured 10 – 26 mm in length, the smallest individual representing a young juvenile (Ovaska and Sopuck unpubl. data). The mantle is smooth and covers about 40% of the length of the body. The pneumostome (breathing pore) is approximately two thirds towards the posterior on the right side of the mantle. The sides and tail have longitudinal and oblique grooves. The tail is keeled with a pronounced ridge and tapers into a laterally compressed tip. The sole is tri-partite (i.e., divided into three sections by longitudinal grooves; Pilsbry 1903). The colour is solid grey or brownish grey. There are often small light flecks on the mantle and tail that give the slug a bluish tint. The sole is dirty white or grey. The mucus is clear.

Figure 1. Sheathed Slug, *Zacoleus idahoensis*, from British Columbia. Photos by K. Ovaska.

Sheathed Slug may be mistaken for the native, sympatric Meadow Slug, *Deroceras laeve*, both having a tripartite sole and pneumostome towards the posterior end of the mantle; however, it lacks the fine concentric wrinkles on the mantle present in *Deroceras*. Internally Sheathed Slug has several features relating to reproductive and digestive systems that permit differentiation from Meadow Slug (Pilsbry 1903, 1948).

Population Spatial Structure and Variability

The genetic structure of Sheathed Slug populations is unknown, apart from a study that focused on *Hemphillia* but included a small number of specimens of other arionid slugs native to the northwestern United States (Wilke and Ziegltrum 2004); no Sheathed Slug specimens from British Columbia were included or available at the time. In British Columbia, the species is known from scattered localities (see **Canadian Distribution**). Two localities along tributaries of the Sundown Creek (#1 and 2 in Table 1) are <1 km apart and considered to be part of the same subpopulation. All other localities are separated from the nearest occupied localities by ≥6 km. The westernmost locality near Trail (#3 in Table 1) is separated from the nearest locality by 92 km. It appears to be isolated from all other Canadian localities and part of the Pend d'Oreille drainage system that extends south into the United States. Given the limited dispersal capabilities of the slugs and their affinity for very moist habitats, it is unlikely that there would be much genetic exchange among subpopulations outside single creeks or sub-drainages.

Table 1. Distribution records for Sheathed Slug, *Zacoleus idahoensis*, in Canada. RBCM – Royal British Columbia Museum, Victoria, British Columbia.

Site #	Date	Site description	Elev. (m)	BEC* zone	Habitat	Appr. stand age (years)	# slugs found	Source^
1	08-Oct-09	Sundown Cr. FSR (by 2 km post), ca. 5 km SE from Moyie, BC	1040	ICHdw1	Moist riparian area along small creek/ seepage area in coniferous forest	60-70	1	Ovaska and Sopuck 2009b (RBCM 009-00233-001)
2	11-Sep-10	Sundown Cr, SW of Moyie, BC	1140	ICHdw1	Seepage area by small creek; moist mixed-wood forest abundant shrubs and herbs; recent logging in general area	50	2	Ovaska *et al.* 2010 (photos)
3	23-Sep-13	9 Mile Cr. (Site 2A), Pend d'Oreille, BC	618	ICHxw	Riparian area in patch of old coniferous forest (slug found ca. 30 m from creek)	100	2	Field verification for COSEWIC status report for the Pygmy Slug (RBCM 014-00056-001)
4	24-Sep-13	Carroll Cr. Road, W of Yahk, BC	993	ICHdw1	Old-growth coniferous forest with sparse understorey; very moist area along creek with numerous mushrooms; signs of old selective logging	200+	1	Field verification for COSEWIC status report for the Pygmy Slug (RBCM 014-00061-002)
5	19-Sep-14	Cherry Cr. FSR (Site 1), near Cherry Lake, BC	1231	MSdk1/ ICHdm border	Stunted forest on south-facing slope at south end of lake	40-50	2	MoE (Ovaska and Sopuck 2014) & fieldwork for this report ** (RBCM uncatalogued)
6	20-Sep-14	Yahk R FSR (Site 1; near Blacktail Cr.), BC	1595	ESSFdk1	Seepage along small creek in spruce forest on north-facing slope	120+	1	MoE (Ovaska and Sopuck 2014) & fieldwork for this report ** (RBCM uncatalogued)
7	21-Sep-14	Yahk R FSR (Site 8), BC	1612	ESSFdk1	Patch of trees in ravine	60-70	1	MoE (Ovaska and Sopuck 2014) & fieldwork for this report ** (RBCM uncatalogued)

Site #	Date	Site description	Elev. (m)	BEC* zone	Habitat	Appr. stand age (years)	# slugs found	Source^
8	23-Sep-14; 24 Sep-15	American Cr. FSR, off Hawkins Cr, Meadow Rd, E of Yahk, BC	1135	ICHdm	Canopy gap with abundant herbaceous growth on sloping terrain in moist forest; seepage area (mostly dry) on site	60-70	1; 1	MoE (Ovaska and Sopuck 2014) & fieldwork for this report ** (RBCM uncatalogued); MoE (Ovaska and Sopuck 2015)
9	23-Sep-14	West Yahk Rd, East of Yahk, BC	1150	ICHmk4	Bottom of gully of small tributary creek in older forest	100+	4	MoE (Ovaska and Sopuck 2014) & fieldwork for this report** (RBCM uncatalogued)

*Biogeoclimatic zones (see BC Ministry of Forests and Range undated for the classification of zones)

**Surveys conducted by K. Ovaska and L. Sopuck for BC Ministry of Environment (MoE) and in support of the preparation of COSEWIC status report for Sheathed Slug (*Zacoleus idahoensis*). RBCM catalogue number to be assigned.

^*MoE-BC Ministry of Environment; RBCM-Royal British Columbia Museum

Designatable Units

Sheathed Slug is known from a relatively small area within one COSEWIC National Ecological Area (Southern Mountain). There are no range disjunctions or other information that would suggest the presence of separate discrete and evolutionarily significant units within the Canadian population, but the genetic, anatomical, or ecological variability within the species has not been studied. The species is treated as one designatable unit.

Special Significance

Sheathed Slug is a regional endemic to moist forests of the northern Columbia Basin, an area that contains many unique plants and animals (Brunsfeld *et al.* 2001). This area extends from southeastern British Columbia and northeastern Washington through the Idaho Panhandle to northwestern Montana. Sheathed Slug is part of the unique fauna of this region, and has scientific value for the study of glacial history and evolutionary relationships.

DISTRIBUTION

Global Range

The global distribution of Sheathed Slug includes northern Idaho, northwestern Montana, and southeastern British Columbia (Figure 2). The species may also occur in extreme northeastern Washington, based on proximity of one locality in British Columbia to the international border (#3 in Table 1), but there are no records from the state (Burke 2013; Leonard pers. comm. 2015). The species is known from approximately 38 localities in Montana (Montana Government undated), 30 in Idaho (NatureServe 2015), and nine in British Columbia (Table 1).

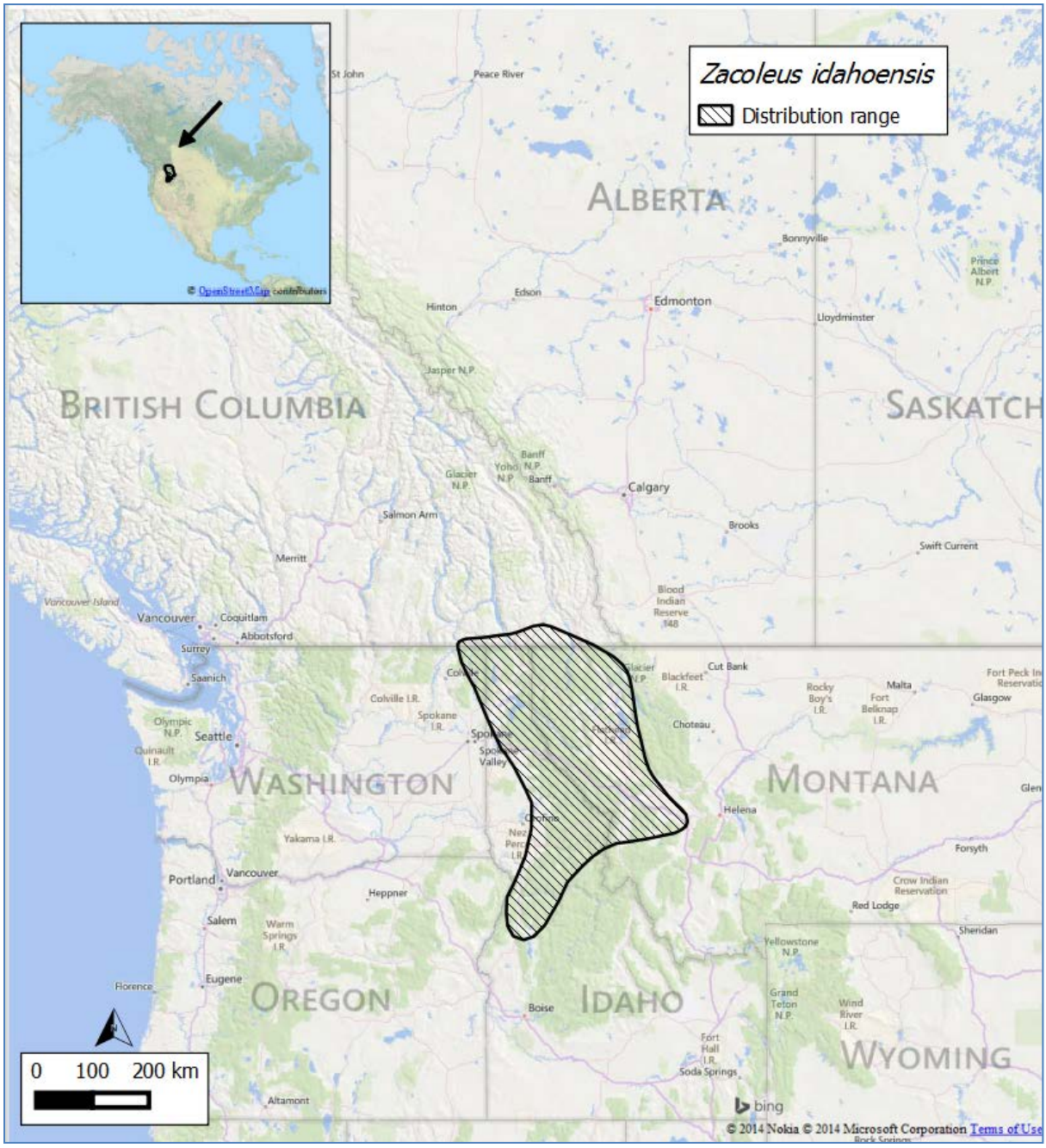

Figure 2. Global distribution of Sheathed Slug in western North America. Map prepared by Lennart Sopuck based on BC records compiled for this report and US distribution from Burke (2013).

Canadian Range

In Canada, Sheathed Slug occurs in southeastern British Columbia, where it is known from scattered localities south of 49°22'N within approximately 25 km of the Canada-United States border (Figure 3). Records exist from just east of Trail eastwards to approximately 25 km west of Koocanusa Lake and northwards to approximately 30 km south of Cranbrook. The 92 km gap between the westernmost record and the remaining records east of Creston may be real, if the slugs in the Trail area are restricted to the Pend d'Oreille drainage. There are records for the species from nine sites (Table 1). Field verification surveys targeting habitats of this species for the preparation of this status report in September 2014 resulted in finding the species at five of 72 sites surveyed; all five sites represented new localities. Additional, undocumented sites probably exist.

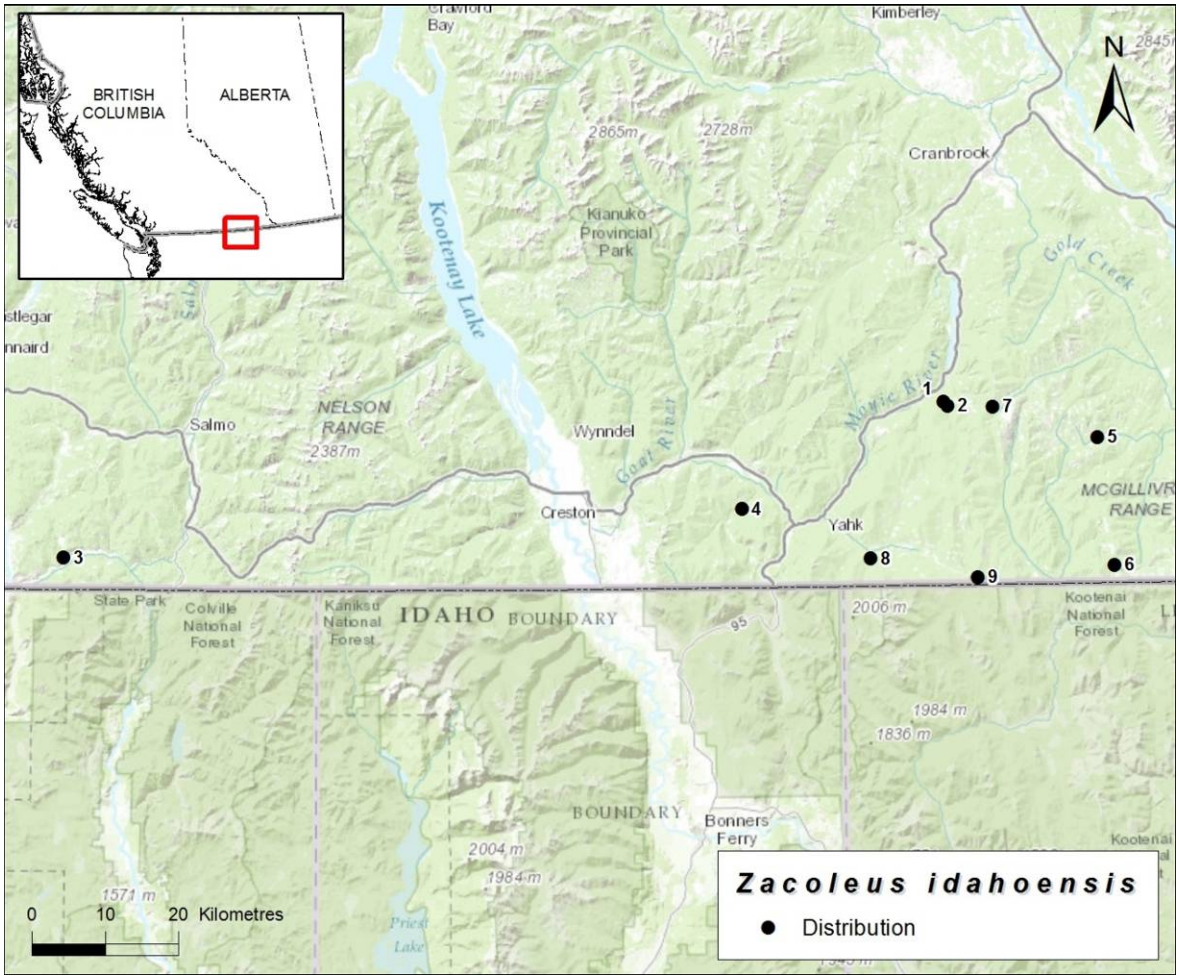

Figure 3. Distribution of Sheathed Slug in Canada. Map prepared by Jenny Wu. See Table 1 for records.

Sheathed Slug has been known from Canada only since 2009. Despite its recent documentation from Canada, it has a long evolutionary history as part of an adaptive radiation of arionid slugs in western North America (Pilsbry 1948). Its current distribution in Canada represents northward post-glacial expansion to south-central British Columbia, most likely from refugia to the south. No Aboriginal Traditional Knowledge for Sheathed Slug is available at this time.

Extent of Occurrence and Area of Occupancy

Using the minimum convex polygon method and existing distribution records, the extent of occurrence (EOO) of Sheathed Slug in Canada is 1,892 km^2 if only known occurrences are taken into account. Extending the EOO polygon southward to the Canada-US border results in a value of 2,295 km^2. This value may more accurately reflect the EOO, although there are no records from near the border in Idaho. The index of area of occupancy (IAO) was calculated as 36 km^2, based on 2 x 2 km grid cells on known occurrences. Only a discrete IAO was calculated (i.e., no extrapolation to adjacent unsurveyed habitat was included), because records could not be joined along stream systems (potential dispersal habitat) by filling in intervening areas. Undocumented occurrences that would increase the IAO probably exist. However, it is unlikely that they would increase the IAO beyond 500 km^2 (from 9 to 125 grid cells). Also, given the survey coverage in the Kootenay Region (see **Search Effort**), it is unlikely that the actual EOO is much larger than shown.

Search Effort

Little information exists on survey effort from the Kootenay region in British Columbia before the 1990s. In his review of terrestrial gastropods of the Columbia Basin, Forsyth (1999) reported only four brief accounts that included terrestrial molluscs (from 1905 – 1945). Since the early 1990s, extensive surveys have been carried out in the Kootenay region, and over 700 sites have been surveyed (Table 2; Figure 4). Most of these surveys specifically targeted terrestrial gastropods, with the exception of those by Copley and Copley, which were general arthropod surveys in which all gastropods encountered were collected and subsequently identified. Surveys have been carried out mostly in autumn, which generally is the best time for locating terrestrial gastropods, especially slugs; at this time, conditions are favourable for gastropod activity (wet and mild) and most slugs are mature, facilitating their detection.

Table 2. Summary of survey effort for terrestrial gastropods in southeastern British Columbia. Number of non-overlapping survey sites were calculated from GIS maps within the area of interest delineated in Figure 4.

Year	Months	# sites	Search time	Surveys conducted by:	Source or project*
1998-1999	September (1 in July)	40		RBCM (Kelly Sendall, Phil Lambert)	Living Landscape project; RBCM files
1990-2013	Various	135		Robert Forsyth	R. Forsyth personal main database (current up to 2013) and other unique sites; includes Flathead Bioblitz 2012
2007	July, September	63	66.1 person-hours	Biolinx Environmental Research Ltd (Kristiina Ovaska, Lennart Sopuck)	Ovaska and Sopuck 2009a
2008	September, October	45	48 person-hours	Biolinx Environmental Research Ltd (Kristiina Ovaska, Lennart Sopuck)	Ovaska and Sopuck 2009a
2009	October	17	20.9 person-hours	Biolinx Environmental Research Ltd (Kristiina Ovaska, Lennart Sopuck)	Ovaska and Sopuck 2009b
2009 - 2013	July - September	96		Claudia and Darren Copley	C. Copley data files
2008 - 2011	Various	85		Dwayne Lepitzki	Surveys in Alberta and BC; Lepitzki personal database
2010	September	56	67.9 person-hours	Biolinx Environmental Research Ltd (Kristiina Ovaska, Lennart Sopuck)	Ovaska *et al.* 2010
2011	August, September	29		Jeff Nekola, Brian Coles, Michael Horsek	Surveys for Valhalla Wilderness Society; Nekola *et al.* 2011
2012	August	6		Melissa Frey	Flathead Bioblitz; RBCM database; Note: additional sites that overlap with those of Forsyth are excluded.
2013	September	36	31.7 person-hours	Biolinx Environmental Research Ltd (Kristiina Ovaska, Lennart Sopuck)	Fieldwork associated with the preparation of COSEWIC status report for the Pygmy Slug
2013	June	14		Dwayne and Brenda Lepitzki	Flathead Bioblitz; Lepitzki data files
2014	September	72	72.2	Kristiina Ovaska and Lennart Sopuck	Gastropod surveys for BC Ministry of Environment and fieldwork associated with the preparation of COSEWIC status report for Sheathed Slug
2014	October	13		Dwayne and Brenda Lepitzki	Lepitzki and Lepitzki 2014; 26 sites were surveyed for freshwater and terrestrial molluscs, of which 13 included searches for terrestrial species
2015	September	36**	38.5 person-hours	Biolinx Environmental Research Ltd (Kristiina Ovaska, Lennart Sopuck)	Gastropod surveys for BC Ministry of Environment (Ovaska and Sopuck 2015)

*MoE-BC Ministry of Environment; RBCM-Royal British Columbia Museum

**6 sites were revisits to sites where Pygmy Slug or Sheathed Slug had been found previously.

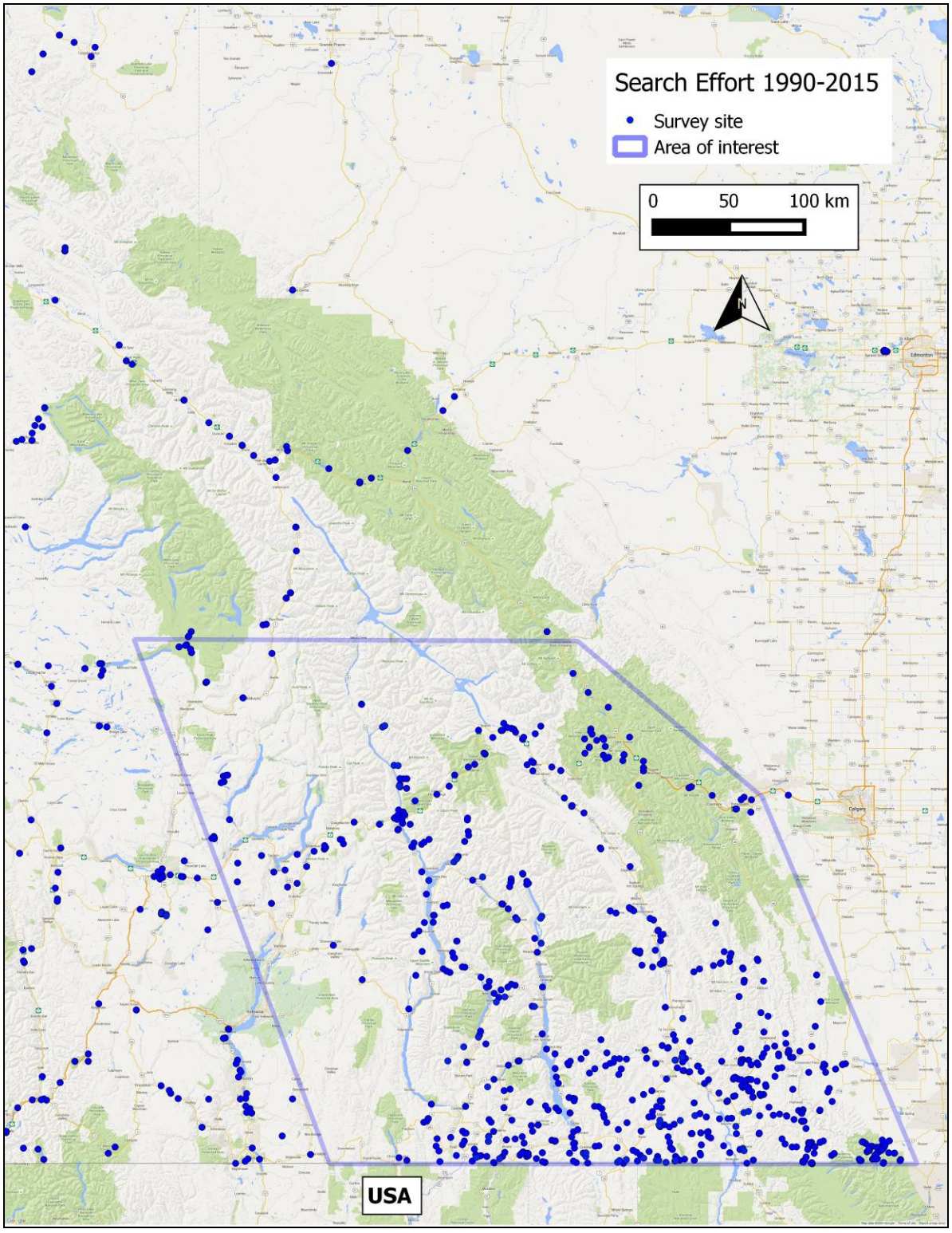

Figure 4. Overview of sites surveyed for gastropods in and around the range of Sheathed Slug in southeastern British Columbia (see Table 2 for data sources within the area of interest; map prepared by Lennart Sopuck).

Sheathed Slug was first found by Biolinx Environmental Research Ltd. in 2009; their surveys in subsequent years (2010, 2013, and 2014) resulted in further records for the species. Surveys in September 2014 and 2013 are particularly relevant and were in support of the preparation of this status report and that of Pygmy Slug (*Kootenaia burkei*), respectively (see Appendix 1 for survey sites and species found). The two species occupy similar moist forest habitats, which were targeted in both years, but the distribution of the Pygmy Slug extends farther north (to 50.5 N°) than that of Sheathed Slug (COSEWIC 2016). In 2014, when the primary target species was Sheathed Slug, the surveys focused on the southern portion of the West Kootenays, working progressively inwards towards the known range. Particular attention was paid to locating suitable survey sites in areas where gaps existed in previous survey coverage, including areas near the international border. The surveys in 2013 and 2014 resulted in the finding of two and five new records for Sheathed Slug, respectively (Sites 3 – 9 in Table 1 and Figure 3). Additional surveys of 30 new sites within the known range of the species supported by the BC Ministry of Environment in 2015 resulted in no new occurrences (Ovaska and Sopuck 2015).

Most sites in Table 2 have been surveyed only once with the objective to increase survey coverage over the large and often rugged landscape. Single visits to sites raise questions about detection probability (i.e., species present but not found). A pilot study in Kootenay National Forest in Montana examined the detection probability of 19 species of terrestrial gastropods (Hendricks *et al.* 2007). The average detection probability for slugs in general was lower ($P < 0.6$) than for large snails (shell diameter $\geq$2 cm; P usually > 0.5). The mean detection probability for Sheathed Slug ($P = 0.403$) was higher than for three other species of slugs (Pale Jumping-slug, *Hemphillia camelus*: $P = 0.277$; Pygmy Slug, *Kootenaia burkei*: $P = 0.357$; Magnum Mantleslug, *Magnipelta mycophaga*: $P = 0.264$) but lower than for the Reticulate Taildropper, *Prophysaon andersoni* ($P = 0.886$); all the above species of slugs are sympatric in British Columbia and were found during the surveys for Sheathed Slug. Hendricks *et al.* (2007) noted that the study was carried out under relatively dry conditions that curtailed surface activity of slugs and made them more difficult to detect than would be the case under wetter conditions (dead shells of large snails would still be visible). Therefore, they suggested that the values given probably represent the lower end of detection probability for both slugs and large snails.

HABITAT

Habitat Requirements

In British Columbia, six of the nine records for Sheathed Slug are from the Interior Cedar – Hemlock (ICH), three from the Engelmann Spruce – Subalpine Fir (ESSF), and one from the transitional zone between the Montane Spruce (MS) and Interior Cedar – Hemlock biogeoclimatic zones (Table 1; see Meidinger and Pojar 1991 for the classification of zones). The Interior Cedar – Hemlock zone occurs from low to mid-elevations on the slopes of the Columbia Mountains in southeastern British Columbia, extending south to eastern Washington, Idaho Panhandle, and western Montana (Ketcheson *et al*. 1991). It is characterized by cool, wet winters and warm, dry summers with much of the soil moisture

derived from snowmelt. The growing season (with above 0°C temperatures) extends up to five months, depending on the latitude and elevation. It is among the wettest interior BC zones, sharing features with moist coniferous forests along the Pacific Coast; it is sometimes referred to as the Interior Wet Belt. Productive upland coniferous forests are prevalent throughout the landscape, but topography and soil conditions have resulted in a mosaic of wetter and drier forest types with relatively high over- and understorey diversity. It is flanked at higher elevations by the Engelmann Spruce – Subalpine Fir zone, which is also wet, but conditions are harsher.

In British Columbia, Sheathed Slug has been found in mainly coniferous forest stands of varying ages, ranging from 40 – 50 years to old growth (>200 years old); most records are from older forest (Table 1). Shady, moist forest stands appear to be preferred. The slugs are often associated with abundant coarse woody debris, and moist microhabitats and refuges provided by decaying logs appear to be important. Within the forested landscape in the Kootenay region, riparian areas and gullies associated with small, often fast-flowing tributary streams provide consistently moist microhabitats for the slugs, and most records are from such habitats, seepage areas, or other very moist microsites (Table 1).

In the United States, Sheathed Slug occurs in moist forest stands, ravines, and riparian zones (Montana Government undated; Hendricks *et al*. 2007; Burke 2013). According to Frest and Johannes (1995, p. 233), “the species is restricted to rather moist sites, generally in exceptionally botanically diverse and intact forests”; this habitat description is repeated by the Montana Government (undated). Hendricks *et al*. (2007) reported the habitat as Cedar-Hemlock, Grand Fir, Douglas-fir, and Spruce-Fir associations. The slugs are frequently encountered under rocks or woody debris, or within leaf litter (Terrestrial Slugs Web undated). Pilsbry (1948, p. 732) reported that specimens had been found “…in meadows and in rock-slides, both in igneous and metamorphic rock and in limestone”. In Montana, they can be found also within talus on both north- and south-facing slopes (Montana Government undated).

The majority of records of Sheathed Slug are from mid-elevations below 1200 m above sea level both in Montana and British Columbia. The Canadian records are from 618 – 1612 m; Table 1), while the US records are from 488 – 1705 m. Montana Government undated).

Habitat suitability mapping for the Montana distribution of Sheathed Slug show that highest suitability habitat is largely confined to riparian areas and gullies along mountain streams (Montana Government undated).

Habitat Trends

Habitat trends for Sheathed Slug’s range are similar to those described for Pygmy Slug because the ranges of the two species overlap extensively in the southern Kootenay region. Where applicable, the following section uses pertinent habitat trend information from the Pygmy Slug status report (COSEWIC 2016).

Within the Sheathed Slug's Canadian range, most suitable habitats are on provincial and private forestry lands subjected to ongoing logging. The removal of tree cover, building of forestry roads, and silvicultural activities associated with forestry have had the greatest impact on the availability of habitat within the species' range, and logging continues to fragment and alter habitats. All of the known Sheathed Slug sites are within landscapes with ongoing logging (see **Threats**).

The annual allowable cut (AAC) established for Crown lands on the three timber supply areas encompassing the species' range (Arrow, Kootenay Lake, and Cranbrook) has been relatively constant over the past four decades (MFLNRO 2014a). The latest AAC for these timber supply areas, covering the next 5 – 10 years, suggests that a slightly lower level of harvest will be maintained. Most of the timber harvested in the past was from old-growth and from maturing forests on naturally disturbed areas. In the future, a greater proportion of the harvest will be obtained from regenerating second growth stands. In areas where the forest was logged 50 – 60 years ago (mainly lower to mid-elevations), conditions in maturing forests may allow the slugs to re-colonize some previously logged areas. Such increases in habitat availability will only partially compensate for the continuing degradation of habitat from logging. It is important to note, however, that logging does not occur, or is restricted, in parks, conservation lands, near fish-bearing streams, community watersheds, old-growth management areas, and special resource management zones that are scattered throughout the slug's range. The available land base for harvest for the Kootenay Lake timber supply area, which includes over half of the slugs' range, is estimated at 42% of productive forest land, after accounting for these conservation areas and other constraints to logging (MFLNRO 2014b). Additional timber is harvested each year on private lands and by woodlot licensees on Crown land (quantitative information could not be found).

Land conversions for residential and industrial developments and for agriculture have resulted in the permanent loss of slug habitat mainly on private land at lower elevations, especially along river valleys, lake shores, and highways. However, the human population density of the West Kootenay region is relatively low compared to other areas of southern BC, such as the Okanagan Valley and eastern Columbia Basin. Since 2001, the human population in the West Kootenay region has increased at a rate of only 1.3% per decade, reaching 64,379 people in 2011 (Columbia Basin Rural Development Institute 2012). Creston is the only large population centre within the species' range, and a few much smaller communities occur at Fruitvale, Salmo, Moyie Lake and Yahk. The relatively large cities of Trail and Cranbrook lie just to the west and northeast of the species' range, respectively.

Previous and ongoing habitat fragmentation due to all human activities combined, especially at lower elevations, is a concern for Sheathed Slug. Fragmentation has occurred as a result of extensive logging, increased frequency of catastrophic wildfires (due to build-up of fuels to unnatural levels), the creation of hydroelectric reservoirs and infrastructure, highway construction, urbanization, and land conversions for agriculture. The ICH biogeoclimatic zone is prone to periodic fire disturbance but to a lesser degree than drier biogeoclimatic zones in the southern interior of British Columbia (Biodiversity Guidebook 1995). Logging, on the other hand, selectively removes high-value timber in moist,

productive sites, resulting in fewer refuges being available to slugs after logging.

Climate Change

The West Kootenay Resilience Program (undated) has produced a series of documents addressing climate change and its implications in the West Kootenay region of British Columbia. A large portion of Sheathed Slug range occurs in the southern subzones of the West Kootenays. All models and scenarios examined project higher mean seasonal temperatures that increase progressively by the 2020s, 2050s and 2080s (Utzig 2012a). By 2080, winters are predicted to be 2 – 5 C° warmer and 10 – 25% wetter and summers 3 – 7°C warmer and up to 30% drier than during the baseline period (poorest performance models excluded). Associated changes that have implications for Sheathed Slug include increase in summer moisture stress, reduced levels of insulating snow cover in winter, potential increase in wildfires and insect and disease outbreaks that would reduce forest cover, and changes in seasonal stream flow patterns as a result of reduced snow-packs and summer droughts, which would alter the riparian areas inhabited by the slugs. An increase in the magnitude and frequency of extreme events, such as high intensity rain events, severe droughts, and wind storms, is also predicted (Utzig 2012a).

Wang *et al.* (2012) examined climate change effects on BC's 16 biogeoclimatic zones, which are based on large scale climate gradients and widely used to classify ecosystems in the province (Meidinger and Pojar 1991; BC Ministry of Forests and Range undated). Models showed that climate envelopes supporting this zonation have already shifted since the 1970s (Wang *et al.* 2012). Projected into the future (2020s, 2050s, and 2080s) and across the entire province, the models predict a substantial expansion of moist continental cedar-hemlock forests, typical of the ICH zone where Sheathed Slug is found, potentially expanding this zone up to three-fold by 2080, with the ICH zone becoming the most common forest type in the province over the long term (Wang *et al*. 2012).

At a regional scale, climate change projections are more complex and influenced by topography and local factors (Utzig 2012b). Climate models for the southern section of the West Kootenays within the range of Sheathed Slug indicate that the ICH zone will shift upslope and decline slightly in area over the long term under one of three climate change scenarios examined ("Warm/Moist" scenario), while it is predicted to be largely displaced by the Montane Spruce and Grand Fir ecozones under the "Hot/Wet" scenario, and by the much drier Grassland-steppe, Ponderosa Pine and Interior Douglas-fir woodlands under the "Very Hot/Dry" scenario (Table 3.1 and Figure 3.5 in Utzig 2012b). Similar declines in the extent of the ESSF zone are predicted under each scenario, being replaced by the Coastal Western Hemlock, Coast Transition, Montane Spruce and ICH ecozones. The expansion of moist and wet forest types favourable to Sheathed Slug is mostly at higher elevations (>1500 m asl) and to the north. Correspondingly, suitable habitat would shrink at lower elevations. Whether Sheathed Slug would be able to spread upwards or northwards in pace with the ecosystem shifts to take advantage of the newly available habitats is questionable. The changes may be driven largely by extreme climatic events such as summer droughts or storms and mediated through pest outbreaks, fires or other disturbances rather than occurring through gradual transition (Pojar 2010; Utzig 2012b); also novel bioclimatic zones may emerge with new combinations of seasonal climatic

variables (Utzig 2012b), increasing the unpredictability of the projections.

Historical fire regimes and projections for the future under climate change have been examined in detail for the southern portion of the West Kootenays (Utzig *et al*. 2011). Over the first half of the 20th century, fires occurred almost annually and burned large areas, with annual burn exceeding 30,000 ha in some years (Figures 2 and 3 in Utzig *et al*. 2011). A threshold appeared to have been reached around 1940 with greatly diminished annual fire frequency until the 1980s, with slight increases thereafter. The decrease was associated with a cooling trend in spring and summer and fire suppression efforts in the latter half of the century. Projected into the future, all models showed increases in the area burned. Reflecting uncertainty, there is much variability in the outputs from the different models about the magnitude of the increase in fire frequency, but by 2050 the mean projected increase for the southern West Kootenays could be 15-fold. The projected increases are more modest by 2020 (Figure 9 in Utzig *et al*. 2011).

BIOLOGY

Life Cycle and Reproduction

Sheathed Slug is hermaphroditic and lays eggs (Pilsbry 1948). However, like most pulmonate gastropods, individuals probably exchange sperm (Tompa 1984); there is no evidence of self-fertilization in this species. No details of the reproductive biology of Sheathed Slug are known.

The Montana Natural Heritage Program database contains 34 records of Sheathed Slug from June to November, with the majority of the records (24) from October (Montana Government undated; data current up to January 2015). In British Columbia, all records are from September – October, but few surveys targeting slugs have been conducted at other times of the year. Of the 15 slugs found in British Columbia, seven were deemed juveniles, based on their small size (slender body, length 10 – 16 mm; Ovaska and Sopuck unpubl. data). The smallest slugs probably represented recently hatched individuals. Juveniles presumably overwinter, but the proportion of adults that do so is unknown. The generation time is probably 1 year or slightly more, based on the small body size of the adults and relatively short life spans of arionid slugs in general.

Physiology and Adaptability

Sheathed Slug appears to require a high level of environmental moisture based on its habitat associations. Terrestrial pulmonate gastropods obtain water from the environment mainly through the integument, and mucous glands in the body and foot play an active role in water uptake (Riddle 2013). Water uptake through food ingestion is not sufficient to maintain a positive water balance, and evidence for drinking is inconclusive. Slugs are more susceptible to dehydration than snails that can withdraw into their shell to slow down water loss. Both air temperature and soil humidity are thought to be important factors affecting activity and foraging by slugs (Riddle 2013 and references therein). The existing

information is mostly from studies on European slugs, such as *Arion* species, in relation to pest control on agricultural lands, and no specific information is available on the physiology of water relations for western North American forest slugs.

The degree to which this species tolerates habitat disturbance is unknown, but it is most likely adversely affected by human activities that alter the hydrology of occupied sites and result in drying or flooding of the forest floor. Isolated habitat patches from where the species becomes extirpated are unlikely to be repopulated through immigration, at least over the short term.

Dispersal and Migration

Movements and dispersal of Sheathed Slug are unknown. Land snails in general have poor dispersal abilities if not aided by humans or transported by other passive means, such as wind or water (review in Cordeiro 2004). No passive means of transport are known for Sheathed Slug, but it is conceivable that the slugs may be transported downstream in flowing water or inadvertently attach to the fur of mammals such as bears, as speculated for other slugs (COSEWIC 2012, 2016).

Interspecific Interactions

Sheathed Slug is herbivorous/fungivorous/detrivorous, but specifics of its diet are poorly known. Pilsbry (1948) reported that the crop and stomach of the type specimen were filled with liverwort leaves (Jungermanniaceae: *Frullania* species). In British Columbia, one slug was found feeding on a well-decayed mushroom (Ovaska and Sopuck unpubl. data 2013). Similar to other western North American slugs (*Prophysaon coeruleum*: McGraw *et al.* 2002), Sheathed Slug may feed on fungi with symbiotic mycorrhizal associations with tree roots, but data are lacking.

A variety of forest floor invertebrates such as ground beetles (Coleoptera: Carabidae) and centipedes (Chilopoda) prey on slugs and probably also on Sheathed Slug. A damaged tail was noted on one specimen from British Columbia, suggesting predation by invertebrates (Ovaska and Sopuck unpubl. data 2014). Predation of the slug by vertebrates such as birds, shrews, and salamanders is also possible, but undocumented.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Surveys have focused on locating Sheathed Slug rather than on obtaining estimates of abundance or other population characteristics (see **Search Effort**). Methods have consisted of manual examination of moist microhabitats on the forest floor along meandering transects or plots, mostly during the day. In surveys by Biolinx Environmental Research Ltd., the surveys were timed to obtain an index of survey effort.

Abundance

There are no estimates of densities or population sizes. The species appears to be patchily distributed within the landscape and occurs at apparently low abundance. At occupied sites, the number of slugs found ranged from one to four, although considerable search effort was expended at some sites (Table 1). Comparisons of Sheathed Slug records with those of other native forest slugs provide some information on their relative rarity. During surveys by Biolinx Environmental Research Ltd. in 2007 – 2015, Sheathed Slug was found rarely when compared to Pale Jumping-slug, Reticulate Taildropper, and Pygmy Slug and at a similar proportion of sites as Magnum Mantleslug; (COSEWIC 2012 status: Special Concern). Records of Sheathed Slug were restricted to the southern portion of the survey area, while those of the other species were widespread.

Fluctuations and Trends

Sheathed Slug was documented from Canada only in 2009, and consequently there is no information on population trends. A historical decline can be inferred from habitat trends since European settlement and associated land conversions and resource extraction. Ongoing declines are suspected, as habitats continue to be degraded by forestry and other causes (see **Habitat Trends** and **Threats**).

In the United States, Sheathed Slug appears to be declining. Frest and Johannes (1995) reported that this species had lost most of its habitat and historical sites, but that a fair number of potentially viable sites still existed. Since then, expanded survey efforts have increased the known distribution of the species in Montana, but population trends there are unknown. NatureServe (2015) inferred a global short-term decline of 10 – 30%, based on threats and on trends reported by Frest and Johannes (1995).

Population Fragmentation

Sheathed Slug exists within a landscape that is highly fragmented and modified by logging. Six of the known occurrences are within a patchwork of active logging (# 1, 2, 4, 5, 7, 8); one site (#9) is adjacent to a large clearcut and the larger area of intact forest to the north may be logged in the future; one site (#3) is within habitat fragmented by a transmission line and infrastructure associated with a hydroelectric plant. Only one site (#6) is within a larger area of intact forest and is relatively secure. Considering the entire range of the species in British Columbia, largely intact forest exists within only one drainage system, but it is unknown whether Sheathed Slug occurs within the protected areas there (Gilnockie Provincial Park and Gilnockie Ecological Reserve).

It is possible that populations in remnant forest patches within recently logged or otherwise fragmented landscapes are not viable over the long-term, given the slugs' low dispersal capabilities, but there are no data on this. Logging and increased frequency of droughts associated with climate change exacerbate natural fragmentation of the habitat resulting from complex topography, likely further impeding movements both within and among watersheds. While riparian buffers will help alleviate adverse effects and preserve

connectivity to some degree, they are often too narrow to protect the habitat from drying through edge effects and could also expose subpopulations to flooding events, which are expected to increase in the future (see **Threats**).

Sheathed Slug was selected as one of six terrestrial mollusc target species in an assessment of conservation needs for maintaining biodiversity in the Rocky Mountains ecoregion spanning southeastern British Columbia and northwestern Montana (Rumsay *et al*. 2003). In Montana, the ecological goals for conservation of Sheathed Slug were considered not met due to its limited range and an assessment of threats such as logging, invasive species, and climate change. The specific details of this threat assessment were not provided.

Rescue Effect

Some interchange of individuals could occur with populations of Sheathed Slug in the United States, but such exchange is expected to be infrequent and slow given the poor dispersal capabilities of the slugs. Three records east of Yahk (Sites 6, 8, and 9 in Table 1) are from 1 – 5 km north of the border of British Columbia with Montana. In Montana, the nearest record is approximately 8 km south of the border (and 10 km to the southwest from Site 9, the nearest record in British Columbia); two other records are within 27 km from the border. The predicted distribution of the species in Montana according to habitat suitability modelling is patchy and less continuous near the border in the northwest than farther south (Montana Government undated). On both sides of the border, GoogleEarth™ imagery shows a mosaic of clearcuts in various stages of regeneration, which are likely to impede dispersal. An additional potential area of connectivity across the international border is through the Pend d'Oreille drainage, where an isolated record exists in British Columbia (Site 3 in Table 1). However, no records of Sheathed Slug exist from the Washington side of the border.

THREATS AND LIMITING FACTORS

Limiting Factors

Sheathed Slug exists at the northern limits of its global distribution in southeastern British Columbia, where its distribution most likely reflects post-glacial expansion from refugia farther south. Its northward expansion is probably limited by a short growing season and/or long and cold winters. Low dispersal capabilities may also be limiting its northward expansion. Due to the species' dependence on moist micro-habitats, the complex topography and the resulting mosaic of drier and wetter habitats probably constrain its distribution both within and among watersheds.

Threats

The IUCN threats calculator (Master *et al.* 2009) was used to assess threats to Sheathed Slug (Appendix 2). Threats were considered across the entire Canadian distribution of the species to account for possible undocumented sites, but using threats and land uses at known sites as guidance. The threats calculator method consists of scoring the scope, severity, and timing for each standard threat category; the overall threat impact is then computed from these ratings.

The overall threat impact for Sheathed Slug was scored as "medium" based on six low impact threats. Headings in the following narrative correspond to categories of the threats calculator, in the approximate order of their perceived importance.

Biological Resource Use (Threat 5.0):

Logging and wood harvesting (Threat 5.3) is probably the greatest threat to Sheathed Slug at present. Most of the Canadian distribution of this species is within lands used for forestry. All known sites for Sheathed Slug are within active logging landscapes; one site (Site 6) is within a larger area of relatively intact forest. Large areas of the landscape have already been subjected to clearcut and selective logging, and new logging continues to degrade habitat and fragment the species' range, but quantitative data on the amount of habitat affected over the next ten years are lacking (see **Habitat Trends**). Harvesting of maturing second growth has started in the region, also at largely unknown rates. Effects of logging on the slugs result from changes in moisture and temperature regimes on the forest floor due to canopy removal and from disturbance to the understorey vegetation and forest floor structure. Effects of recent logging on slugs in small remnant leave areas are probably still ongoing through edge effects such as drying of forest floor and lack of connectivity across the landscape.

Sheathed Slugs may be able to persist in small forest patches or riparian buffers within logged sites over the short term, as evidenced by their presence in such habitats within recently logged landscapes. However, it is conceivable that there is a time lag before the full effects of recent logging are manifested, and the long-term viability of populations in these habitats is unknown.

Within logged landscapes, this species could receive protection from forested riparian buffers. Riparian buffers are required along larger, fish-bearing streams under the BC *Forest and Range Practices Act*, but there are no such requirements for small, fishless streams (S6 streams), along which the slugs are usually found; nor are there required buffers for other non-classified drainage features, such as seepages. However, some forestry companies operating in the Kootenay region voluntarily leave buffers along all streams, regardless of their size or status (Stuart-Smith pers. comm. 2014). Even with voluntary efforts, many small streams are likely to be impacted. In addition to riparian buffers, there is usually a 7 m wide no-machinery zone along creeks, although trees may be taken from this zone. Slug habitat along creeks in steep-sided gullies would be buffered, because the terrain is usually too steep for timber harvesting (Stuart-Smith pers. comm. 2014). However, not all known sites are on steep terrain.

Climate Change and Severe Weather (Threat 11):

Severe weather and increased frequency of extreme events associated with climate change are considered pervasive in scope, because the entire Canadian range of the species is likely to be influenced by the same broad weather patterns. However, terrain and habitat features could modulate impacts on the slugs among watersheds and sites. The main impacts on the slugs will probably accrue from droughts (Threat 11.2) and flood events (Threat 11.4), both of which are predicted to increase in frequency and severity under climate change scenarios (Utzig 2012a). Because of its reliance on habitats with high moisture, prolonged and severe summer droughts may be particularly devastating to local slug populations both directly by increasing mortality and indirectly by reducing the length of time available for growth and reproduction. Consecutive years with droughts that extend well into the autumn are expected to be particularly detrimental. The Kootenay region of British Columbia experienced Stage 2 drought conditions (dry) during May, June and July 2015, followed by Stage 3 conditions (very dry) from August to mid-September (BC Ministry of Forests, Lands and Natural Resource Operations 2015). Three sites where Sheathed Slug had been found in previous years were revisited in late September 2015; the species was found at only one of these sites (1 individual within a moist log at American Creek, Site 8, where few such moist refuges were noted; Ovaska and Sopuck 2015). The species was not found at the westernmost site (9-Mile Creek), which still appeared to suffer from drought conditions and where the only moisture was restricted to a narrow strip along a creek, which was reduced to a trickle. Similarly, the species was not found at the West Yahk Road site (Site 9), where four individuals were found in September 2014. The drought may have reduced the abundance or detectability of the slugs, but the sample size is too small to draw reliable conclusions. Whether the slugs were deeper in the substrate or had suffered declines is unknown.

Increased frequency of flooding events could result in mortality or displacement of slugs living close to water courses and could scour riparian areas of the duff layer and refuges. While flooding might be of short duration along mountain streams, its effects are potentially more severe where the slugs inhabit flatter terrain that may remain inundated for longer periods.

Much uncertainty exists about the severity of the impacts of climate change and severe weather on this species, except that they are expected to be negative. Although climate patterns and droughts would be region-wide, slugs in different parts of the range may be affected differently because of differences in moisture regimes due to hydrology, terrain and availability of refuges. A precautionary approach is warranted because of the potentially widespread and serious nature of this threat. With a few exceptions, impacts associated with climate change are unstudied for terrestrial gastropods. The studies that do exist have focused on habitat shifts along altitudinal gradients in Europe and have projected range shrinkages and population declines for high elevation species (Müller *et al.* 2009) and upward altitudinal shifts for lower elevation species (Baur and Baur 2013). For Sheathed Slug, it is likely that proximate factors such as droughts that drive ecosystem shifts are more important than the shifts themselves; with their low dispersal capability and reliance on moist habitats, the slugs may not be able to track ecosystem shifts that may occur.

Invasive and Other Problematic Species (Threat 8.0):

The impact from invasive non-native species (Threat 8.1) consists of direct effects on Sheathed Slug from introduced invertebrates through predation and/or competition for food and shelter. Over 20 species of non-native gastropods have been recorded from British Columbia (Forsyth 2004). Although mostly found in disturbed areas, many are spreading into forested habitats in fragmented landscapes. Humans continue to facilitate the spread of introduced gastropods across the province, where they can be found in most areas frequented by humans, including picnic sites, campsites, and rest stops along highways. Other widely introduced invertebrates in British Columbia include carabid beetles (Coleoptera: Carabidae), which prey on gastropods (Symondson 2004). An introduced carabid beetle (*Carabus granulatus*) was observed preying on native slugs (*Hemphillia camelus* and *Prophysaon andersonii*) in the West Kootenays (Ovaska and Sopuck unpubl. data 2013). Introduced gastropods were not found at any of the sites occupied by Sheathed Slug but could be introduced to those sites readily accessed by recreational users (Sites #4, 5, 8, 9). Increased human access to the backcountry associated with resource extraction activities and an expanding road network will facilitate the spread of these and other introduced invertebrates to new areas.

Much uncertainty exists with the severity of impacts of introduced species on Sheathed Slug, as reflected in the severity rating range (1-30% decline predicted over the next 10 years). While introduced gastropods pose a threat to native gastropod faunas around the world (Mahtfeld 2000), their effects in terrestrial habitats are generally poorly documented. An exception is island faunas, where alien invertebrate predators and competitors, including other gastropods, have been largely responsible for the demise of native land snail faunas (e.g., Hawaii: Hadfield *et al*. 1993; South Pacific: Cowie 2001). In British Columbia, introduced gastropods include scavengers/predators, such as *Oxychilus* species and *Boettgerilla pallens* (an egg predator), and herbivores/detrivores, such as *Arion* species that can become exceedingly abundant in suitable habitats and could have a demographic advantage over native species in competition for resources. Carabid beetles are known predators of terrestrial gastropods in both natural and disturbed habitats, and slugs form a large portion of the diet of many generalist carabids (Symondson 2004). While snail predators tend to be specialized, predation on slugs does not appear to require specific adaptations by the beetles. Defences of slugs against carabid attacks include the production of copious amounts of highly viscous mucus, repellants or toxic chemicals in the mucus or tissues, and tail autotomy (Symondson 2004). Sheathed Slug is not known to possess any of these mechanisms.

Natural Ecosystem Modifications (Threat 7.0):

The impacts on the slugs are mainly from fire and fire suppression (Threat 7.1); Other ecosystem modifications (Threat 7.3), resulting from indirect effects of non-native species on slug habitat, were rated as unknown. Fires are harmful to terrestrial gastropods by causing direct mortality and, perhaps more importantly, by altering habitat through reduction in shelter and food sources (Jordan and Hoffman Black 2012). Due to their generally low

mobility, gastropods are both unable to escape fire events by moving away and are slow to recolonize burnt areas. In the West Kootenay region, more frequent and severe fires are predicted as climate change proceeds (see **Habitat Trends**). The size and intensity of the burn are expected to greatly influence the outcome for gastropod populations; greatest effects are likely when the burn covers a large continuous area and extends deep into the ground, while smaller, discontinuous, and less severe burns would be less devastating. In the latter situation, gastropods could survive in underground refugia or unburned habitat patches, which could serve as sources for recolonization once the habitat regenerates. Riparian areas along small creeks inhabited by the slugs may be somewhat protected from fires that sweep the landscape, especially in steep gullies and on north-facing slopes; unburned streamsides within large recent burns were observed at such sites (Ovaska and Sopuck unpubl. data 2013 - 2014).

Several studies have reported negative effects of fire on species richness and/or abundance of terrestrial gastropods (review in Jordan and Hoffman Black 2012). Snails seem to be particularly vulnerable (Anderson 2004; Duncan 2005), but effects on slugs have also been reported (Duncan 2005). In southwestern Oregon, both the distribution and abundance of four species of terrestrial gastropods studied were reduced after low-intensity prescribed fires (Duncan 2005). The effects were more severe on snails than on slugs (e.g., *Prophysaon coeruleum*), but slugs were not found at over a quarter of the sites that supported them during pre-fire surveys. The author suggested that at sites with continued persistence, slugs survived in deep fissures in coarse rock substrate or other underground refuges and suggested that the distribution of microhabitats that allow for vertical movements is important for the long-term viability of slug populations within the landscape. Fire retardants used in fighting fires can also be detrimental to slugs, but no data are available.

Transportation and Service Corridors (Threat 4.0):

The impact is mostly from roads and railroads (Threat 4.1), while land clearing associated with utility and service lines (Thread 4.2) is considered negligible. Logging roads crisscross much of the Sheathed Slug's range. New roads associated with forestry and other types of resource extraction are likely to increase over the next ten years at largely unknown rates with the expansion of these activities to new areas or reactivation of roads in previously logged areas. An extensive logging road network is already in place over much of the species' range, and mostly spur roads will be required to access new areas. Therefore, the scope for this threat was rated as "small" (1 – 10% of slugs affected). Adverse effects on slugs from new roads result from habitat loss on the road corridor and through edge effects that can extend far into the forest, including drier forest floor conditions due to increased exposure to wind and solar radiation (erosion and dust from gravel roads is considered under Pollution). Road corridors may also act as barriers to movements, resulting in increasing isolation of subpopulations.

Agriculture (Threat 2.0):

Impacts to the slugs are from livestock farming and ranching (Threat 2.3). Livestock are usually not free-ranged in dense, steep forested areas characteristic of the West Kootenays, and grazing tenures occur mostly in drier more open forests to the east of the Sheathed Slug's range (iMapBC 2015). Furthermore, cattle tend to avoid steep, forested gullies, reducing exposure of slug habitat to this threat. However, where free-ranging does occur, cattle and other livestock tend to concentrate in riparian areas, where they can affect slug habitat by compacting soils and removing understorey vegetation. Although rated as of low impact, this threat is not as significant as the other threats, especially logging and droughts.

Threats with Negligible Impacts:

The following additional threat categories were identified as potentially impacting Sheathed Slug populations, but their impacts were deemed to be currently negligible for the Canadian population as a whole; however, they could be important locally. These include housing and commercial development (Threat 1.0), energy production and mining (Threat 3.0), human intrusions and disturbance (Threat 6.0), and geological events (Threat 10.0). Development of new residential, industrial, and recreational facilities (Threats 1.1 – 1.3) is probably minimal in the slugs' habitats over the next ten years, and no proposals of such developments are known. Mining exploration (Threat 6.2) has occurred historically and continues at present, but the likelihood of new operating mines is low over the next ten years. Mining and quarrying activities are also present in the area but involve a small percentage of the Sheathed Slug's range. Recreational activities (Threat 6.1) occur sporadically throughout the species' range, but much habitat is away from well-travelled areas. Impacts are from off-trail all-terrain vehicle use that can result in soil compaction and damage to vegetation; hiking on trails has little or no impact. Where the slugs occupy steep gullies, their habitat is susceptible to landslides (Threat 10.3). Large landslides may be increasing in frequency as a result of severe storms associated with climate change. A large landslide occurred in 2008 in the vicinity of occupied sites on the slope from Sundown Creek Forest Service Road down to the creek as a result of poor drainage of the logging road. However, such occurrences are limited in scope and impact, when the entire range of the species is considered.

Threats with Unknown Impacts:

Threats with unknown impacts include pollution (Threat 9.0), other ecosystem modifications (Threat 7.3), and habitat shifting and alteration associated with climate change (Threat 11.1), which are flagged for requiring further documentation and research. Pesticides and herbicides are generally not used in forestry within the species' range, but fertilizers are occasionally applied to planted areas (Threat 9.3). Erosion and dust from gravel roads that crisscross the habitat might affect slugs and degrade their habitat (Threat 9.5). Both the scope and severity of impact of the above activities are unknown. Ecosystem modifications (Threat 7.3) are pervasive in scope, and include reforestation with Douglas-fir as part of silviculture systems and the spread of invasive plants and invertebrates, including

non-native earthworms. All the above are modifying the understorey vegetation and forest floor conditions but with largely unknown effects on native gastropods. For habitat shifting (Threat 11.1), see discussion under Climate Change and Severe Weather.

Cumulative Effects

Cumulative impacts result from additive or synergistic interactions among two or more threats, which would elevate the level of the overall threats. For Sheathed Slug, cumulative effects are likely to accrue from interactions among climate change and severe weather, fire and fire suppression, and forestry. Increased frequency and severity of prolonged summer droughts is likely to exacerbate the effects of logging (both recent and planned) and wildfires on the slug's habitat. For example, narrow forested riparian buffer zones that would otherwise support viable slug populations may no longer do so under prolonged and more frequent droughts. Severe droughts will probably increase the frequency, areal extent, and intensity of wildfires, potentially resulting in the loss of subpopulations from local areas. Both interactions would increase habitat fragmentation and isolation of subpopulations of the slugs. Any activities that increase human access, such as resource roads, increase the potential for the introduction or spread of invasive, non-native gastropods and other invertebrates. Climate change and forest disturbance are also expected to facilitate their spread with largely unknown and untracked but potentially serious impacts on native gastropod faunas.

Number of Locations

The most plausible severe threat to the Sheathed Slug is probably from logging, followed by climate change and severe weather. Considering each known site as a separate location based on logging, the number of locations corresponds to the nine occupied sites. Considering each occupied watershed as a separate location where all slugs could be affected by a single threatening event from a severe drought, then there are eight locations. Although droughts are likely to be broad-scale across the entire region, impacts on the slugs may be better assessed at the watershed scale, depending on amount of logging in the landscape, width of riparian buffers, availability of coarse woody debris, and other site-specific conditions that affect refuges for slugs and moisture regimes on the forest floor. The number of locations based solely on known sites is most likely an underestimate given incomplete survey coverage and issues related to detection probability (see **Search Effort**).

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Currently, Sheathed Slug has no official protection or status under the federal *Species at Risk Act*, B.C. *Wildlife Act*, or other legislation.

Non-Legal Status and Ranks

NatureServe (2015) provides the following global, national, and sub-national rankings for Sheathed Slug: Global status – G3G4 (rounded global status G3 - vulnerable; last reviewed Feb 2006); United States – N3N4 (vulnerable – apparently secure); Canada - N1N3 (critically imperilled – vulnerable; assigned September 2011); Idaho: S2 (imperilled); Montana – S2S3 (imperilled – vulnerable); BC - S1S3 (critically imperilled – vulnerable). In BC, Sheathed Slug is on the provincial red list of species at risk. In Montana, the species is designated as a Species of Concern (Montana Government undated).

Habitat Protection and Ownership

Several provincial parks occur within the distribution of Sheathed Slug in British Columbia, covering approximately 3% of its range, although none of the known occurrences are in these or other protected areas. Protected areas include Gilnockie (2815 ha), Stagleap (1203 ha), Ryan (58.5 ha), and Yahk (9 ha), Moyie Lake (103.9 ha) provincial parks and Gilnockie Ecological Reserve (53.5 ha). Other conservation lands with potential habitat for the species include parcels north of Pend d'Oreille Reservoir (approximately 1500 ha), Newgate-Gordon Earl Reserve (235 ha), and Gold Creek Game Reserve (35 ha) just west of Koocanusa Lake (IMap 2015). Overall, approximately 3% of the EOO is within protected areas such as parks or areas managed for wildlife habitat. Several provincial parks exist north of the known range of the species, including the relatively large West Arm, Lockhart Creek, Champion Lakes and Kianuko provincial parks. Rugged terrain and access have restricted targeted surveys for terrestrial gastropods in these areas.

Private rural and forestry lands are prevalent in the landscape in the southeast portion of the species' range between Trail and Salmo, but most of the distribution and records of Sheathed Slug are on unprotected provincial forestry lands (IMap 2015). As a provincially red-listed species impacted by forest and range practices, Sheathed Slug is potentially eligible for management under the Identified Wildlife Management Strategy of the B.C. *Forest and Range Practices Act*. However, it is not listed as identified wildlife at present, and hence no specific management measures are available or required. Riparian reserves around fish-bearing streams required under the act may help protect Sheathed Slug in logged areas, but no such protection is required around smaller, non-fish-bearing (S6) streams. Some forest companies voluntarily leave reserve areas around all water courses, including S6 streams (Stuart-Smith pers. comm. 2014).

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B.C. Conservation Data Centre:
Lea Gelling

Additional Contacts:

- Melissa Frey, Curator (molluscs), Royal British Columbia Museum, Victoria, B.C.
- Heidi Gardner, Collection Manager (molluscs), Royal British Columbia Museum, Victoria, B.C.
- Claudia Copley, Collections manager (arthropods), Royal British Columbia Museum, Victoria, B.C.
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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., biologist with Habitat Acquisition Trust, and research associate at the Royal British Columbia Museum. 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 the Kootenays. She has prepared status reports, recovery documents, and best management practices guidelines for terrestrial gastropods. Her photographs of gastropods appeared in the Royal B.C. 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 40 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. He is co-author of several status reports, recovery strategies, a multi-species action plan, and management documents for terrestrial gastropod species.

COLLECTIONS EXAMINED

Collections at Royal British Columbia Museum were queried, but no specimens were examined.

Appendix 1. Summary of sites surveyed and gastropods found by Biolinx Environmental Research Ltd. (K. Ovaska and L. Sopuck) during fieldwork for this status report in September 2014 and for the Pygmy Slug (*Kootenaia burkei*) in September 2013 in the Kootenay region of British Columbia. Additional support for surveys in 2014 came from BC Ministry of Environment. [Editoral note: This table has been modified to remove geographic coordinates. The complete table can be obtained by contacting the COSEWIC Secretariat.]

Site ID	Site description	Elev. (m)	Habitat type	Stand age (yrs)	Date	Search effort (person-min)	Species found (# of animals)
2013-1	Echo Lake Recr. Site, Akolkolex R. FSR, BC	859	Second-growth coniferous forest	80	20-Sep-13	50	*Arion rufus* (1), *Euconulus fulvus* (1), *Hemphillia camelus* (1), *Vertigo* sp (1)
2013-2	Akolkolex-Dumont FSR, BC	600	Coniferous old growth forest; moist & rich site	200	20-Sep-13	60	*Arion* sp *(7), Cryptomastix mullani (2), Discus* sp *(1), Discus whitneyi (1), Euconulus fulvus (1) Microphysula ingersollii (2), Nesovitrea* sp*. (1), Vitrina pellucida (3), Zonitoides* sp *(1)*
2013-3	Akolkolex FSR (Site 1), BC	646	Second-growth mixed-wood forest; along small creek	50	20-Sep-13	60	*Discus whitneyi (12), Euconulus fulvus (1), Hemphillia camelus (1), Microphysula ingersollii (3), Nesovitrea* sp.*(2), Punctum randolphii (1), Vertigo* sp*. (1), Vitrina pellucida (4)*
2013-4	Akolkolex FSR (Site 2), BC	635	Second-growth mixed-wood forest; along small creek	60-70	20-Sep-13	60	*Deroceras laeve* (1), *Discus* sp (1), *Hemphillia camelus* (8), *Microphysula ingersollii* (1)
2013-5	Little Fish Creek (near), off HWY 23, S of Revelstoke, BC	560	Second-growth mixed-wood forest; moist depression	30-40	20-Sep-13	40	*Allogona ptygophora (1), Discus whitneyi (6), Nesovitrea* sp*. (3), Zonitoides arboreus (1)*
2013-6	Eagle Bay Recr. Site, off Shelter Bay FSR, on Arrow Lake, BC	451	Second-growth coniferous forest; narrow strip of riparian habitat along small creek	70	20-Sep-13	90	*Prophysaon andersoni* (3), *Zonitoides arboreus* (2)
2013-7	Catherine Lake, W side of Upper Arrow Lake, BC	833	Second-growth mixed-wood forest; along lakeshore	40-50	21-Sep-13	60	*Allogona ptygophora* (9), *Euconulus fulvus* (3), *Hemphillia camelus* (6), *Zonitoides* sp (3)
2013-8	Fosthall/Mosquito Lake FSR, W of Upper Arrow Lake, BC	700	Older coniferous forest; moist depression	100	21-Sep-13	60	None
2013-9	Mosquito Lake Recr. Site, W of Upper Arrow Lake, BC	682	Older mixed-wood forest; narrow remnant strip of forest along lake shore	100	21-Sep-13	40	*Euconulus praticola*, *Vertigo* sp, *Zonitoides* sp
2013-10	Mosquito Cr. FSR, W of Upper Arrow Lake, BC	612	Young second-growth mixed-wood forest; along small creek	30	21-Sep-13	60	*Cryptomastix mullani (2), Hemphillia camelus (9), Microphysula ingersollii (1), Nesovitrea* sp.*(1), Vertigo* sp *(1), Vitrina pellucida (3)*
2013-11	Steven's Cr. Recr. Site, W of Upper Arrow Lake, BC	842	Second-growth mixed-wood forest, along fast-flowing creek	40-50	21-Sep-13	60	*Cryptomastix mullani (4), Euconulus fulvus (1), Hemphillia camelus (1), Nesovitrea* sp.*(1), Punctum randolphii (5), Vertigo* sp *(1)*

Site ID	Site description	Elev. (m)	Habitat type	Stand age (yrs)	Date	Search effort (person-min)	Species found (# of animals)
2013-12	Whatshan R. FSR (near east end of Whatshan Lake), BC	693	Second-growth mixed-wood forest; moist site	60	21-Sep-13	40	*Cryptomastix mullani (3), Discus whitneyi (4), Euconulus fulvus (2), Hemphillia camelus (1), Nesovitrea* sp*. (2), Zonitoides* sp *(1)*
2013-13	McDonald Cr. Prov. Park, E side of Arrow Lake, BC	456	Second-growth mixed-wood forest; Disturbed camping area	70	21-Sep-13	120	*Allogona ptygophora* (1), *Arion rufus* (2), *Cepaea nemoralis* (20), *Hemphillia camelus* (1), *Prophysaon andersoni* (22)
2013-14	Slewiskin (McDonald) FSR (Site 1), S of Nakusp, BC	745	Older mostly coniferous forest; along fast-flowing tributary stream	100	22-Sep-13	40	*Discus whitneyi* (5), *Euconulus fulvus* (3), *Vertigo* sp (1), *Zonitoides* sp (2), *Zonitoides arboreus* (1)
2013-15	Slewiskin (McDonald) FSR (Site 2), S of Nakusp, BC	640	Second-growth mixed-wood forest; along fast-flowing tributary creek	60-70	22-Sep-13	60	*Allogona ptygophora (1), Cryptomastix mullani (3), Discus whitneyi (1), Kootenaia burkei (1), Microphysula ingersollii (2), Nesovitrea* sp*. (1), Planigyra clappi (6), Punctum randolphii (1), Vertigo* sp*. (8), Vitrina pellucida (3), Zonitoides arboreus (3)*
2013-16	East Wilson Cr. FSR (Site 1), N of New Denver, BC	673	Young second-growth mixed-wood forest; along fast-flowing tributary creek	40	22-Sep-13	50	*Discus whitneyi (20; may include Radiodiscus), Euconulus fulvus (2), Microphysula ingersollii (1), Nesovitrea* sp*. (3), Punctum randolphii (1), Radiodiscus abietum (1), Vertigo* sp*. (10), Zonitoides arboreus (1)*
2013-17	East Wilson Cr. FSR (Site 2), N of New Denver, BC	581	Second-growth mixed-wood forest; along fast-flowing tributary creek	40-50	22-Sep-13	60	*Arion* sp*. (2), Cryptomastix mullani (3), Discus whitneyi (2), Euconulus fulvus (2), Kootenaia burkei (1), Punctum randolphii (5), Vertigo* sp*. (10), Zoogenetes harpa (10)*
2013-18	Kane Cr. FSR, E of New Denver, BC	829	Second-growth mixed-wood forest; along fast-flowing tributary creek	70-80	22-Sep-13	60	*Arion* sp*. (3), Euconulus fulvus (1), Hemphillia camelus (2), Nesovitrea* sp*. (1), Oreohelix* sp *(1), Radiodiscus abietum (1),Vertigo* sp*. (1), Zonitoides arboreus (1)*
2013-19	Keen Cr. FSR, W of Kaslo, BC	758	Old-growth coniferous forest; moist area along creek	200+	22-Sep-13	50	*Discus* sp. (1), *Euconulus fulvus* (3), *Pristiloma* sp (1), *Vertigo* sp. (3), *Zonitoides* sp (1)
2013-20	Kokanee Cr. Prov. Park, BC	558	Second-growth mixed-wood forest; Disturbed forest at campsite	80	22-Sep-13	80	*Arion rufus* (3), *Cepaea nemoralis* (50), *Cryptomastix mullani* (1), *Limax maximus* (1)
2013-21	Sentinel Mtn FSR, E of Castlegar, BC	526	Second-growth mixed-wood forest; forest edge at roadside	50	23-Sep-13	50	*Arion* sp *(6), Arion intermedius (10), Cryptomastix mullani (9), Deroceras reticulatum (8), Discus whitneyi (25), Euconulus fulvus (4), Nesovitrea* sp*.ovitrea* sp *(2), Vertigo* sp *(1), Vitrina pellucida (7), Zonitoides* sp *(1)*
2013-22	Murphy Cr., S of Castlegar, BC	437	Young second-growth mixed-wood forest; Disturbed site along creek-side	30	23-Sep-13	40	*Cryptomastix mullani (4), Nesovitrea* sp*. (7), Punctum randolphii (1), Zonitoides arboreus (2)*
2013-23	Casino Cr., SE of Trail, BC	1070	Second-growth mixed-wood forest; seepage area within dry forest	70	23-Sep-13	60	*Anguispira kochi (3), Cryptomastix mullani (4), Euconulus fulvus (2), Punctum randolphii (2), Vertigo* sp*. (5), Zonitoides arboreus (2)*

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2013-24	Seven Mile Road, Pend d'Oreille, BC	521	Second-growth coniferous forest; Disturbed stream-side forest	60	23-Sep-13	40	*Allogona ptygophora (4), Deroceras reticulatum (4), Euconulus fulvus (1), Haplotrema vancouverense (2), Microphysula ingersollii (1), Prophysaon andersoni (1), Punctum randolphii (2), Vertigo* sp. *(2)*
2013-25	9 Mile Cr. (Site 1), Pend d'Oreille, BC	703	Young second-growth mixed-wood stand; Disturbed stream-side forest	30	23-Sep-13	40	*Cryptomastix mullani* (1), *Deroceras laeve* (2), *Discus whitneyi* (2), *Euconulus fulvus* (1), *Oreohelix* sp. (1)
2013-26	9 Mile Cr. (Site 2A), Pend d'Oreille, BC	618	Older coniferous forest; moist forest along creek	100	23-Sep-13	60	*Allogona ptygophora* (5), *Cryptomastix mullani* (4), *Euconulus fulvus* (1), *Kootenaia burkei* (1), *Oreohelix* sp. (2), *Zacoleus idahoensis* (2)
2013-27	Sheep Cr. FSR (Site 1), S of Salmo, BC	1179	Older mixed-wood forest; riparian forest along fast-flowing tributary creek	100+	24-Sep-13	50	*Discus whitneyi* (1), *Euconulus fulvus* (15), *Kootenaia burkei* (3)
2013-28	Sheep Cr. FSR (Site 2), S of Salmo, BC	969	Second-growth mixed-wood forest; riparian area along fast-flowing creek	80	24-Sep-13	40	*Discus whitneyi* (1), *Euconulus fulvus* (20), *Hemphillia camelus* (3), *Kootenaia burkei* (2), *Prophysaon andersoni* (2), *Vertigo* sp. (1), *Zonitoides arboreus* (3)
2013-29	Ezekiel - Corn Cr. FSR, SW of Creston, BC	841	Second-growth coniferous forest; along fast-flowing creek	70-80	24-Sep-13	40	*Allogona ptygophora* (1), *Anguispira kochi* (1), *Cryptomastix mullani* (1), *Discus whitneyi* (1), *Euconulus fulvus* (5), *Microphysula ingersollii* (1)
2013-30	Spider-Kid Cr. FSR, E of Creston, BC	961	Older mixed-wood forest; along fast-flowing creek	100+	24-Sep-13	70	*Cryptomastix mullani* (3), *Discus* sp. (2), *Euconulus fulvus* (2), *Hemphillia camelus* (2), *Vertigo* sp. (5), *Zonitoides* sp (1)
2013-31	Carroll Cr. Road, W of Yahk, BC	993	Old-growth coniferous forest; moist area along creek	200+	24-Sep-13	50	*Kootenaia burkei* (1), *Zacoleus idahoensis* (1)
2013-32	Gold Cr. FSR, E of Cranbrook, BC	1199	Second-growth coniferous forest; moist stream-side in dry landscape	80	25-Sep-13	40	*Deroceras laeve* (1), *Discus* sp. (1), *Euconulus fulvus* (2), *Vertigo* sp. (3), *Zonitoides arboreus* (1)
2013-33	Teepee Cr. FSR, SE of Cranbrook, BC	1125	Older coniferous forest; moist creek-side	100	25-Sep-13	40	*Discus whitneyi* (1), *Euconulus fulvus* (1), *Kootenaia burkei* (9), *Vertigo* sp. (1)
2013-34	Plumbob Cr. FSR, SE of Cranbrook, BC	1059	Second-growth mixed-wood forest; moist depression and riparian area along slow-moving creek	80	25-Sep-13	40	*Discus whitneyi* (1), *Euconulus fulvus* (4), *Oreohelix* sp. (2)
2013-35	Caven Cr. FSR, ca. 4 km W of Koocanusa Lake, BC	810	Second-growth coniferous forest; moist depression in dry landscape	80	25-Sep-13	40	*Euconulus fulvus* (3), *Zonitoides arboreus* (2)
2014-1A	Wait Cr/Lost Dog Cr, junction ca. 20 km NE from Kimberley, BC	867	Bottom of ravine in drier forest	20	16-Sep-14	170	*Euconulus fulvus* (10), *Microphysula ingersollii* (5), *Zonitoides arboreus* (1)

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2014-1B	Wait Cr/Lost Dog Cr, junction ca. 20 km NE from Kimberley, BC	849	Tributary creek bed on floodplain (dry)	15	16-Sep-14	60	*Deroceras reticulatum* (25), *Euconulus fulvus* (1), *Nesovitrea* sp. (3), *Zonitoides arboreus* (1)
2014-1C	Wait Cr/Lost Dog Cr,junction ca. 20 km NE from Kimberley, BC	856	Riparian area along creek in ranchland meadow	NA	15-Sep-14	40	*Deroceras reticulatum* (12), *Vitrina pellucida* (1), *Zonitoides nitidus* (3)
2014-2A	Kimberley Nature Park (Site 1), Kimberley, BC	1117	Riparian area along small, fast-flowing creek in shaded forest	70	16-Sep-14	50	*Deroceras reticulatum* (2), *Discus* sp. (1), *Euconulus fulvus* (2), *Hemphillia camelus* (2), *Zonitoides arboreus* (2)
2014-2B	Kimberley Nature Park (Site 2), Kimberley, BC	1114	Riparian area along small, fast-flowing creek under cottonwoods in shaded forest	70	16-Sep-14	30	*Arion circumscriptus* (1), *Discus whitneyi* (3), *Euconulus fulvus* (3), *Nesovitrea* sp. (6), *Vitrina pellucida* (1), *Zonitoides arboreus* (2)
2014-2C	Kimberley Nature Park (Site C, Elmer Lake), Kimberley, BC	1144	Riparian area along small creek flowing into Elmer Lake in shaded forest	60	16-Sep-14	30	*Discus whitneyi* (5), *Euconulus fulvus* (12), *Zonitoides arboreus* (2)
2014-3	Norbury Provincial Park, NE of Cranbrook, BC	849	Moist pocket of habitat in woodlot in lowland depression	50	17-Sep-14	70	*Deroceras laeve* (3), *Discus whitneyi* (8), *Euconulus fulvus* (2), *Punctum randolphii* (1), *Vitrina pellucida* (15), *Zonitoides nitidus* (38)
2014-4	Bummers Flats (Site 1), NE of Cranbrook, BC	767	Forest edge on floodplain of Kootenay R.; patch of aspens (some large) and thicket of shrubs	60	17-Sep-14	50	*Deroceras laeve* (4), *Discus whitneyi* (2), *Euconulus fulvus* (1), *Euconulus praticola* (4), *Nesovitrea* sp. (1), *Zonitoides nitidus* (1)
2014-5	Rest area on HWY 95A (Lost Dog Creek area), ca. 10 km E of Kimberley, BC	892	Floodplain of river; dense spruce stands along river; periodic flooding	100	17-Sep-14	60	*Deroceras laeve* (1), *Deroceras reticulatum* (2), *Discus whitneyi* (5), *Euconulus fulvus* (2)
2014-6	Meachen Cr. Falls (Site 1), S of St. Mary's Lake, BC	1100	Ravine along river; lots of windthrow	100	18-Sep-14	60	*Hemphillia camelus* (1), *Vertigo* sp. (6)
2014-7	Meachen Cr. FSR (Site 2), ca 11 km S of St. Mary's Lake, BC	1208	Steep mossy ravine of fast-flowing tributary creek of Meachen Cr.; rocky, substrate along creek	100+	18-Sep-14	50	*Hemphillia camelus* (5), *Vertigo* sp. (5)
2014-8	Meachen Cr. FSR (Site 3 at Fiddler Cr.), ca. 14 S of Mary's Lake, BC	1284	North-facing sloping side of ravine with young cottonwoods along fast-flowing tributary creek; pockets of deep leaf litter under cottonwoods	60-70	18-Sep-14	40	*Euconulus fulvus* (1), *Kootenaia burkei* (4), *Microphysula ingersollii* (1), *Vertigo* sp. (7)
2014-9	Meachen Cr. FSR (Site 4), S of St. Mary's Lake, BC	1457	Seepage on north slope		18-Sep-14	50	*Hemphillia camelus* (8)

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2014-10	Meachen Cr. FSR (Site 5) S of St. Mary's Lake, BC	1567	Mid-slope of forest sloping towards river; moist site but not riparian	150+	18-Sep-14	52	*Hemphillia camelus* (2)
2014-11	Hellroaring Cr. FSR (Site 1), S. of St. Mary's Lake, BC	1304	Cottonwood fringe along road in steep mid-slope forest	60-70	18-Sep-14	60	*Discus whitneyi* (3), *Kootenaia burkei* (1), *Microphysula ingersollii* (3), *Punctum randolphii* (1), *Vertigo* sp. (1), *Vitrina pellucida* (1)
2014-12	Hellroaring Cr. FSR (Site 2), S. of St. Mary's Lake, BC	1372	Narrow riparian zone along fast-flowing tributary creek through old clearcut; patch of old forest across road along stream (opposite side of road from search area)	20	18-Sep-14	68	*Euconulus fulvus* (2), *Hemphillia camelus* (9), *Magnipelta mycophaga* (1), M*icrophysula ingersollii* (2), *Punctum randolphii* (2), *Vertigo* sp. (1), *Zonitoides* sp. (1)
2014-13	Gold Cr. FSR (Site 1), ca. 35 km S of Cranbrook, BC	1113	Flat area along creek-side floodplain with some large spruce	100+	19-Sep-14	40	*Deroceras laeve* (8), *Deroceras reticulatum* (5), *Discus whitneyi* (12), *Euconulus fulvus* (4), *Microphysula ingersollii* (1), *Zonitoides arboreus* (2)
2014-14	Gold Cr. FSR (Site 2), W of Koocanusa Lake, BC	972	Well-drained flat area along creek-side	70	19-Sep-14	40	*Discus whitneyi* (1)
2014-15	Wickman Cr. FSR (Site 1), off Yahk R. FSR, W of Koocanusa Lake, BC	1159	Riparian floodplain along creek and upland forest edge (alder fringe)	40	19-Sep-14	50	*Deroceras laeve* (3), *Discus whitneyi* (8), *Euconulus fulvus* (1), *Microphysula ingersollii* (1), *Vitrina pellucida* (1)
2014-16	Wickman Cr. FSR (Site 2), off Yahk R. FSR, W of Koocanusa Lake, BC	1184	Cottonwood stand along creek in moist depression	40	19-Sep-14	50	*Discus whitneyi* (2), *Euconulus fulvus* (2), *Hemphillia camelus* (3), *Microphysula ingersollii* (3), *Vertigo* sp. (2), *Zonitoides* sp. (1)
2014-17A	Cherry Cr. FSR (Site 1), near Cherry Lake, BC	1231	Stunted forest on south-facing slope at south end of lake	40-50	19-Sep-14	70	*Discus whitneyi* (2), *Zacoleus idahoensis* (2), *Zonitoides* sp. (1)
2014-17B	Cherry Cr. FSR (Site 2), SW end of Cherry Lake, BC	1221	Rich alluvial site by stream (inlet/outlet of lake); selectively logged	80-90	20-Sep-14	44	*Hemphillia camelus* (3)
2014-17C	Cherry Cr. FSR (Site 3), near Cherry Lake, BC	1229	Alluvial flat by stream, perhaps seasonally flooded; moist site	80-90	20-Sep-14	50	*Discus whitneyi* (3), *Euconulus fulvus* (2), *Kootenaia burkei* (2), *Nesovitrea* sp. (1), *Zonitoides arboreus* (2)
2014-19	Bloom Cr. FSR (Site 1), BC	1213	Ravine in coniferous forest	100+	20-Sep-14	50	*Discus whitneyi* (4), *Euconulus fulvus* (1), *Hemphillia camelus* (1), *Zonitoides arboreus* (3)
2014-20	Bloom Cr. FSR (Site 2), BC	1246	Riparian zone along fast-flowing tributary creek in otherwise dry forest; north-facing, shaded site	50-60	20-Sep-14	80	*Euconulus fulvus* (1), *Hemphillia camelus* (11), *Microphysula ingersollii* (1), *Vertigo* sp. (2)
2014-21	Bloom Cr. FSR (Site 3), BC	1269	Riparian area along small stream (trickle of water) in second growth forest	60	20-Sep-14	60	*Discus whitneyi* (2), *Euconulus fulvus* (1), *Hemphillia camelus* (5), *Kootenaia burkei* (1), *Punctum randolphii* (1), *Vertigo* sp. (1)

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2014-22	Yahk R FSR (Site 1; near Blacktail Cr.), BC	1595	Seepage along small creek in spruce forest on north-facing slope	120+	20-Sep-14	70	*Hemphillia camelus* (2), *Microphysula ingersollii* (3), *Punctum randolphii* (1), *Zacoleus idahoensis* (1)
2014-23	Gilnockie Cr. (Rec site), off Yahk R FSR, BC	1051	Riparian floodplain forest by creek	80	21-Sep-14	40	*Deroceras reticulatum* (1), *Euconulus fulvus* (1), *Hemphillia camelus* (1), *Zonitoides arboreus* (1)
2014-24	Yahk R FSR (Site 2), BC	1105	Riparian area by slow-moving tributary creek; mostly clearcut, some selective cutting (with some older trees ca. 70 years old)	20	21-Sep-14	40	*Allogona ptygophora* (2), *Oreohelix strigosa* (1)
2014-25	Yahk R FSR (Site 3), BC	1111	Moist, periodically flooded alluvial site along fast-slowing larger stream (Yahk River); forest gap with abundant understorey vegetation	100	21-Sep-14	40	*Allogona ptygophora* (4), *Euconulus fulvus* (2), *Kootenaia burkei* (1), *Magnipelta mycophaga* (1), *Microphysula ingersollii* (1), *Oreohelix* sp. (1), *Zonitoides arboreus* (1)
2014-26	Yahk R FSR (Site 4), BC	1216	Riparian forest along small tributary stream	60-70	21-Sep-14	50	*Discus whitneyi* (1)
2014-27	Yahk R FSR (Site 5), BC	1147	Riparian forest along stream; clearcut on other side of stream	80-100	21-Sep-14	110	None
2014-28	Yahk R FSR (Site 6) at Malpas Cr. FSR, BC	1323	Older moist coniferous stand with small canopy gaps and depressions with herbaceous vegetation	100+	21-Sep-14	50	*Euconulus fulvus* (1), *Hemphillia camelus* (2), *Microphysula ingersollii* (1), *Vertigo* sp. (1)
2014-29	Yahk R FSR (Site 7), BC	1627	Riparian forest along tributary creek in otherwise dry, pine-dominated forest	80	21-Sep-14	40	None
2014-30	Yahk R FSR (Site 8), BC	1612	Patch of trees in ravine	60-70	21-Sep-14	60	*Zacoleus idahoensis* (1)
2014-32	Lamb Cr. FSR (Site 1), W of Moyie, BC	1121	Moist riparian floodplain in narrow ravine (1-sided) within landscape of shelter wood logging; several very large cottonwoods	70	22-Sep-14	40	*Deroceras laeve* (1), *Discus whitneyi* (12), *Euconulus fulvus* (1), *Kootenaia burkei* (1), *Microphysula ingersollii* (1), *Punctum randolphii* (1), *Vertigo* sp. (4)
2014-33	Tate Cr. FSR (Site 1),off Lamb Cr. FSR, BC	1194	Riparian buffer (50-75m wide) in rich floodplain along creek	80	22-Sep-14	40	*Discus whitneyi* (1), *Hemphillia camelus* (1), *Kootenaia burkei* (5), *Vertigo* sp. (1), *Vitrina pellucida* (1)
2014-34	Tate Cr. FSR (Site 2),off Lamb Cr. FSR, BC	1392	Forested ravine along small creek (riparian zone <20 m) and surrounding upland coniferous forest	150	22-Sep-14	50	*Euconulus fulvus* (2), *Hemphillia camelus* (2), *Kootenaia burkei* (2), *Microphysula ingersollii* (1), *Vertigo* sp. (3)

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2014-35	Tate Cr. FSR (Site 3),off Lamb Cr. FSR, BC	1384	Moist coniferous forest with little understorey except in canopy gaps and old road/trail that traverses site; transitional forest between ICH and ESSF	125+	22-Sep-14	40	*Euconulus fulvus* (1), *Hemphillia camelus* (1), *Microphysula ingersollii* (2), *Vertigo* sp. (1), *Zonitoides arboreus* (2)
2014-36	Irishman R. FSR, near Moyie, BC	971	Floodplain of creek in pocket of cedars, continuous with older forest along creek	60-70	22-Sep-14	40	*Discus whitneyi* (1), *Hemphillia camelus* (1), *Kootenaia burkei* (1)
2014-37	Hawkins-Canuck Cr FSR (Site 1), E of Yahk, BC	1041	Shallow ravine with an intermittent, small creek; moist, north-facing site with abundant herbaceous vegetation	70	23-Sep-14	70	*Allogona ptygophora* (7), *Anguispira kochi* (6), *Discus whitneyi* (12), *Hemphillia camelus* (2), *Magnipelta mycophaga* (2), *Prophysaon andersoni* (45), *Punctum randolphii* (1)
2014-38	Hawkins-Canuck Cr FSR (Site 2), E of Yahk, BC	1222	Shallow ravine with flowing creek and narrow riparian zone	50-60	23-Sep-14	40	*Discus whitneyi* (15), *Euconulus fulvus* (3), *Hemphillia camelus* (4), *Punctum randolphii* (1), *Vertigo* sp. (4)
2014-39	American Cr. FSR, off Hawkins Cr, Meadow Rd, E of Yahk, BC	1135	Canopy gap with abundant herbaceous growth on sloping terrain in moist forest; seepage area (mostly dry) on site	60-70	23-Sep-14	60	*Anguispira kochi* (60), *Discus* sp. (20), *Oreohelix strigosa* (4), *Prophysaon andersoni* (1), *Zacoleus idahoensis* (1)
2014-40	West Yahk Rd, West of Yahk, BC	1150	Bottom of gully of small tributary creek (to Hawkins Cr) and surrounding forest	100+	23-Sep-14	80	*Allogona ptygophora* (1), *Discus whitneyi* (10), *Euconulus fulvus* (3), *Vitrina pellucida* (1), *Zacoleus idahoensis* (4)
2014-41	Cold-Freeman FSR (Site 1), off Hawkins FSR, E of Yahk, BC	1277	Forest edge and ravine along small creek, parallel to road	70-80	23-Sep-14	40	*Deroceras laeve* (3), *Hemphillia camelus* (2), *Microphysula ingersollii* (1)
2014-42	Cold-Freeman FSR (Site 2), off Hawkins FSR, E of Yahk, BC	1179	Moist riparian area with hummocks and depressions along creek	70-80	23-Sep-14	40	*Discus whitneyi* (3), *Euconulus fulvus* (2), *Kootenaia burkei* (2)
2014-43	Goat R FSR (Site 1), NE of Creston, BC	849	Narrow riparian zone by fast-flowing tributary creek	70	24-Sep-14	40	*Discus whitneyi* (3), *Euconulus fulvus* (2), *Microphysula ingersollii* (3), *Punctum randolphii* (2)
2014-44	Skelly Cr FSR (Site 1), off Goat Cr. FSR, NE of Creston, BC	944	Riparian floodplain along creek	60-70	24-Sep-14	40	*Discus whitneyi* (1), *Kootenaia burkei* (1), *Microphysula ingersollii* (2), *Punctum randolphii* (1), *Vertigo* sp. (1)
2014-45	Skelly Cr FSR (Site 2), off Goat Cr. FSR, NE of Creston, BC	1095	Narrow (ca 10 m wide) riparian zone along fast-flowing tributary creek, surrounded by dense coniferous forest with little understorey	40-50	24-Sep-14	56	*Discus* sp. (2), *Kootenaia burkei* (1), *Microphysula ingersollii* (1), *Vertigo* sp. (1)

Site ID	Site description	Elev. (m)	Habitat type	Stand age (yrs)	Date	Search effort (person-min)	Species found (# of animals)
2014-46	Goat R FSR (Site 2), NE of Creston, BC	1092	Moist depression within ca. 50 m from river	60-70	24-Sep-14	40	*Deroceras laeve* (1), *Euconulus fulvus* (2), *Kootenaia burkei* (1), *Microphysula ingersollii* (3), *Vertigo* sp. (1), *Zonitoides arboreus* (2)
2014-47	Mt. Thompson FSR (Site 1), E of Creston, BC	855	Moist riparian area along fast-flowing creek in otherwise dry coniferous slope with little understory	90-100	24-Sep-14	54	*Anguispira kochi* (1), *Discus whitneyi* (5), *Euconulus fulvus* (1), *Kootenaia burkei* (1), *Punctum randolphii* (1)
2014-48	Mt. Thompson FSR (Site 2), E of Creston, BC	1538	Seepage area in ravine/canopy gap	150+	24-Sep-14	40	*Discus whitneyi* (1), *Euconulus fulvus* (1), *Vitrina pellucida* (1)
2014-49	Sanca Cr FSR (Site 1), N of Creston, BC	1189	Narrow (ca 10 m wide) riparian zone along fast-flowing tributary creek in otherwise dry, pine-dominated landscape; rare, moist area	40	25-Sep-14	40	*Hemphillia camelus* (1), *Kootenaia burkei* (5), *Microphysula ingersollii* (1), *Nesovitrea* sp. (1), *Punctum randolphii* (2)
2014-50	Sanca Cr FSR (Site 2), N of Creston, BC	1339	Coniferous slope in older forest; small seepage at site	100+	25-Sep-14	40	*Discus whitneyi* (4), *Euconulus fulvus* (4), *Hemphillia camelus* (1), *Punctum randolphii* (1), *Vertigo* sp. (1), *Zonitoides arboreus* (2)
2014-51	Sanca Cr FSR (Site 3; South Fork), N of Creston, BC	1360	Riparian area along small tributary creek in older coniferous forest at valley bottom	150+	25-Sep-14	44	*Hemphillia camelus* (2), *Vertigo* sp. (1)
2014-52	Sanca Cr FSR (Site 4; South Fork), N of Creston, BC	1585	Moist riparian area on floodplain along stream in older forest; abundant blowdown and big boulders	100+	25-Sep-14	40	*Euconulus fulvus* (2), *Kootenaia burkei* (1)
2014-53	Duck Lake (Site 1), Creston Valley, BC	544	Cottonwood stand on floodplain along Kootenay River	50-60	25-Sep-14	30	*Allogona ptygophora* (100+), COCLU (1), *Deroceras reticulatum* (1), *Oreohelix strigosa* (100+)
2014-55	Dodge Cr. FSR (Site 1), S of Creston, BC	1052	Narrow riparian zone along small, dry tributary creek and surrounding upland forest	30-40	26-Sep-14	46	*Anguispira kochi* (13), *Discus whitneyi* (1), *Hemphillia camelus* (2), *Oreohelix strigosa* (1), *Vitrina pellucida* (1)
2014-56	Dodge Cr. FSR (Site 2) at Dodge Cr, S of Creston, BC	1325	Riparian zone in young forest at headwaters of Dodge Cr; landscape is otherwise dry with clearcutting and only a few creeks	30-40	26-Sep-14	80	*Anguispira kochi* (4), *Discus* sp. (3), *Euconulus fulvus* (3), *Hemphillia camelus* (7), *Kootenaia burkei* (1), *Microphysula ingersollii* (1), *Punctum randolphii* (1), *Vertigo* sp. (50), *Vitrina pellucida* (1)
2014-57	Blazed Cr/Jersy Cr FSR off HWY 3, W of Creston, BC	1102	Older coniferous forest along fast-flowing creek	100+	26-Sep-14	44	*Anguispira kochi* (3), *Cryptomastix mullani* (1), *Discus whitneyi* (2), *Hemphillia camelus* (1), *Nesovitrea* sp. (1), *Oreohelix* sp. (1), *Zonitoides arboreus* (1)
2014-58	Maryland FSR (Site 1) off HWY 3, W of Creston, BC	1508	Subalpine open forest; very moist	100+	26-Sep-14	54	*Hemphillia camelus* (2), *Pristiloma chersinella* (1)

Site ID	Site description	Elev. (m)	Habitat type	Stand age (yrs)	Date	Search effort (person-min)	Species found (# of animals)
2014-59B	Boundary Lake off Boundary L. FSR, W of Creston, BC	1288	Moist old growth forest with seepages close to lakeshore	150+	26-Sep-14	50	*Deroceras laeve* (1), *Discus whitneyi* (1), *Hemphillia camelus* (1), *Pristiloma chersinella* (1)
2014-59C	Boundary Lake, W of Creston, BC	1288	Moist old growth forest with seepages close to lakeshore	150+	26-Sep-14	130	*Hemphillia camelus* (2)
2014-60	Maryland Cr FSR, W of Boundary L, BC	1300	Moist coniferous old growth stand by stream	125+	27-Sep-14	40	*Discus whitneyi* (1), *Hemphillia camelus* (2), *Vertigo* sp. (1)
2014-61	Monk Cr FSR, W of Creston, BC	1411	Moist old coniferous forest with productive deep soil in swale	100+	27-Sep-14	60	*Discus whitneyi* (5), *Kootenaia burkei* (2), *Magnipelta mycophaga* (1), *Pristiloma chersinella* (5), *Punctum randolphii* (2)
2014-62	Stagleap Provincial Park (from Monk Cr FSR Entrance), Kootenay Pass, BC	1960	High elevation old growth forest, very moist	150+	27-Sep-14	58	*Hemphillia camelus* (1), *Vitrina pellucida* (1)
2014-64	Rosebud Lake Rd. S of Salmo, BC	810	Shrubby riparian zone along small creek in ravine within mostly young, logged landscape	20	27-Sep-14	48	*Allogona ptygophora* (1), *Arion circumscriptus* (1), *Arion rufus* (2) *Cochlicopa lubrica* (1), *Deroceras laeve* (2), *Discus whitneyi* (8), *Euconulus fulvus* (1), *Vertigo* sp. (1), *Zonitoides* sp. (3)
2014-65	HWY 6 to Nelway (small spur), S of Salmo, BC	668	Moist riparian area along stream	40-60	27-Sep-14	126	*Discus whitneyi* (1), *Haplotrema vancouverense* (1), *Kootenaia burkei* (8), *Nesovitrea* sp. (2)
2014-66A	Champion Lakes (Site 1), N of Trail, BC	1072	Moist old forest with small creek	120+	28-Sep-14	140	*Anguispira kochi* (3), *Cryptomastix mullani* (5), *Discus whitneyi* (10), *Euconulus fulvus* (4), *Nesovitrea* sp. (1), *Punctum randolphii* (2), *Zonitoides arboreus* (1)
2014-66B	Champion Lakes (Site 2), N of Trail, BC	1079	Old forest with abundant well-decayed moist wood	100+	28-Sep-14	40	*Discus whitneyi* (1), *Kootenaia burkei* (1)
2014-67	Nine Mile Rd, S of Fruitvale, BC	850	Disturbed forest in moist depression	40-50	28-Sep-14	50	*Cryptomastix mullani* (2), *Discus whitneyi* (10), *Euconulus fulvus* (6), *Hemphillia camelus* (2), *Nesovitrea* sp. (1), *Oreohelix strigosa* (18), *Prophysaon andersoni* (12), *Zonitoides arboreus* (1)
2014-68	Bear Cr FSR, N of Fruitvale, BC	724	Moist disturbed site in ravine with small creek within landscape of drier forest	40-50	28-Sep-14	40	*Anguispira kochi* (16), *Cryptomastix mullani* (3), *Discus whitneyi* (16), *Hemphillia camelus* (1), *Nesovitrea* sp. (1), *Zonitoides arboreus* (1)
2014-69	Bear Cr FSR (Site 2), N of Fruitvale, BC	821	Ravine with small creek at bottom in patch of second-growth coniferous forest	50-60	28-Sep-14	40	*Deroceras laeve* (1), *Discus whitneyi* (2), *Euconulus fulvus* (4), *Zonitoides arboreus* (1)
2014-70	King George VI Prov Park, off HWY 22, S of Rossland, BC	693	Moist forest edge by dried up creek	80	28-Sep-14	40	*Allogona ptygophora* (3), *Arion circumscriptus* (30), *Cryptomastix mullani* (2), *Euconulus fulvus* (10), *Oreohelix strigosa* (1), *Prophysaon andersoni* (23), *Zonitoides arboreus* (1)

Site ID	Site description	Elev. (m)	Habitat type	Stand age (yrs)	Date	Search effort (person-min)	Species found (# of animals)
2014-71	Archibald - Tillicum FSR (Site 1), SW of Salmo, BC	879	Moist shady forest with big old stumps in depression along creek	70	29-Sep-14	70	*Discus whitneyi* (3), *Haplotrema vancouverense* (1), *Hemphillia camelus* (1)
2014-72	Archibald - Tillicum FSR (Site 2), SW of Salmo, BC	1229	Moist riparian zone along small creek within logged landscape	50-60	29-Sep-14	50	*Euconulus fulvus* (3), *Hemphillia camelus* (2), *Kootenaia burkei* (5), *Microphysula ingersollii* (2), *Vertigo* sp. (10)
2014-73	Erie Cr FSR (Site 1), N of Erie, NW of Salmo, BC	991	Moist ravine along small creek within landscape of dry, younger (logged) forest	60-70	29-Sep-14	40	*Discus whitneyi* (2), *Euconulus fulvus* (2), *Kootenaia burkei* (2), *Nesovitrea* sp. (3), *Punctum randolphii* (2), *Zonitoides arboreus* (1)
2014-74	Erie Cr FSR (Site 2), N of Erie, NW of Salmo, BC	915	Moist riparian floodplain forest	100+	29-Sep-14	40	*Hemphillia camelus* (3), *Kootenaia burkei* (1)

Appendix 2. IUCN threats calculator for Sheathed Slug, based on assessment on 7 July 2015 via a conference call.

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	*Zacoleus idahoenses*		
Element ID		**Elcode**	
Date (Ctrl + ";" for today's date):	07/07/2015		
Assessor(s):	Kristiina Ovaska (status report author), Lennart Sopuck (status report writer), Dwayne Lepitzki (facilitator), Bev McBride (Secretariat), Joe Carney (responsible cochair), Annegret Nicolai, Daelyn Woolnough, Suzanne Dufour, Dave Fraser, Peter Holmes		
References:	Draft COSEWIC status report; threats calculator for the Pygmy Slug (Feb 2014)		

Overall Threat Impact Calculation Help:

		Level 1 Threat Impact Counts	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	0	0
C	Medium	0	0
D	Low	6	6
	Calculated Overall Threat Impact:	Medium	Medium

Assigned Overall Threat Impact:	**C = Medium**
Impact Adjustment Reasons:	
Overall Threat Comments	Generation time 1 year; assessment based on entire Canadian range to account for possible undocumented sites but using threats at known sites as guidance. Modified from threats assessment for the Pygmy Slug (*Kootenaia burkeii*) carried out by a group on 4 Feb 2014 - the two species occupy similar habitats in the Kootenays, with the distribution of Sheathed Slug confined to the southern portion of the Pygmy Slug's range. Overall Threat of Medium results from greater than 4 low impact threats.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
1.1	Housing & urban areas		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	No known sites are in areas with potential residential expansion. Over the entire range, residential development is probably minimal in slug habitats.
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	Potential expansion of infrastructure associated with Pend d'Oreille dam may affect one site.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1.3	Tourism & recreation areas		Negligible	Negligible (<1%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	No plans for new developments are known. Recreational developments such as small ski areas, tourist resorts and campgrounds are scattered within or on the periphery of the Sheathed Slug's range, but infrastructure is limited at present. No large tourist developments are currently under assessment for the area (iMapBC 2014). Widespread recreational activities in the area include use of all terrain vehicles, snowmobiles, and mountain bikes.
2	Agriculture & aquaculture	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
2.1	Annual & perennial non-timber crops						
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Ranching occurs mostly in drier areas of West Kootenays, and there are a few tenures for grazing. Livestock grazing on Crown forest lands is confined mainly to the drier southern and eastern portions of the species' range (iMapBC 2014). Cattle tend to concentrate in riparian areas and affect understorey plants and riparian areas by compacting soils and removing vegetation. Range tenures on Crown lands are managed to avoid excessive grazing, potentially reducing impacts on riparian areas.
2.4	Marine & freshwater aquaculture						
3	Energy production & mining		Negligible	Negligible (<1%)	Extreme - Serious(31-100%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
3.1	Oil & gas drilling						Not scored; no oil and gas drilling or extraction are known within the slug's range at present. Not considered a threat at present.
3.2	Mining & quarrying		Negligible	Negligible (<1%)	Extreme – Serious (31-100%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Much exploration has occurred historically and continues at present, but the likelihood of new operating mines is low over the next 10 years; the scope is probably <1%. Mining and quarrying activities are also present in the area but involve a small percentage of the Sheathed Slug's range. Mining and placer claims are common throughout the species' range, especially in the Trail, Salmo and Moyie Lake areas, and several mineral exploration projects are underway (Grieve 2011). Although new mines could be developed in the future, no mining projects are currently being assessed within the slugs' range (iMapBC 2014). Extensive habitat degradation from air pollution has occurred over the last 100 years in the vicinity of the smelter in Trail, on the periphery of the species' range.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.3	Renewable energy						Not scored. Possible on some of some ridges, but no examples are known. Not considered a threat at present.
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 – Slight (1-30%)	High (Continuing)	Existing logging roads crisscross the slugs' range, and roads are expanding to new areas with resource extraction. A network of roads is already in place, but new spurs may be constructed. Effects on slugs are from habitat loss (within road corridor & through edge effects), possible changes to drainage patterns, and habitat fragmentation (barriers to movements) associated with new roads. Habitat degradation from traffic on existing roads from dust is included under Pollution in 7. Effect of vegetation control on the road margin is minimal.
4.2	Utility & service lines		Negligible	Negligible (<1%)	Moderate (11-30%)	High (Continuing)	Effects are from land clearing associated with the expansion of existing power lines or construction of new lines. Power transmission line corridors are relatively common in the species' range, and more may be built to serve hydro operations. However, the likelihood of new major power lines (apart from minor ones to individual houses) is small. Maintenance activities such as brushing are not a threat because habitat has already been lost. There are existing natural gas pipelines, but future development plans are unknown. Severity is higher than for roads because of the larger footprint and associated edge effects.
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		Negligible	Restricted – Small (1-30%)	Negligible (<1%)	High (Continuing)	Recreational and commercial mushroom picking could be a threat in local areas; this activity occurs mostly in recent burns but also in forest, and some Sheathed Slug sites are near known mushroom picking areas. The effect of mushroom picking is thought to be minimal (negligible severity).

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.3	Logging & wood harvesting	D	Low	Restricted (11-30%)	Moderate (11-30%)	High (Continuing)	All known sites are within active logging areas, and all but 1 (#6) are in landscapes with recent or ongoing logging. While logging is ongoing in the area, it is very difficult to obtain information on trends (% to be cut) for next 10 years. Riparian leave strips may mitigate logging effects to some degree. However, forestry buffers are not required in small creeks with no fish (S6 streams), but some forestry companies voluntarily leave buffers along all water courses (Kari Stuart Smith pers. comm. 2013). Despite of voluntary efforts, many small streams are likely to be impacted, increasing the scope. There is usually also a 7 m wide no-machinery zone along creeks, but trees may be taken from this zone. Non-classified drainages (such as seepages) don't need to be buffered. Gullies would be buffered because the terrain is usually too steep for harvesting. Effects of recent logging on slugs in small remnant leave areas are probably ongoing through edge effects (drying of forest floor) and lack of connectivity across the landscape.
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)	Recreation affects 4 known sites (#4, 5, 8, 9), based on proximity to trailheads & other recreational opportunities; scope for entire range is lower because much habitat is away from well travelled areas. Impacts are from ATV use & snowmobiling (soil compaction & damage to vegetation); hiking on trails has little or no impact.
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						
7	Natural system modifications	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	
7.1	Fire & fire suppression	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	The Interior Cedar-Hemlock biogeoclimatic zone is relatively wet, and stand-replacing events are rare. Fires may occur in drier areas of the zone. Fires tend to be more severe when they do happen, due to fire suppression and climate change. Fires seem to be getting hotter and more severe in the area. Fire retardants using in fighting fires can also be detrimental to slugs, but no data are available.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.2	Dams & water management/use		Negligible	Negligible (<1%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	One known site (#3) is by a hydro-electric dam, which could potentially be expanded or changing water levels could affect this site. Reservoirs associated with hydro-electric development have flooded a relatively small area of potential slug habitat over the past century (Pend D'Oreille within the range; Lake Koocanusa on the periphery). No large scale creation or expansion of reservoirs are planned in the near future (iMapBC 2014). Several smaller-scale run-of river hydroelectric projects are also proposed in the Kootenay region, but none have been approved within the range of the slug (Wildsight 2014).
7.3	Other ecosystem modifications		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Silviculture systems, e.g., predominant planting Douglas-fir; invasive plants and invertebrates (e.g., gastropods, earthworms) are modifying understory vegetation and forest floor conditions, but the effects on native gastropods are unknown. Scope is pervasive, mainly based on invasive earthworms, which are almost ubiquitous, but invasive plants appear to be less common and only sporadically found in slug habitats.
8	Invasive & other problematic species & genes	D	Low	Small(1-10%)	Moderate - Slight(1-30%)	High (Continuing)	
8.1	Invasive non-native/alien species	D	Low	Small (1-10%)	Moderate - Slight(1-30%)	High (Continuing)	This involves direct effects on Sheathed Slug by introduced species through predation and/or competition. Introduced gastropods have not been found at any known sites but may be present or expand their distributions as a result of human activities. Introduced predators within the species' range include ground beetles; they have not been sampled at the occupied sites. Much uncertainty exists with the impacts of introduced species, hence the range in the severity rating.
8.2	Problematic native species						
8.3	Introduced genetic material						
9	Pollution		Unknown	Unknown	Unknown	High (Continuing)	
9.1	Household sewage & urban waste water						
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents		Unknown	Unknown	Unknown	High (Continuing)	Pesticides & herbicides are generally not used in forestry in the area. Fertilizers: occasionally applied to planted areas, but this is not a common practice.
9.4	Garbage & solid waste						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.5	Air-borne pollutants		Unknown	Unknown	Unknown	High (Continuing)	Erosion and dust from gravel roads that crisscross the habitat might affect slugs and degrade their habitat but no information is available
9.6	Excess energy						
10	Geological events		Negligible	Negligible (<1%)	Serious (31-70%)	High (Continuing)	
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides		Negligible	Negligible (<1%)	Serious (31-70%)	High (Continuing)	Where the slugs occupy steep gullies, their habitat is susceptible to landslides. Large landslides may be increasing in frequency as a result of severe storms associated with climate change. A large landslide occurred in 2008 near occupied sites on the slope from Sundown Creek Forest Service Road down to the creek, as a result of poor drainage of the logging road. Another large landslide occurred just northeast of the Sheathed Slug range (Johnsons Landing by Kootenay Lake).
11	Climate change & severe weather	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
11.1	Habitat shifting & alteration		Unknown	Pervasive (71-100%)	Unknown	High - Moderate	Models have shown that habitats are already showing shifting (see **Habitat Trends** section in the draft COSEWIC status report). Hence the timing is high.
11.2	Droughts	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Droughts are probably the main issue for slugs. More prolonged and frequent summer droughts are predicted as climate change proceeds. There is much uncertainty with both the scope and severity of impacts on the slugs. Although climate patterns and droughts would be region-wide, slugs in different parts of the range may be affected differently because of differences in moisture regimes due to hydrology and terrain and availability of refuges. To determine the number of threats-based locations, we should consider effects at watershed scale.
11.3	Temperature extremes						Not scored. The species is at the northern limits of distribution in British Columbia, and temperature extremes, particularly higher temperatures, associated with climate change are probably not an issue.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.4	Storms & flooding	D	Low	Restricted - Small(1-30%)	Moderate - Slight(1-30%)	High (Continuing)	Flooding is an issue at some sites because of the affinity of the slugs to riparian habitats; 3 known sites (#3, 4, 9) in particular might be affected by floods. However, slugs may have some capability of surviving floods, which are a natural seasonal event. Spring freshets may be more intense in the future, although probably of short duration, and may displace slugs. At sites on flatter terrain, flooding could result in local extirpations.