COSEWIC
Assessment and Status Report

on the

Yellow Scarab Hunter Wasp
Dielis pilipes

in Canada

SPECIAL CONCERN
2018

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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COSEWIC would like to acknowledge Jennifer Heron and Cory S. Sheffield for writing the status report on Yellow Scarab Hunter Wasp *Dielis pilipes*, prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by Paul Grant, COSEWIC Arthropods Specialist Subcommittee Co-chair.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Scolie dorée (*Dielis pilipes*) au Canada.

Cover illustration/photo:
Cover photograph of the Yellow Scarab Hunter Wasp resting on Alfalfa (*Medicago sativa*) by Jennifer Heron, taken on June 15, 2017 at Haynes Lease Ecological Reserve (BC Parks and Protected Areas), Osoyoos, BC.

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COSEWIC
Assessment Summary

Assessment Summary – November 2018

Common name
Yellow Scarab Hunter Wasp

Scientific name
Dielis pilipes

Status
Special Concern

Reason for designation
This large distinctive wasp is restricted to the low-elevation Antelope-brush and sagebrush ecological communities of the south Okanagan and Similkameen valleys of British Columbia. The larvae feed on the underground grubs of Ten-lined June Beetle that occur in sandy soils west of the Rocky Mountains. The loss, degradation, and fragmentation of open, sandy habitats, and pesticide application on adjacent agricultural lands during the adult flight period are the primary threats to the species. Further threats include increasing numbers of non-native plants into the open sand habitats, which limit detectability of host beetle larvae by adult female wasps. The species may become Threatened if factors suspected of negatively influencing the persistence of the species are not managed.

Occurrence
British Columbia

Status history
Designated Special Concern in November 2018.

COSEWIC
Executive Summary

Yellow Scarab Hunter Wasp
Dielis pilipes

Wildlife Species Description and Significance

Yellow Scarab Hunter Wasp (*Dielis pilipes*) is a large (20–25 mm length), uncommon black and yellow wasp; one of four scoliid wasp species reported from Canada. The wasp is a solitary ectoparasitoid of one or both of the two species of Ten-lined June beetles (*Polyphylla crinita* and *P. decemlineata*) that range in southern British Columbia. June beetle larvae are considered pests on a wide range of native shrubs, fruit trees, ornamental and garden plants, and the wasp is considered a natural biological control for the beetle larvae.

Distribution

The global range of Yellow Scarab Hunter Wasp extends from extreme south-central British Columbia into the United States through central Washington east to North Dakota and Oklahoma, and south to the Mexican border through New Mexico, Arizona and California. In Canada, Yellow Scarab Hunter Wasp has a range restricted to the Antelope-brush and sagebrush ecological communities in the valley bottoms of the southern Okanagan and lower Similkameen valleys, British Columbia. Specifically, the species is recorded from the east side of Skaha Lake south to Osoyoos; west to White Lake and one site south of Cawston and adjacent to the international border at Nighthawk Road in the Similkameen Valley.

Habitat

All known Canadian records for Yellow Scarab Hunter Wasp are within the low elevation (< 600 m) Antelope-brush or sagebrush ecological communities. Soils where both the adult wasps and the host beetles are found together have open bare ground and soft, sandy friable substrates that are deep and relatively free of rocks, cobble, other larger substrates and surface weedy vegetation. Once a female wasp has found and oviposited on the host beetle larva, this burrow site will become the feeding site of the developing wasp larva, and site of diapause/overwintering of the pupa. Because of their long flight period, adult wasps likely nectar on a wide range of flowering plants.

Biology

The Yellow Scarab Hunter Wasp has four life stages (egg, larva, pupa and adult) and develops through complete metamorphosis. Most scoliid wasps have an annual life cycle and it is likely the Yellow Scarab Hunter Wasp also has one generation per year. Host beetles have one generation every two to four years, and overwinter as first and third instar larvae.

Adult Yellow Scarab Hunter Wasps have been recorded from April 20–August 2, during which mating and oviposition occur. The female detects the host beetle larva by the kairomones the beetle emits. Once she finds a patch of habitat containing the host, she will dig into the ground in search of it, and ultimately paralyze the beetle larva. The female wasp will attach her egg to the scarab larva and prepare a crude cell around both, leaving the paralyzed larva *in situ*. The egg hatches and the wasp larva begins feeding upon the paralyzed host for 1–2 weeks, consuming the entire beetle larva, spinning a cocoon and remaining in diapause until the following spring. Although unconfirmed, the wasp likely parasitizes the host beetle between its second and third instar.

Population Sizes and Trends

Yellow Scarab Hunter Wasp surveys to date have been primarily by wandering transects through suitable habitat and focused on recording new sites, natural history and habitat information. No information on the Canadian population size or trends is available.

Threats and Limiting Factors

The highest impact threat to Yellow Scarab Hunter Wasp is the application of pesticides to control grape and orchard pests throughout the region, which can directly and indirectly impact the Yellow Scarab Hunter Wasp. Additional threats include the cumulative loss, degradation, and fragmentation of habitat (open and sandy Antelope-brush and sagebrush ecological communities). Biologically limiting factors include small population size, vulnerability to changing weather patterns, and availability of deep, sandy soil that is required to complete life stages.

Protection, Status and Ranks

Yellow Scarab Hunter Wasp, and its scarab beetle hosts, is not specifically protected under provincial or federal legislation. The wasp is known from at least three private properties; the Osoyoos/Inkameep Indian Reserve (Osoyoos First Nation); the federal property at White Lake; and three provincial protected areas. The species is not yet ranked by the British Columbia Conservation Data Centre, Natureserve or the General Status of Wildlife in Canada.

TECHNICAL SUMMARY

Yellow Scarab Hunter Wasp

Dielis pilipes

French name: Scolie dorée

Range: British Columbia

Demographic Information

Generation time	1 year
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Inferred continuing decline based on habitat loss and pesticide application within agricultural areas
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; b. understood; c. ceased?	a. no b. partially understood c. no
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	420 km²
Index of area of occupancy (IAO)	44 km²
Is the population “severely fragmented” i.e., 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. no b. no
Number of “locations”* (use plausible range to reflect uncertainty if appropriate)	>10 plausible (8–14 known) locations. Additional search effort would more than likely result in additional sites and locations.

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

Is there an [observed, inferred, or projected] decline in extent of occurrence?	Yes. Inferred and projected for habitats not within protected areas and in general for areas of potential Antelope-brush and sagebrush habitat.
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes. Inferred and projected for habitats not within protected areas and in general for areas of potential Antelope-brush and sagebrush habitat.
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Yes. Inferred and projected for habitats not within protected areas and in general for areas of potential Antelope-brush and sagebrush habitat.
Is there an [observed, inferred, or projected] decline in number of “locations”*?	Yes. Inferred and projected for habitats not within protected areas and in general for areas of potential Antelope-brush and sagebrush habitat.
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes. Inferred and projected for habitats not within protected areas and in general for areas of potential Antelope-brush and sagebrush 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**
Low number of specimens collected, insufficient information to calculate mature individuals	Unknown
Total	Unknown

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	Not applicable, insufficient data.

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

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species? Yes; calculated at Very High – High impact

9.3 Agricultural & forestry effluents – High-Medium impact
2.1 Annual & perennial non-timber crops – High-Medium impact
7.1 Fire & fire suppression – Medium impact
2.3 Livestock farming & ranching – Medium-low impact
1.1 Housing & urban areas – Low
1.2 Commercial & industrial areas – Low

What additional limiting factors are relevant?

- Small population size and genetic isolation.
- Natural parasitic enemies.
- Vulnerability to changing weather patterns.
- Host beetle specificity.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Unknown
Is immigration known or possible?	Unknown, likely possible; adult wasps are large and likely capable of flying between potential habitat patches.
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada?[+]	Yes, see Threats.
Are conditions for the source (i.e., outside) population deteriorating?[+]	Yes, see Rescue Effect.
Is the Canadian population considered to be a sink?[+]	Unknown, likely not.
Is rescue from outside populations likely?	Unlikely

Data Sensitive Species

Is this a data sensitive species?	Yes, private land sites.

Status History

COSEWIC: Designated Special Concern in November 2018.

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

Status and Reasons for Designation:

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

Reasons for designation:
This large distinctive wasp is restricted to the low-elevation Antelope-brush and sagebrush ecological communities of the south Okanagan and Similkameen valleys of British Columbia. The larvae feed on the underground grubs of Ten-lined June Beetle that occur in sandy soils west of the Rocky Mountains. The loss, degradation, and fragmentation of open, sandy habitats, and pesticide application on adjacent agricultural lands during the adult flight period are the primary threats to the species. Further threats include increasing numbers of non-native plants into the open sand habitats, which limit detectability of host beetle larvae by adult female wasps. The species may become Threatened if factors suspected of negatively influencing the persistence of the species are not managed.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable, insufficient data.
Criterion B (Small Distribution Range and Decline or Fluctuation): Comes close to meeting Endangered, B1 (EOO under 5000 km²; actual 418 km²) and B2 (IAO under 500 km²; actual 44 km²). However, while there is a decline in area, extent and/or quality of habitat, the wasp likely occurs within other intervening habitats (e.g., vineyards, orchards) where Ten-lined June Beetle may also be present, and therefore number of locations is more than likely over 10 and above thresholds.
Criterion C (Small and Declining Number of Mature Individuals): Insufficient data to determine the number of mature individuals.
Criterion D (Very Small or Restricted Population): Insufficient data to determine the number of mature individuals.
Criterion E (Quantitative Analysis): Not applicable, insufficient data.

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 (2018)

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.

COSEWIC Status Report

on the

Yellow Scarab Hunter Wasp

Dielis pilipes

in Canada

2018

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific Name: *Dielis pilipes*

Classification:

Order:	Hymenoptera (ants, bees, wasps)
Family:	Scoliidae (Scoliid Wasps)
Subfamily:	Campsomerinae
Genus:	*Dielis*
Species:	*pilipes* (Saussure, 1858)

Synonyms: *Elis pilipes*, *Campsomeris pilipes*

Type locality: Western Texas (from Bradley 1928)

English Names: Yellow Scarab Hunter Wasp

French Name: Scolie dorée

Taxonomic Background and Similarities:

Yellow Scarab Hunter Wasp (*Dielis pilipes*) is a member of the family Scoliidae. Worldwide there are approximately 560 species of scoliid wasp, with 24 species (some with subspecies) that range in North America north of Mexico. All species are ectoparasitoids of scarab beetles (Goulet and Huber 1993). *Dielis* is one of eight genera of scoliid wasp occurring in North America; additional genera are *Campsomeriella* Betrem, *Colpa* Dufour, *Micromeriella* Betrem, *Pygodasis* Bradley, *Xanthocampsomeris* Bradley, *Scolia* Fabricius, and *Triscolia* Saussure (Krombein 1951, 1958, 1967; Betrem 1972; Osten 2005).

Seven species of *Dielis* are found in North America, three of which range into Canada: *D*. *pilipes* (Saussure 1858) (Okanagan and Similkameen valleys, British Columbia [BC]), *D. plumipes* (Drurry 1770) (subspecies *confluenta* (Say 1823), southern Ontario), and *D. tolteca* (Saussure 1857) (historical records labelled 'Victoria', BC). The fourth scoliid wasp in Canada is *Scolia bicincta* (Fabricius 1775) (southern Ontario and Québec). The geographic ranges of the two species that occur in BC do not overlap.

Yellow Scarab Hunter Wasp was first described by Saussure (1858) as *Elis pilipes*, though was later placed in the genus *Campsomeris*. Bradley (1928) revised the *plumipes* species group of *Campsomeris* in North America, which included *C. pilipes*. Argaman (1996) commented on the nomenclature of Scoliidae, stating "at the least, [it is] disastrous", but offered some clarification on the designation of type material for *Campsomeris*, and treated it as a valid genus. In a world checklist of Scoliidae, Osten (2005) proposed significant changes to the taxonomy of some scoliid wasps, and placed species of *Campsomeris* within other genera, including treating *C. pilipes* as *Dielis pilipes*. This status

report follows Osten's (2005) checklist and taxonomy, even though some authors (e.g., Beaty *et al.* 2009; Rasmussen and Asenjo 2009) have not adopted it.

Morphological Description

Scoliid wasps are large, flying insects, normally with smooth black bodies and bold yellow or orange markings. The larvae of Yellow Scarab Hunter Wasp are solitary ectoparasitoids of scarab beetles (Scarabidae) (Goulet and Huber 1993; O'Neill 2001) and the hosts are likely one or both of the larger Ten-lined June Beetles (*Polyphylla crinita* and *P. decemlineata*) that occur in BC. For the purposes of this status report, it is assumed both beetles could be hosts to Yellow Scarab Hunter Wasp.

Adults:

Large (20–25 mm body length) stout-bodied wasps with a black/brown body with bright yellow stripes. Portions of the head and the entire thorax, including the legs, are covered with medium length conspicuous grey/white hairs. Females (Figure 1) are slightly larger and more robust than males (Figure 2). Like most stinging wasps, males have one additional antennal and abdominal segment.

Figure 1. Yellow Scarab Hunter Wasp (*Dielis pilipes*) female collected within private property (vineyard) on May 26, 2010 near Okanagan Falls, Skaha Lake (49.383815; -119.558022). Photo by Cory Sheffield.

Figure 2. Yellow Scarab Hunter Wasp (*Dielis pilipes*) male collected within private property (vineyard) June 3, 2010 near Okanagan Falls, Skaha Lake (49.386718; -119.554508). Photo by Cory Sheffield.

Eggs:

The eggs of Yellow Scarab Hunter Wasp have not been described, nor have they been found in BC. In general, the eggs of scoliid wasps are 2–4 mm long, the width approximately 1/4 the length of the egg, and rounded at one end (O'Neill 2001). The wasp egg is externally attached to the underside of the abdomen of the host beetle larva (O'Neill 2001). The approximate shape (elongate, tapering slightly at the end of attachment to host) and oviposition position of *Campsomeriella annulata* (Fabricius) and other scoliid wasps on a typical scarab beetle larvae were illustrated in O'Neill (2001). This information is unknown for Yellow Scarab Hunter Wasp.

Larvae:

The larvae of Yellow Scarab Hunter Wasp (Figure 3) have not been described nor have they been found in BC. In general, a first hatched larva is 2–4 mm long and grows through a series of moults and eventually reaches 12–15 mm. The larvae are beige to light brown, somewhat translucent with a smooth body, and have a head capsule that is darker brown than the rest of the body.

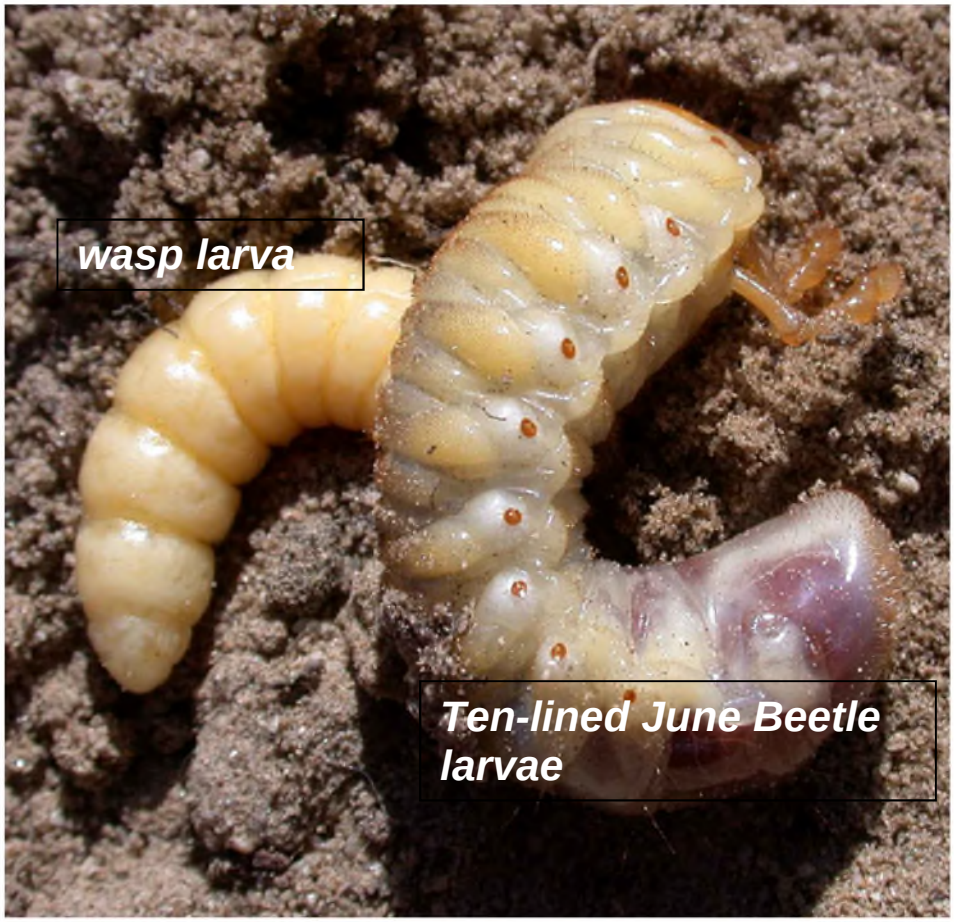

Figure 3. Yellow Scarab Hunter Wasp (*Dielis pilipes*) larva underneath a 3rd instar Ten-lined June Beetle larva. Photo of larvae observed within an agricultural field in California (photo and observation by Marshall W. Johnson).

Pupae:

The pupae of Yellow Scarab Hunter Wasp (Figure 4) have not been described or observed in BC. The cocoon containing the pupa is brown, approximately 15 mm long and cigar shaped, with rounded ends and a smooth outer finish (Marshall pers. comm. 2017).

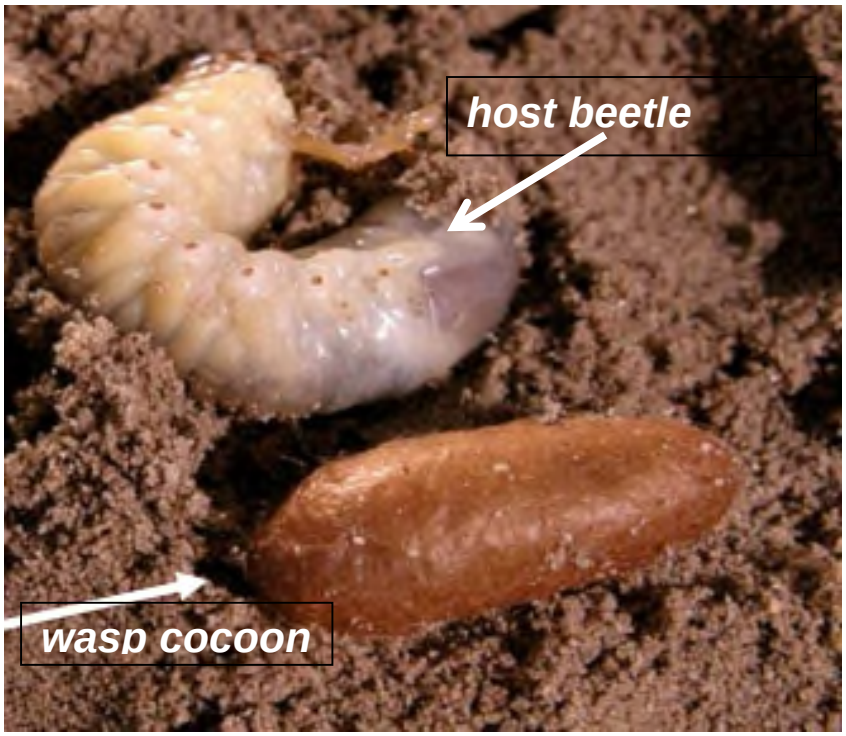

Figure 4. Ten-lined June Beetle larva (*Polyphylla decemlineata*) and Yellow Scarab Hunter Wasp pupa. Photo of pupa observed within an agricultural field in California (photo and observation by Marshall W. Johnson).

Population Spatial Structure and Variability

The population structure of Yellow Scarab Hunter Wasp in Canada has not been studied. These large wasps are likely mobile and presumably can fly between habitat patches, although females with eggs may be heavier, and may not fly as far. Individuals within its small geographic range in Canada and the adjacent United States likely interbreed over time. There is no reason to suspect that the Canadian population is disjunct from the United States population.

Designatable Units

The Yellow Scarab Hunter Wasp is being assessed as one designatable unit. There is no information on discreteness or evolutionary significance in Canada. The species occurs solely within the COSEWIC Southern Mountain Ecological Area.

Special Significance

The Yellow Scarab Hunter Wasp appears to be closely associated with the Antelope-brush and sagebrush ecological communities of the southern Okanagan and lower Similkameen river valleys. Both these ecosystems contain numerous ecological communities that are rare and at-risk in the province and in Canada (BC Conservation Data Centre 2018). This wasp, like numerous other arthropod species unique to this region, can be considered one of several focal species representing the sensitivity and uniqueness of these habitat types in Canada.

The host(s) of Yellow Scarab Hunter Wasp is one or both species of Ten-lined June Beetle that range in the province, of which the larvae are considered plant pests because they feed on the roots of native woody plants including willows (*Salix spp*.), rose (*Rosa spp*.) sagebrush (*Artemisia spp*.) and poplars (*Populus spp*.). The beetle larvae can also be a significant agricultural pest to tree fruits such as apple and pear, and other food crops such as strawberries, potatoes, corn and cane fruits (among others) (See Interspecific Interactions). The Yellow Scarab Hunter Wasp is a natural biological control agent of Ten-lined June Beetles.

Scoliid wasps are of interest to entomologists and taxonomists because of their large size, rarity, and association with scarab beetles. Adult scoliid wasps are large, highly mobile, and visit many flowers so they are likely pollinators of many of the plants they visit. There is no information that suggests that the Yellow Scarab Hunter Wasp has, or had, a specific cultural or economic importance for First Nations.

DISTRIBUTION

Global Range

The global range of the Yellow Scarab Hunter Wasp extends from the extreme southern Okanagan Valley, BC into the United States through central Washington, south to California, east to along the Mexican/United States border through Arizona, New Mexico and Oklahoma and north to North Dakota (Hurd 1952) (Figure 5).

The estimated global range extent is 3,000,000 km^2. The sites within its global range are likely discontinuous due to its association with arid habitats. This geographic range is an estimate: museum specimens need confirmation and surveys at the periphery of its range.

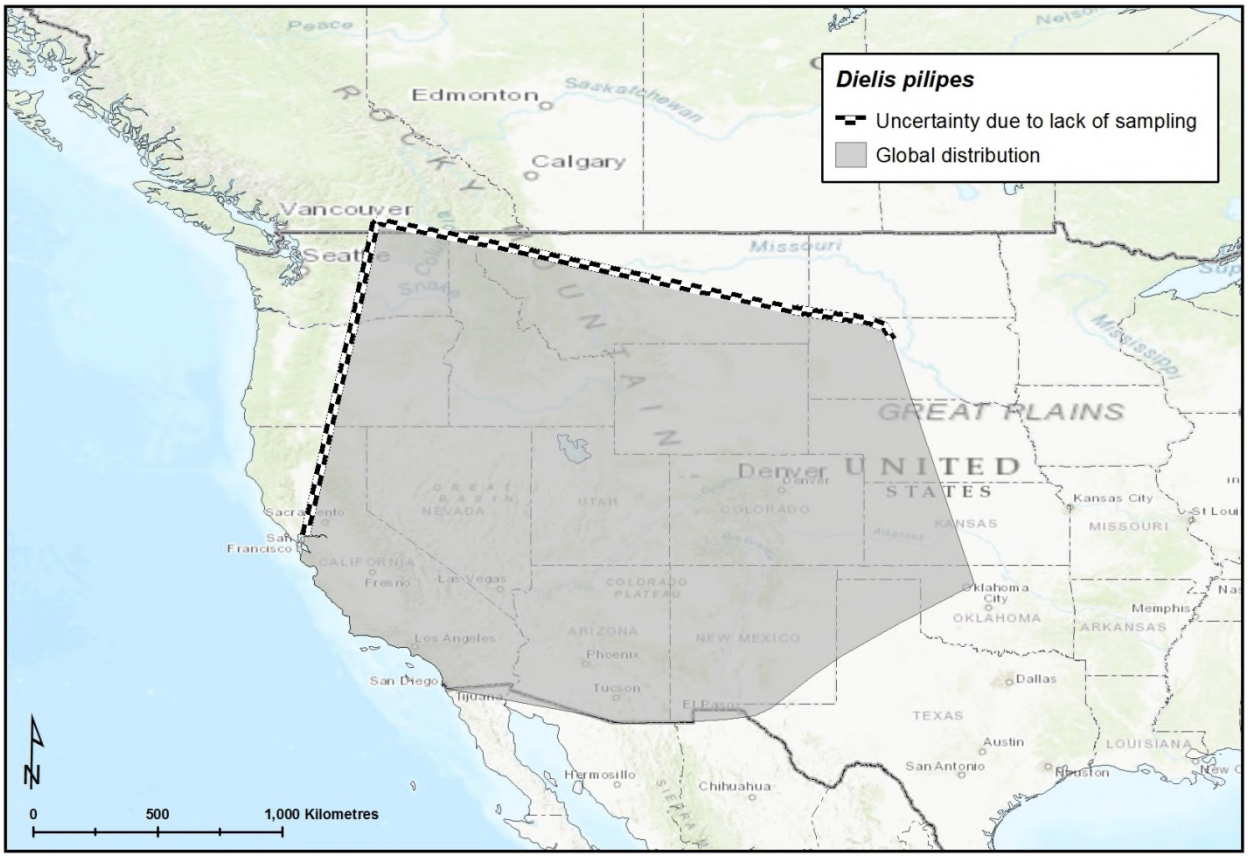

Figure 5. Global range of Yellow Scarab Hunter Wasp (*Dielis pilipes*) based on Bradley (1928). The global range is unconfirmed; databasing and confirmation of specimen collection sites is not complete for the species' global range.

Canadian Range

In Canada, the range of Yellow Scarab Hunter Wasp is restricted to the Antelope-brush and sagebrush ecological communities in the valley bottoms of the southern Okanagan and lower Similkameen valleys in British Columbia. Records range from Skaha Lake (north of Okanagan Falls and the northernmost locality) to Osoyoos and west to Nighthawk Road (south of Cawston) in the Similkameen Valley (Table 1; Figure 6).

Table 1. Yellow Scarab Hunter Wasp museum and collection records.

Specimen #	Map #	Prov.	Collection Locality Name (private land sites masked)	Land Ownership	Day	Month	Year	Collector/ Observer	Habitat Notes
1	4	BC	Black Sage Road	Public (municipal) roadside	15	6	2017	J. Heron	collected from roadside flowers
2	6	BC	Cawston, 12 mi. S. Cawston [South Okanagan Wildlife Management Area [SOWMA] - Nighthawk]	Provincial (likely)	2	8	1987	J. Shepard	Likely the Nighthawk Road portion of SOGPA property or close by
3	N/A	WA	N Potholes Reservoir	N/A	20	5	1989	S.G. Cannings	
4	3	BC	Okanagan Falls; PLS-B	private	3	6	2010	J. Heron, D. Marks and O. Dyer	vineyard; weedy habitat, dandelions, tall tumble-mustard, Loesel's tumble-mustard, clover; tended gardens with rose bushes
5	5	BC	Okanagan Falls; PLS-C	private	26	5	2010	J. Heron, D. Marks and O. Dyer	farm: apples, peaches, grapes, pears, raspberries, plums, tomatoes, corn; antelope-brush, brittle prickly-pear cactus (*Opuntia fragilis*), phlox (Phlox), arrow-leaf balsam root; yarrow, mustard, clover, showy milkweed
6	9	BC	Okanagan Falls, White Lake to Kearns Creek	Provincial/ Federal	29	6	1996	L.R. Ramsay	
7	13	BC	Oliver	Unknown	26	5	1945	D. Blair	
8	4	BC	Oliver, S. of; PL-B	private	19	5	2010	J. Heron, D. Marks and O. Dyer	vineyard; showy milkweed; antelope-brush, wild rose (Rosa sp.); weeds, clover (Trifolium sp.), dandelions & Loesel's tumble-mustard
9	1	BC	Osoyoos Lake; Inkameep [Osoyoos] IR; East side	Federal	30	6	1996	S.G. Cannings	Purshia steppe overgrazed; along sandy road
10	1 or 2	BC	Osoyoos Lake; Inkameep [Osoyoos] IR	Federal	30	6	1996	R.A. Cannings	
11	2	BC	Osoyoos Lake; Inkameep [Osoyoos] IR, South end	Federal	30	6	1996	G.G.E. Scudder	Collected on Sweet White Clover (Melilotus alba Desr.)
12	2	BC	Osoyoos Lake; Inkameep [Osoyoos] IR, South end	Federal	30	6	1996	G.G.E. Scudder	Collected on Sweet White Clover (Melilotus alba Desr.)
13	2	BC	Osoyoos Lake; Inkameep [Osoyoos] IR, South end	Federal	30	6	1996	G.G.E. Scudder	Collected on Sweet White Clover (Melilotus alba Desr.)
14	2	BC	Osoyoos Lake; Inkameep [Osoyoos] IR, South end	Federal	30	6	1996	G.G.E. Scudder	Collected on Sweet White Clover (Melilotus alba Desr.)
15	2	BC	Osoyoos Lake; Inkameep [Osoyoos] IR, South end	Federal	30	6	1996	G.G.E. Scudder	Collected on Sweet White Clover (Melilotus alba Desr.)
16	11	BC	Osoyoos Lake, north end	Unknown	19	5	1980	B. Gill	

Specimen #	Map #	Prov.	Collection Locality Name (private land sites masked)	Land Ownership	Day	Month	Year	Collector/ Observer	Habitat Notes
17	11	BC	Osoyoos Lake, north end	Unknown	19	5	1980	B. Gill	
18	11	BC	Osoyoos Lake, north end	Unknown	19	5	1980	B. Gill	
19	11	BC	Osoyoos Lake, north end	Unknown	19	5	1980	B. Gill	
20	11	BC	Osoyoos Lake, north end	Unknown	19	5	1980	B. Gill	
21	12	BC	Osoyoos Lake, Northeast end	Unknown	19	5	1980	S.G. Cannings	
22	12	BC	Osoyoos Lake, Northeast end	Unknown	27	6	1981	S.G. Cannings	
23	12	BC	Osoyoos Lake, Northeast end	Unknown	27	6	1981	S.G. Cannings	
24	10	BC	Osoyoos, East Bench	Unknown	2	5	2006	G.G.E. Scudder	
25	10	BC	Osoyoos, East Bench	Unknown	2	5	2006	G.G.E. Scudder	
26	10	BC	Osoyoos, East Bench	Unknown	6	5	2008	G.G.E. Scudder	
27	10	BC	Osoyoos, East Bench	Unknown	6	5	2008	G.G.E. Scudder	
28	10	BC	Osoyoos, East Bench	Unknown	18	5	2008	J. Scudder	
29	10	BC	Osoyoos, East Bench	Unknown	14	7	1990	G.G.E. Scudder	
30	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial crown	20	4	1980	R.A. Cannings	dry benchland
31	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial crown	12	5	1983	S.G. Cannings	
32	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial crown	12	5	1983	S.G. Cannings	
33	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial crown	12	5	1983	S.G. Cannings	
34	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial crown	12	5	1983	S.G. Cannings	
35	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial crown	12	5	1983	S.G. Cannings	
36	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial crown	12	5	1983	S.G. Cannings	
37	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial crown	12	5	1983	S.G. Cannings	
38	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial crown	12	5	1983	S.G. Cannings	

Specimen #	Map #	Prov.	Collection Locality Name (private land sites masked)	Land Ownership	Day	Month	Year	Collector/ Observer	Habitat Notes
39	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial crown	20	5	1986	S.G. Cannings	
40	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial crown	20	5	1986	S.G. Cannings	
41	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial crown	15	6	2017	J.Heron	observed on alfalfa
42	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial crown	15	6	2017	J.Heron	observed on alfalfa
43	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial crown	15	6	2017	J.Heron	observed on alfalfa
44	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial crown	25	6	2003	G.G.E. Scudder	BGxh1, AN Recovery after 1993 fire
45	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial crown	17	7	1993	G.G.E. Scudder	
46	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial crown	18	6	2016	D.Holden	Collected while nectaring on Baby's Breath; near the north entrance to the property, off the main parking lot at the top of the hill.
47	8	BC	Osoyoos, Haynes Lease, Road #22; sandy bench below "The Throne" cliff, within Eco Res #100 (Haynes Lease), near barn	provincial crown	17	5	1980	R.A. Cannings	*Purshia tridentata* steppe with sparse grasses such as *Pseudoroegneria spicata*, *Hesperostipa comata* and *Bromus tectorum*. Also considerable sage, sumac, cactus and other plants
48	8	BC	Osoyoos, Haynes Lease, Road #22; sandy bench below "The Throne" cliff, within Eco Res #100 (Haynes Lease), near barn	provincial crown	17	5	1980	R.A. Cannings	*Purshia tridentata* steppe with sparse grasses such as *Pseudoroegneria spicata*, *Hesperostipa comata* and *Bromus tectorum*. Also considerable sage, sumac, cactus and other plants
49	8	BC	Osoyoos, Haynes Lease, Road #22; sandy bench below "The Throne" cliff, within Eco Res #100 (Haynes Lease), near barn	provincial crown	17	5	1980	R.A. Cannings	*Purshia tridentata* steppe with sparse grasses such as *Pseudoroegneria spicata*, *Hesperostipa comata* and *Bromus tectorum*. Also considerable sage, sumac, cactus and other plants
50	1	BC	Osoyoos Lake; Inkameep [Osoyoos] IR, East side	Federal	30	6	1996	R.A. Cannings	Lakeshore/sand benches. *Purshia/Chrysothamnus* ex *Melilotus alba*
51	1	BC	Osoyoos Lake; Inkameep [Osoyoos] IR, East side	Federal	30	6	1996	R.A. Cannings	Lakeshore/sand benches. *Purshia/Chrysothamnus* ex *Melilotus alba*
52	1	BC	Osoyoos Lake; Inkameep [Osoyoos] IR, East side	Federal	30	6	1996	R.A. Cannings	Lakeshore/sand benches. *Purshia/Chrysothamnus* ex *Melilotus* alba
53	1	BC	Osoyoos Lake; Inkameep [Osoyoos] IR, East side	Federal	30	6	1996	R.A. Cannings	Lakeshore/*sand* benches. *Purshia/Chrysothamnus* ex *Melilotus alba*

Specimen #	Map #	Prov.	Collection Locality Name (private land sites masked)	Land Ownership	Day	Month	Year	Collector/ Observer	Habitat Notes
54	1	BC	Osoyoos Lake; Inkameep [Osoyoos] IR, East side	Federal	30	6	1996	R.A. Cannings	Lakeshore/sand benches. *Purshia/Chrysothamnus* ex *Melilotus alba*
55	1	BC	Osoyoos Lake; Inkameep [Osoyoos] IR, East side	Federal	30	6	1996	R.A. Cannings	Lakeshore/sand benches. *Purshia/Chrysothamnus* ex *Melilotus alba*
56	3	BC	Okanagan Falls; PLS-B	Private	23	6	2017	D.Marks,K.Grant	
57	8	BC	North of Road 22 - South Okanagan Wildlife Management Area	Provincial	23	6	2017	D.Marks,K.Grant	
58	8	BC	North of Road 22 - South Okanagan Wildlife Management Area	Provincial	23	6	2017	D.Marks,K.Grant	
59	14	BC	Oliver, S. of; PL-D	Private	15	6	2017	D.Marks,K.Grant	
60	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial	13	6	2017	D.Marks,K.Grant	
61	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial	13	6	2017	D.Marks,K.Grant	
62	7	BC	Osoyoos, Haynes Lease Ecological Reserve	Provincial	13	6	2017	D.Marks, K.Grant	
63	8	BC	North of Road 22 - South Okanagan Wildlife Management Area	Provincial	5	6	2017	D.Marks, K.Grant	
64	8	BC	North of Road 22 - South Okanagan Wildlife Management Area	Provincial	5	6	2017	D.Marks, K.Grant	
65	1 or 2	BC	Osoyoos Lake; Inkameep [Osoyoos] IR	Federal (Indian Reserve)	12	5	2007	Libby Avis	Field trip with Botany BC to look at beach grasses, came across the wasp on the edge of the beach just above the water line, sparsely vegetated - just a few grasses.
66	N/A	BC	Osoyoos; no specific locality recorded	Unknown	20	5	2018	Iris' - no contact information given on BugGuide	
67	N/A	BC	Osoyoos; no specific locality recorded	Unknown	22	5	2018	Iris' - no contact information given on BugGuide	
68	13	BC	Oliver; no specific locality recorded	Unknown	6	6	2006	Werner Eigelsreiter - passed away and account deleted	Assume the 5km separation distance would include 1945 record

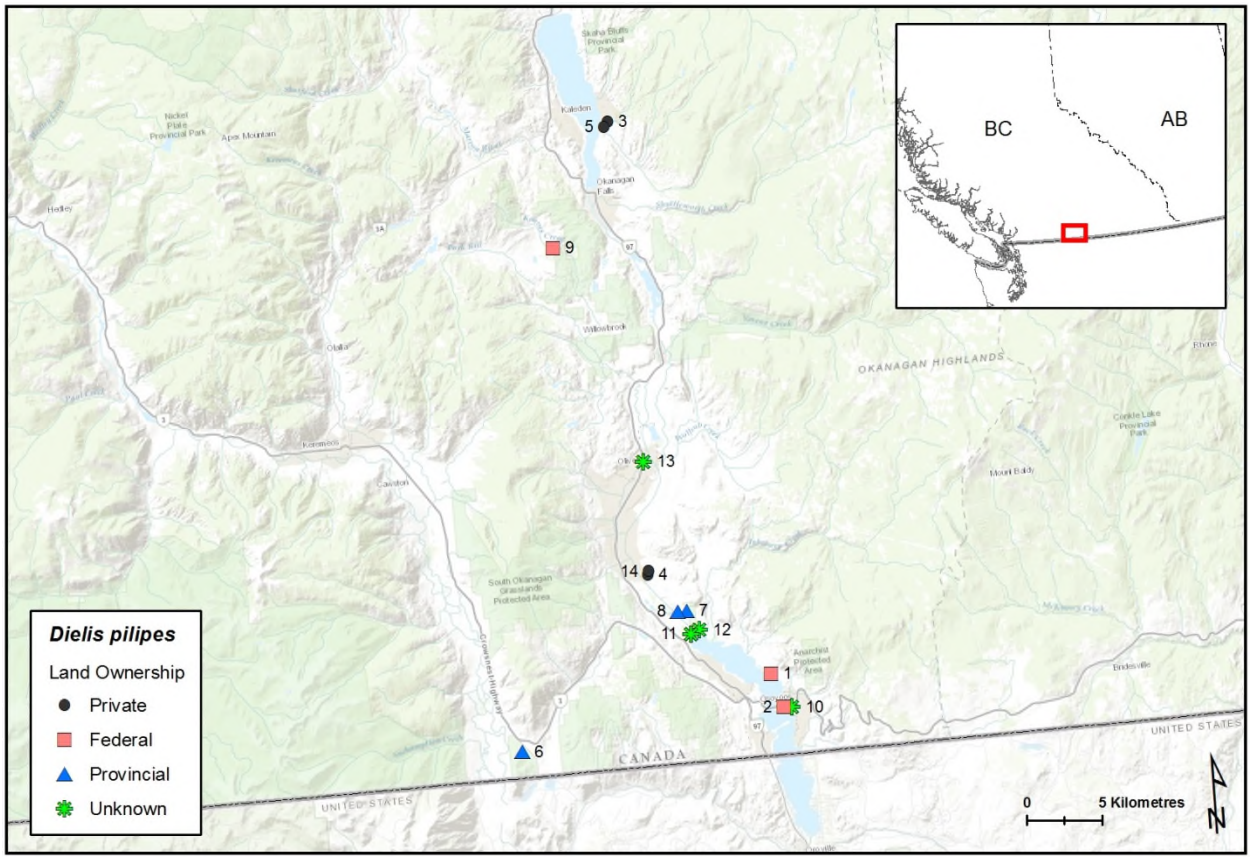

Figure 6. Yellow Scarab Hunter Wasp sites in Canada. All records are listed in Table 1, and for ease of display those records were grouped by landowner(s) and plotted. See Table 2 for locality names and additional information.

Yellow Scarab Hunter Wasp has been recorded from 14 sites, which are defined based on land ownership/management. All 14 sites are extant with at least one recent record within the past 20 years.

The Canadian range of the two host June beetle species (*P. crinita* and *P. decemlineata*) (Figure 7) is much larger than Yellow Scarab Hunter Wasp. Both species range across southern British Columbia, from the Victoria area through Vancouver and the lower mainland towards the Kootenays and southern Alberta. *Polyphylla crinita* ranges as far north as Terrace and as far east as the Kootenays, but appears entirely confined within British Columbia. *Polyphylla decemlineata* ranges as far north as Red Deer (Alberta) and east as Cabri (Saskatchewan). In general, *P. crinita* is more common along the coast of British Columbia and Vancouver Island while *P. decemlineata* is more common in the Okanagan Valley (Smith pers. comm. 2018). Abundance or number of sites recorded should not be inferred from the map; both beetles are likely more common within their range; however, the extent of their geographic ranges is well defined (Smith pers. comm. 2018).

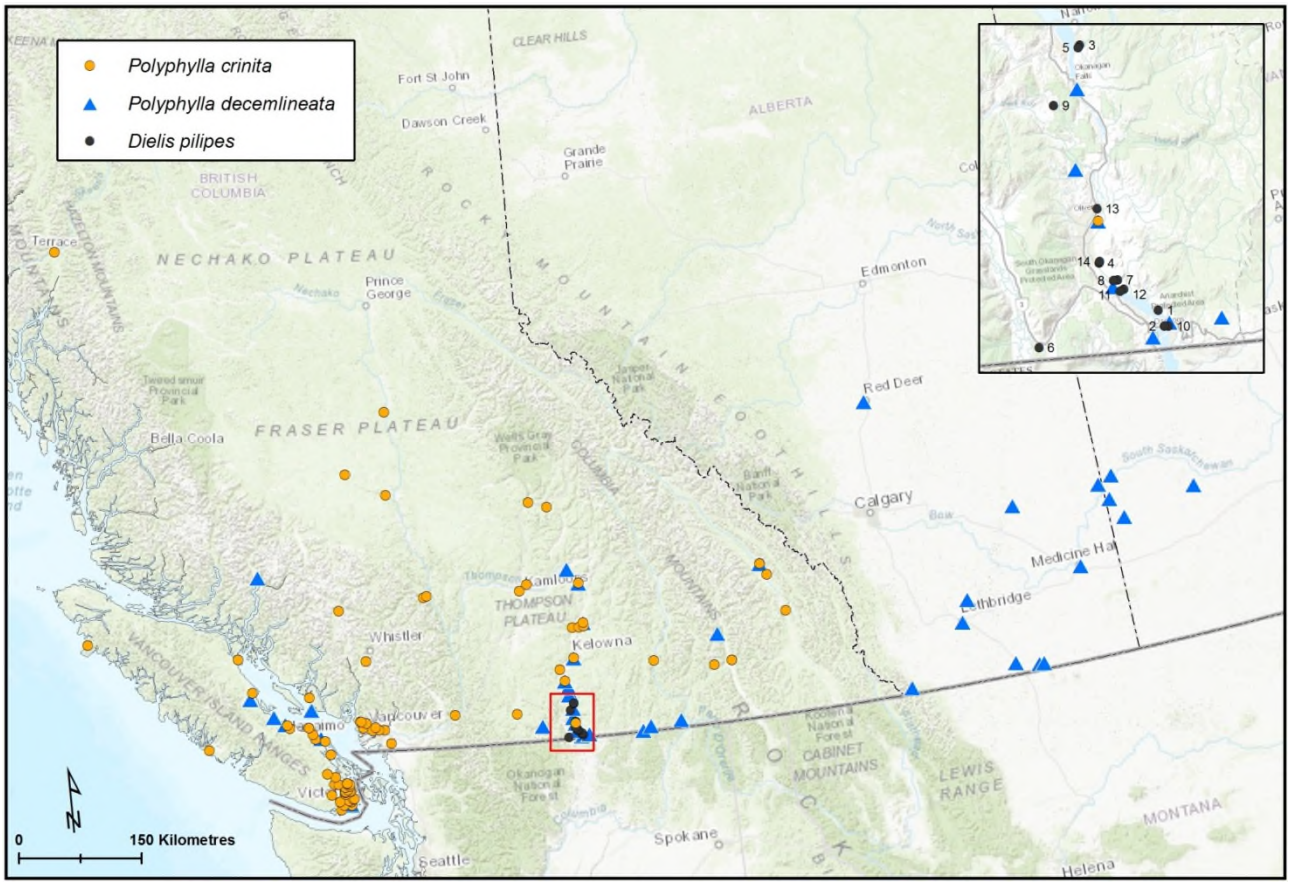

Figure 7. The distribution of the two ten-lined June beetle (*Polyphylla crinita* and *P. decemlineata*) hosts in Canada. There are likely many additional sites than specimens databased from museum collections and each symbol represents a site of beetles (i.e., symbols do not represent beetle abundance).

The absence of the Yellow Scarab Hunter Wasp in Alberta and Saskatchewan, where *P. decemlineata* and other large potential host beetles in genus *Cotalpa* occur, suggests there are other unknown factors that restrict the scoliid wasp to the Okanagan and Similkameen areas in Canada (see **Limiting Factors**).

Extent of Occurrence and Area of Occupancy

The estimated extent of occurrence (EOO) in Canada is 420 km^2 (Figures 9 and 10). Less than 1% of the species global range is in Canada. The estimated index of area of occupancy (IAO) is 44 km^2 based on all known records for the species in Canada (Figure 9).

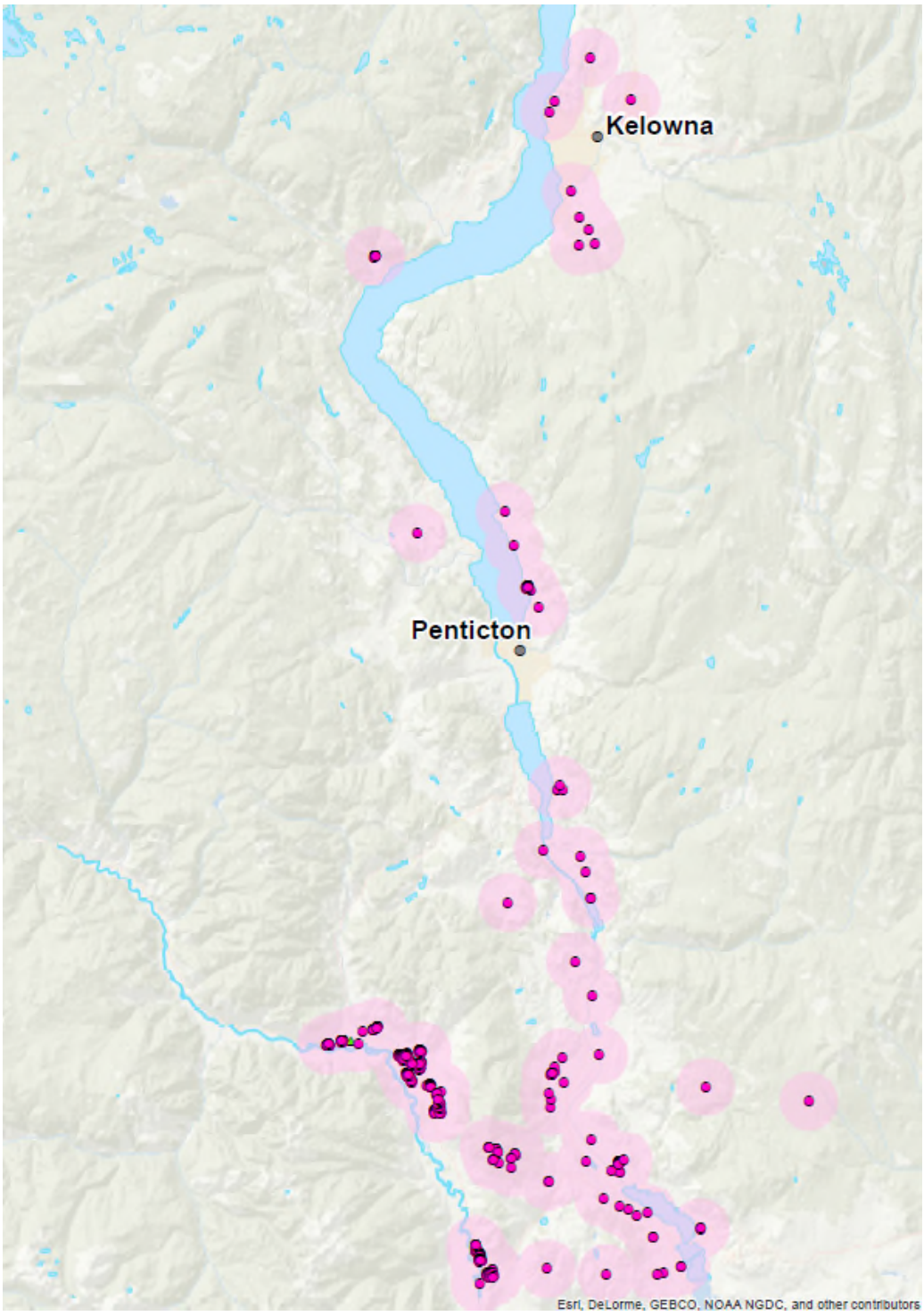

Figure 8. Pollinator (bees and wasps) surveys (2010–2017) within the range of Yellow Scarab Hunter Wasp (*Dielis pilipes*) from 30 minutes to three hours search effort where all bees and larger wasps were targeted during wandering transect surveys (see Table 3).

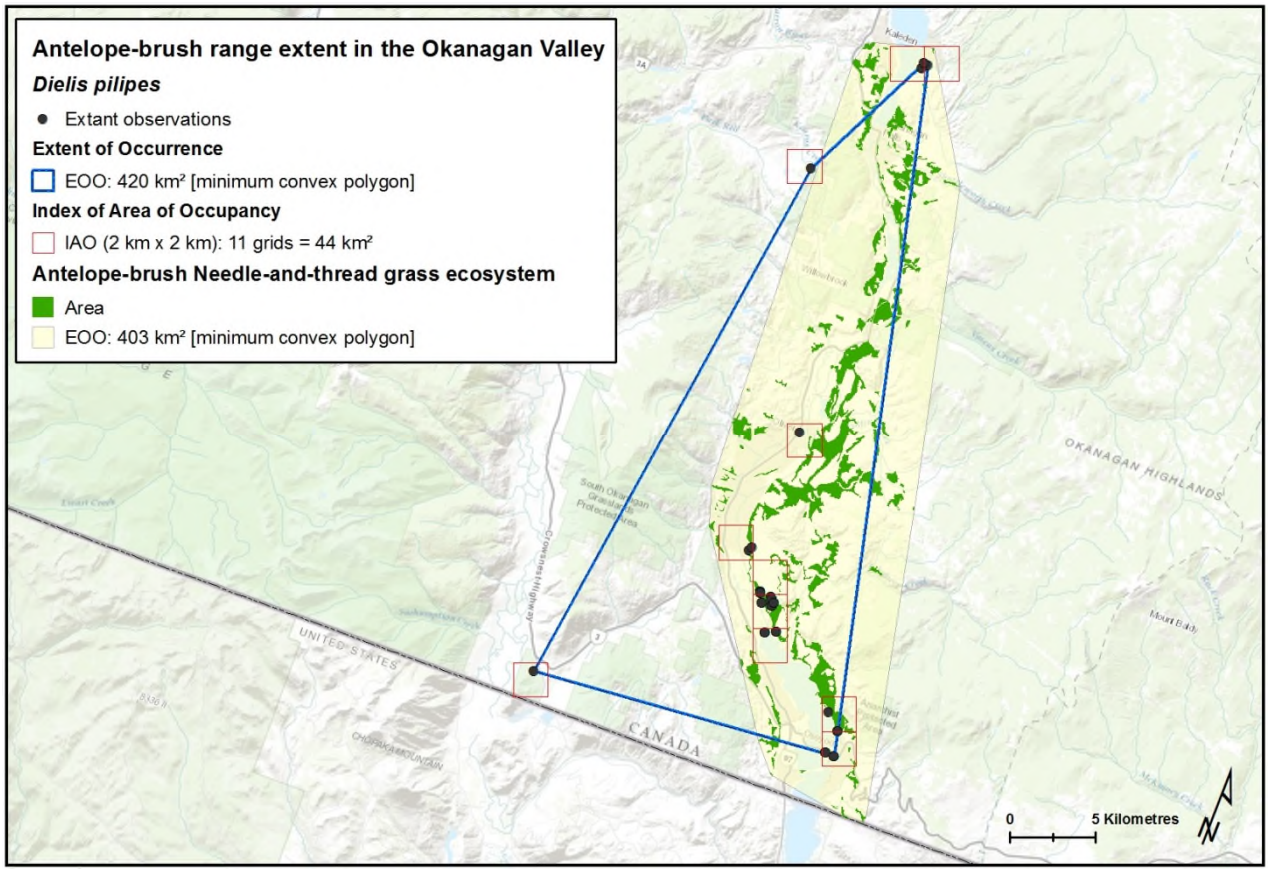

Figure 9. Antelope-brush Needle-and-Thread-grass ecosystem mapping (as of 2017) in the south Okanagan overlaid with Yellow Scarab Hunter Wasp collection sites.

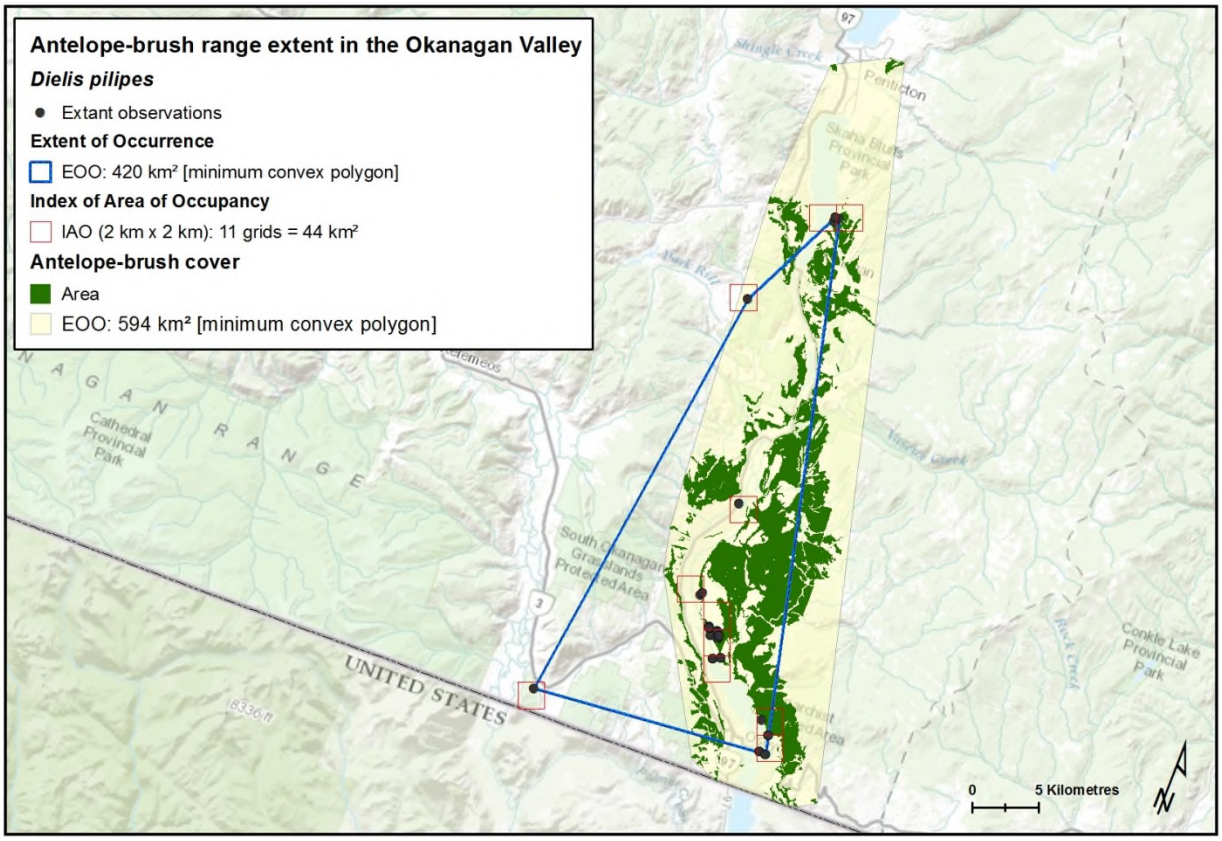

Figure 10. Distribution of the Antelope-brush plant within the south Okanagan grasslands overlaid with Yellow Scarab Hunter Wasp collection sites.

Search Effort

Yellow Scarab Hunter Wasp museum specimens and photographic records in Canada date from 1945 to 2018. A minimum of 68 adult museum specimens and observations (Table 1 and Figure 5) are known. Data was assembled from numerous sources (**See Collections Examined**). The first Canadian record (1945) is labelled 'Oliver' and refers to an unknown collection site within the area around the Town of Oliver. There may be earlier records; however, no Canadian material was examined in the revisions of Bradley (1928) or Hurd (1952), nor mentioned in the catalog of North American Hymenoptera (Krombein 1979). The most recent records (2018) are photographs from an unknown site in Osoyoos (see Table 1).

Surveys for the Yellow Scarab Hunter Wasp in the past 15 years (Table 3) have focused on recording the species' abundance, and collecting habitat and biological information (Table 1). Adult wasps are collected by aerial net while conducting wandering transects through potential habitat, stopping periodically to disturb herbaceous and shrubby vegetation in order to flush out resting wasps, and observe for wasp nectaring, mating and larva-host burrowing activity. Wandering transects are preferred over grid-based transects because they allow the surveyor to change course depending on habitat suitability. They

are an efficient method of determining wasp presence when little information on the species' preferred microhabitats, roosting, mating or resting sites are available. Sandy banks, dense flower patches, shrubs, plant stems and other roosting sites were concurrently examined for perched individuals. Surveys do not typically target the larval life stage because the species is ectoparasitic on underground beetle larvae (**see Life Cycle**), which are cryptic and difficult to locate because both are burrowed in the soil.

The Canadian range of the Yellow Scarab Hunter Wasp is within an area of southern British Columbia that has been frequently visited for purposes of recreational and research-related insect collecting for more than 100 years. Researchers, conservancies, naturalists and biologists have conducted non-quantified surveys for wasps, bees and flies, concurrent with their own areas of focus. It is not possible to accurately quantify all search effort by these individuals. There are many thousands of specimens and specimen records of pollinating insects (wasps, flies, bees and beetles) from this area, yet specimen records for the Yellow Scarab Hunter Wasp remain low. The Yellow Scarab Hunter Wasp is a large and distinct wasp. It is therefore reasonable to conclude, solely on the basis of historical collection information, that this species is not a common species.

Search effort in preparation for this status report and specifically targeting large pollinators including the Yellow Scarab Hunter Wasp (e.g., bees, wasps, butterflies, flies) took place in 2010, 2013, 2015, 2016 and 2017 (Table 2; Figure 6) within the Similkameen and Okanagan valleys of BC and north to Quesnel.

Table 2. Collection locality, land ownership, date observed and threats applicable to Yellow Scarab Hunter Wasp sites in Canada. See Figure 6 for map.

Map #	Locality Name	Land Ownership	Symbol	Recent search effort (year)	First & Most Recent Year Observed	1.1 Housing and urban areas	1.2 Commercial & industrial areas	2.1 Annual & perennial non-timber crops	2.3 Livestock farming & ranching	6.1 Recreational activities	7.1 Fire and Fire suppression	7.3 Other ecosystem modifications	8.1 Invasive non-natives	9.3 Agricultural & forestry effluents	11.2 Droughts
1	Osoyoos Lake, East side; Inkameep [Osoyoos] Indian Reserve (IR)	Federal	square	no recent surveys	1996; 2007	x	x	x	x		x	x	x	x (some areas have vineyards; subject to pesticides)	x
2	Osoyoos Lake, Inkameep IR	Federal	square	no recent surveys	1996	x	x	x	x		x	x	x	x (some areas have vineyards; subject to pesticides)	x
3	Okanagan Falls, Skaha Lake PLS-A	private	solid dot	2017	2010; 2017			x			x	x	x	x	x

Map #	Locality Name	Land Ownership	Symbol	Recent search effort (year)	First & Most Recent Year Observed	1.1 Housing and urban areas	1.2 Commercial & industrial areas	2.1 Annual & perennial non-timber crops	2.3 Livestock farming & ranching	6.1 Recreational activities	7.1 Fire and Fire suppression	7.3 Other ecosystem modifications	8.1 Invasive non-natives	9.3 Agricultural & forestry effluents	11.2 Droughts
4a and b	Oliver, S. of; PLS-B and roadside verge	Private (a) land and adjacent public roadside (b)	solid dot	2017	2010; 2017			x			x	x	x	x	x
5	Okanagan Falls, Skaha Lake; PLS-C	private	solid dot	2017	2010			x			x	x	x	x	x
6	Cawston, 12 mi. S. Cawston	Provincial (likely)	triangle	2015, 2016, 2017, 2018	1987				x	x	x	x	x		x
7	Osoyoos, Haynes Lease Ecological Reserve	Provincial crown	triangle	2015, 2016, 2017, 2018	1980; 2017				x	x	x	x	x	x (overspray from adjacent agricultural areas)	x
8	Osoyoos, Road #22 (Haynes & WMA)	provincial crown	triangle	2015, 2016, 2017, 2018	1980; 2017					x	x	x	x	x (overspray from adjacent agricultural areas)	x
9	Okanagan Falls, White Lake to Kearns Creek	Provincial/Federal	square	2009;	1996				x	x	x	x	x		x
10	Osoyoos, E Bench	Unknown	asterisk	2008	2006 - 2008						x	x	x		x
11	Osoyoos L., N end	Unknown	asterisk	1980	1980						x	x	x		x
12	Osoyoos L., NE end	Unknown	asterisk	1981	1980 - 1981						x	x	x		x
13	Oliver	Unknown; likely private	solid dot	2017	1945; 2006						x	x	x		x
14	Oliver, S of; PLS-D	Private	solid dot	2017	2017			x			x	x	x	x	x
			Total			**2**	**2**	**6**	**5**	**4**	**14**	**14**	**14**	**8**	**14**

Both #1 and #2 are recorded from the Osoyoos Indian Reserve, although the collection sites are separated the wasp is likely in intervening habitat.
Both #7 and #8 are within close proximity.
Both #4 (private property and public roadside area) and #14 are adjacent private properties.

Table 3. Pollinator (larger bee, wasp, fly) surveys within the potential range of Yellow Scarab Hunter Wasp.

Date	General Location	Number of properties/sites searched and distance walked during surveys (if information available)	Number of specimens	Reference
2010	Okanagan and Similkameen Valleys	40 sites (separate properties) were surveyed from May 5–August 19, 2010. A total of 158 hours of aerial net captures, 147.6 kilometres over 50 days. Sites surveyed included 9 farms, 17 vineyards, 9 parks and 5 provincial crown properties in the south Okanagan - Similkameen. More than 1000 specimens of pollinating insects were collected.	4 specimens collected from three properties	Heron pers. data
2013	Okanagan, from Penticton north to Quesnel	99 sites (at least 10km apart) were surveyed from August 2–28, 2013. A total of 161 hours of aerial net captures with a minimum of 30 minutes to 8 hours at a site; distances was not recorded; all public land sites. Note only a portion of this search effort was during wasp flight season, these surveys are included because the wasp would likely fly longer at higher latitudes than the south.	None	Heron and Sheffield pers. data
2014	Okanagan and Similkameen valleys	17 sites surveyed in August 2018; a total of 17 hours with a minimum of one hour at each site; all public land sites. Note this search effort was at the end of the wasp's flight season.	None, although late in the flight season for the wasp	Heron pers. data
2015	Okanagan and Similkameen valleys	26 sites (separate properties); 17 farms, 5 vineyards, and 4 provincial crown properties. Surveys started August 18th and ended on October 6th, for a total survey period of fifty-one days. A cumulative total distance of 134.6 kilometres was covered and a cumulative search effort of 120 person-hours was spent walking through vineyards, farms and crown lands.	None, although late in the flight season for the wasp	Heron, Marks and Dawson. 2015
2016	Okanagan and Similkameen valleys	Surveys took place between May 6 and October 6, 2016. The survey sites included 1 farm, 2 vineyards, 1 provincial wildlife management area (numerous sites throughout this property), 1 ecological reserve, 3 private conservation properties (all owned by The Nature Trust), 3 City of Kelowna parks/properties, 1 river channel, 5 provincial parks, 3 BC protected areas and 3 undesignated provincial crown properties. Hand-netting was employed during wandering transect surveys performed at each property while blue vane traps, pan traps, and occasionally malaise traps were placed for passive collection at sites during the survey period. In 2016, a total of 8664 pollinators (mainly bees and larger wasps) from the Okanagan and Similkameen valley were prepared for identification, although none were the wasp.	None	Heron 2016
2017	Okanagan Valley and Chopaka West (Nighthawk Road) in the Similkameen Valley	41 sites (some properties had multiple collection sites) for a minimum of 15 minutes search effort per property. Surveys May 10–August 21, 2017 for a total of 383 hours of search effort.	11 observations; All previously recorded sites.	Heron and Sheffield pers. data

Date	General Location	Number of properties/sites searched and distance walked during surveys (if information available)	Number of specimens	Reference
2000–2018	Okanagan Valley, from Summerland south to Osoyoos	Non-quantified general insect collection, during which Yellow Scarab Hunter Wasp would have likely been collected. Surveys conducted from 1–7 days at various properties in the general area of Vaseux Lake, White Lake, west of Osoyoos, Highway 7 from Osoyoos to Nighthawk, Anarchist Mountain, Mount Kobau.	Some of the records noted in Table 1 are derived from incidental collection	Syd Cannings, Rob Cannings, Claudia Copley, Patrice Bouchard, David Holden, Werner Eigelsreiter, G.G.E. Scudder, Blades and Maier (1996)

In 2010, search effort took place from May 6 to August 19. Forty separate properties were surveyed including 9 farms, 17 vineyards, 9 parks and 5 provincial crown properties in the south Okanagan - Similkameen. A total of 158 hours of aerial net captures, 147.6 kilometres over 50 days. More than 1000 specimens of larger pollinating insects were collected. Four specimens of Yellow Scarab Hunter Wasp were collected on three separate properties.

In 2013, search effort took place from August 2–28. Ninety-nine public land sites were surveyed (roadsides, undesignated crown land, provincial parks and protected areas) from Kelowna north to Quesnel. More than 8000 specimens were collected; mainly bumble bees; however, larger wasps and solitary bees were also collected. Although the survey area was outside Yellow Scarab Hunter Wasp's known range, these null results are important for establishing whether the wasp ranges north of Skaha Lake and whether its flight period could possibly include late August.

In 2015, search effort took place from August 18 to October 5. Twenty-six sites were surveyed including 17 farms, 5 vineyards, and 4 provincial Crown properties. Hand-netting was employed during wandering transect surveys performed at each property. A total of 120 person-hours over 134.6 kilometres was covered, and over 1000 larger wasps and bees were collected. This time period is likely too late for the Yellow Scarab Hunter Wasp; however, the null data from these surveys helps confirm the flight period for the species.

In 2016, search effort took place from May 6 to October 6, 2016 (multiple visits at some of these properties, over the course of the time period). This entire search period is not applicable because the latest observation date for the wasp is early August (see Table 1 for all wasp records). A total of 22 properties were surveyed (1 farm, 2 vineyards, 1 provincial wildlife management area [numerous sites throughout this property], 1 ecological reserve, 3 private conservation properties [The Nature Trust], 3 City of Kelowna parks/properties, 1 natural habitat with a walking trail with natural habitat adjacent to a river channel, 5 provincial parks, 3 provincial protected areas and 3 undesignated provincial crown properties). Hand-netting was employed during wandering transect surveys performed at each property. A total of 8664 pollinators (bees and large wasps) from the Okanagan and Similkameen valley were pinned for identification; however, no Yellow Scarab Hunter Wasp specimens were recorded.

In 2017, search effort took place at 35 properties (multiple visits at some of these properties, over the course of the time period) and the Yellow Scarab Hunter Wasp was recorded at three sites during these surveys (Haynes Lease Ecological Reserve and adjacent South Okanagan Wildlife Management Area [Road 22], Black Sage Road and adjacent private property; and a private property near Okanagan Falls). From 10 minutes to one hour was spent surveying each of these sites, on multiple visits over the flight period, for a total of 383 hours of cumulative search effort. All bees and wasps were hand netted, with the larger specimens pinned and identified.

The Okanagan region is popular destination amongst those working on taxonomic, systematic and diversity entomological research, and those conducting research also tend to collect incidental specimens. This non-quantified search effort, as part of general insect surveys and collection, is difficult to tally; however, it should be noted. Most notably, surveys within the Vaseux Lake area, Anarchist Mountain, Mount Kobau, White Lake grasslands and other areas have been surveyed with null results for the wasp (see Table 3 for complete list of surveys and surveyors/research). The Yellow Scarab Hunter Wasp has not been recorded from the Nature Conservancy Sage and Sparrow Conservation Area (1,390 hectares of sagebrush grasslands) during general aerial insect surveys (approximately 2–5 days per year during the wasp flight season) from 2010 to present. The wasp has also not been recorded from a large parcel of BC Crown property on the west site of Osoyoos (called Osoyoos West Bench) during surveys in 2013, 2015, 2016, 2017 or 2018. Both of these areas represent intervening habitat between the Osoyoos collection sites (#2, #10) and Cawston site (#6). There is still the possibility the wasp is present in this habitat, although it is likely the abundance and distribution is low.

The Yellow Scarab Hunter Wasp has been caught once in a pitfall trap at Haynes Lease Ecological Reserve in 2003 (record #44 in Table 1). This trapping method is not thought to be an optimal or accurate survey method for the wasp.

Online observation forums and data providers, such as BugGuide® and iNaturalist® are valuable information sources from the naturalist and photographer community. There are three records from BC posted on BugGuide® (as of September 8, 2018) (Table 1; #65–68). There are no Canadian records of Yellow Scarab Hunter Wasp on iNaturalist® (as of September 8, 2018).

HABITAT

Habitat Requirements

General ecological community habitat:

All known Canadian records for Yellow Scarab Hunter Wasps are from the low elevation (< 600 metres) Antelope-brush (Figure 11) or sagebrush (Figure 13) ecological communities within the Okanagan and Similkameen valleys. The distribution of Antelope-brush (the plant only) (Figure 9) is more widespread.

There are two Antelope-brush ecological communities within the wasp's range: Antelope-brush/Needle-and-Thread Grass (*Purshia tridentata / Hesperostipa comata*) and Antelope-brush/Bluebunch Wheatgrass (*Purshia tridentata / Pseudoroegneria spicata*) (Parish *et al.* 1996; Lea *et al.* 2004; Iverson *et al.* 2005; Iverson and Haney 2012; Klinkenberg 2017). When wasp records are overlaid with ecological community mapping they are primarily within the Antelope-brush/Needle-and-Thread Grass ecological community, which is restricted to the lowlands of the Okanagan valley, from Skaha Lake south to the international border. Antelope-brush (the plant) ranges outside of these ecological communities with a small isolated patch in the Kootenay region of British Columbia; however, there are no wasp records from these areas.

Figure 11. Habitat at Haynes Lease Ecological Reserve (BC Parks) where Yellow Scarab Hunter Wasp (*Dielis pilipes*) was photographed (cover photograph and photo above) on June 15, 2017. Photo by Jennifer Heron.

Figure 12. Sagebrush habitat at White Lake (#9 on Figure 6) (west of Okanagan Falls), June 29, 2010. Yellow Scarab Hunter Wasp (*Dielis pilipes*) was collected on June 29, 1996 at White Lake. Photo by Jennifer Heron.

There are seven sagebrush ecological communities within the wasp's range; however, the wasp has only been recorded from the Big Sagebrush / Bluebunch Wheatgrass (*Artemisia tridentata / Pseudoroegneria spicata*) ecological community. There are two site records from this ecological community (see Figure 6): one in the Similkameen Valley (Cawston #6) and the other in the White Lake basin (White Lake #9). This community is more widespread than the Antelope-brush ecological community although geographically limited to Okanagan and Similkameen valleys. Common plants in this ecological community include Big Sagebrush (*Artemisia tridentata*), Prairie Junegrass (*Koeleria cristata*), Bluebunch Wheatgrass (*Pseudoroegneria spicata*), Idaho Fescue (*Festuca idahoensis*) and Pinegrass (*Calamagrostis rubescens*).

Larval habitat for the both the host beetle and Yellow Scarab Hunter Wasp:

Ten-lined June beetle larvae (both species) are typically found within soft, friable sandy soil with minimal rocks and little clay or gravel. The beetle larvae do not construct a tunnel-like burrow that is reused. The beetle larvae burrow through the soil and as it moves forward, they push dirt to the back of their pathway, making it difficult for a natural enemy to

follow such a path (Marshall pers. comm. 2017). Beetle larvae are typically 0.1 m–0.35 m below-ground surface, but have been found up to a depth of 1 m (Van Steenwyk and Rough 1989), and are also typically within close proximity to the roots of their preferred host plants.

When the adult female Yellow Scarab Hunter Wasp has oviposited on the host beetle larva, this burrow site will become the resting site of the developing wasp larva and the overwintering pupa. A study from California, which dug up thousands of Ten-lined June beetle grubs over the course of a 7-year time frame, found Yellow Scarab Hunter Wasp larva adjacent, but not attached to any of the beetle larva (Marshall pers. comm. 2017). Other research suggests that once the adult female scoliid paralyzes the beetle larva, they dig deeper into the soil and pull the beetle larva down further into the soil before ovipositing on the beetle larva (Marshall pers. comm. 2017).

Adult female Yellow Scarab Hunter Wasps are adept at burrowing in the soil and have been found up to 0.30 m underground (Marshall pers. comm. 2017).

Host beetle larval and adult habitat:

larvae are generalists and feed upon the fine roots and hairs of native, garden and ornamental shrubs and trees including sagebrush, willow, rose and poplar. They are often a localized pest on agricultural fruit trees and other crops such as strawberries, potatoes and corn. The adult beetles feed upon foliage.

Adult nectar plants and resting habitat:

Adult wasps feed on flower nectar and it is assumed do not have floral nectar specificity and are likely opportunistic due to their long adult flight period (April 20–August 2 in BC). Adult wasps have been observed in British Columbia nectaring on Showy Milkweed (*Asclepias speciosa*), Alfalfa (*Medicago sativa*), and White Sweet Clover (*Melilotus albus*) (Table 1).

Habitat Trends

Antelope-brush ecological communities in the Okanagan Valley have significantly declined in quality and spatial area since the 1800s (Schluter *et al.* 1995; Lea 2001; Dyer and Lea 2002; Iverson *et al.* 2005; Lea 2008; Iverson and Haney 2012; Iverson 2012). More specifically, the Antelope-brush/ Needle-and-thread Grass ecological community has declined from 9863 ha in 1800 to 3217 ha in 2009, a loss of 67.4% of the original extent of this ecosystem (Iverson 2012). This natural habitat has been converted to orchards, vineyards, housing and other non-natural use and is where the wasp has been most frequently recorded (Table 1). From 1995–2003, 1077 ha of Antelope-brush/Needle-and-thread Grass was lost to habitat conversion at an average rate of 134.6 ha/year (Iverson 2012). From 2003 to 2008, only 82 ha of habitat were lost to development, at an average rate of 16.4 ha/year (Iverson 2012). Regardless of the rate of development, any loss of this spatially limited ecological community impacts the species that live within that community. Trends in sagebrush ecological community loss are not as well documented.

One prominent example of recent habitat loss is the habitat surrounding Haynes Lease Ecological Reserve (#8) and the adjacent provincial wildlife management area (#7). The habitat surrounding these protected areas was Antelope-brush ecological community that was converted to vineyards in the 1990s, where once the habitat was continuous throughout the east side of Osoyoos Lake. Further development nearby these protected areas includes an urban housing project with approximately 300 homes to be built in the next 10-15 years.

Trends in habitat loss continue due to high pressure to develop undesignated provincial crown land and natural areas into housing, commercial and agricultural use. Agricultural conversion of orchards and other fruit trees to vineyards is prevalent throughout the region. Vineyard agriculture is typically more land-intensive, with fewer weeds and natural pockets of habitat. The rich, sandy and well-drained soils that support the Antelope-brush ecological communities are considered an indicator for high grape crop production and specifically targeted by the wine industry for development (Dyer pers. comm. 2018; COSEWIC 2012). There are approximately 172 of the 346 licensed wineries in BC in the Okanagan (both winery and independently owned) and represent 82% of the total acreage in the province used for grape production (BC Wine Institute 2017). To date, a total of 3488 hectares of vineyards are planted in this region (from Kelowna south to Osoyoos). These trends will continue to place more pressure on Antelope-brush ecological communities, particularly those on undesignated provincial crown land that can then be sold into the private sector for further land development.

BIOLOGY

Life Cycle and Reproduction

The Yellow Scarab Hunter Wasp develops via complete metamorphosis, thus has four life stages (egg, larva, pupa and adult). Most scoliid wasps have an annual life cycle so it is likely Yellow Scarab Hunter Wasp also has one generation per year.

The Yellow Scarab Hunter Wasp is a solitary ectoparasitoid of scarab beetle larvae (Scarabaeidae: Melolonthinae) (Goulet and Huber 1993; O'Neil 2001). In BC, there are two large species of Melolonthinae, commonly referred to as Ten-lined June Beetles (*P. crinita* and *P. decemlineata*). The larvae of these two species are found widely in sandy soils west of the Rocky Mountains in western Canada and the United States and are likely hosts to the wasp. The adult beetles are distinctive and commonly reported within the Okanagan and Similkameen valleys (**see Interspecific Interactions**). One additional genus of June beetle, *Cotalpa,* is listed as a host to the genus *Dielis* (= *Campsomeris*) (Krombein 1979); however, these beetles have not been recorded from BC and range from Alberta to Ontario (Bousquet *et al.* 2013).

In BC adult Yellow Scarab Hunter Wasps have been recorded from April 20–August 2, suggesting mating and oviposition occur during this time period.

The life cycle for Yellow Scarab Hunter Wasp written below is inferred from general life history information available about other *Dielis* (=*Campsomeris*) species, and scoliid wasps in general.

Fertilized adult females will circle in a figure eight pattern above a suitable area where there is a likely host beetle larva. The female is likely able to detect beetle larvae and whether they have already been ectoparasitized via chemical cues (e.g., kairomones), though the specific mechanisms and/or chemicals are unstudied. Females of the Yellow-flower Scoliid Wasp (*Radumeris tasmaniensis*), a species native to Australia and Papua New Guinea, tap the sand surface with their antennae and appear to know if another wasp has already oviposited on a host beetle larva (Hardwick and Wilson 2006). Once the female locates a host larva, she will burrow or dig into the ground in search of the specimen. The female will use her mandibles and then her fore- and mid-legs to dig into the soil to find the host larvae (Iwata 1976) and then use her stinger to paralyze it. The beetle larva is often situated within an established burrow and, according to Bradley (1945), female scoliid wasps do not construct a burrow of their own, but attach their eggs to the scarab larva and prepare a crude cell around them leaving the paralyzed larva *in situ* (reviewed by O'Neill 2001 for scoliids in general). The female likely uses the same burrow as the host larva (Iwata 1976). She may also dig deeper into the sand, move the beetle larva deeper too, and create a chamber around the host larva before laying an egg (Clausen 1940; Iwata 1976) and covering them both with sand.

One egg is laid per beetle larva, though in some cases larva are paralyzed but no egg is laid. The number of eggs an individual female wasp will oviposit over the season is unknown. The posterior end of the egg is always laid free of the host larva's body (Malyshev 1968, Iwata 1976). The egg hatches and the wasp larva begins feeding upon the paralyzed beetle larva. The wasp larva feeds for 1–2 weeks (Grissell 2007), likely consuming the entire host beetle larva. The larva then spins a cocoon and remains dormant in the cocoon until the following spring (Clausen 1940).

Beetle larvae that have been stung and paralyzed by Yellow Scarab Hunter Wasp, but not necessarily parasitized (e.g., egg is not laid on the larva) do not recover from the paralysis of the sting (Clausen 1940; Fleming 1968; O'Neill 2001). The female selective process for the size, age (larvae live from 2–4 years in the soil) and health of host larvae is unknown.

There is no information on the development time from one life stage to the next for the Yellow Scarab Hunter Wasp. Adult Yellow Scarab Hunter Wasps have been recorded as early as April 20, suggesting pupation takes place early to mid-April and two weeks prior to adult emergence. The timeline for the wasp's life cycle is based on information from other scoliids. In general, upon oviposition on the host beetle larva, egg incubation is 2–3 days; larval period 6–9 days and wasp pupal stage 30–40 days in summer, although for adult females that lay eggs towards the end of the summer, their progeny likely overwinter as pupae in the soil until the following spring (Grissell 2007).

It is unknown if Yellow Scarab Hunter Wasps that emerge early are able to complete another generation within the same summer. Information is available for *Radumeris tasmaniensis* Saussure, a species native to Australia and Papua New Guinea, but invasive in New Zealand. Information on this wasp documents larval development times from 68 and 76 days at 25°C in summer and 126 days in winter (Willoughby and Wilson 2006). This same wasp has one generation in warmer and cooler climates.

Yellow Scarab Hunter Wasps are solitary, though there appear to be yearly occurrences within specific areas, as inferred from ongoing observations of the wasp at the same locality over time (e.g., Haynes Lease Ecological Reserve and Black Sage Winery) (Tables 1 and 2).

The general life cycle of Ten-lined June beetles is summarized from information in Downes and Andison (1940); Banham and Arrand (1970) and Van Steenwyk and Rough (1989). June beetles live from 2–4 years. Female beetles lay 60–70 eggs within sandy soft soil which hatch after 3–4 weeks. Larvae remain in the soil for 2–3 years depending on the site and length of the growing season. Larvae pupate from May to June and the pupal period lasts approximately 5 weeks before adults emerge in June to August.

Physiology and Adaptability

The Yellow Scarab Hunter Wasp is an ectoparasitoid of Ten-lined June Beetles. There are no other large scarab beetles in the region, and information from other areas of the wasp's range suggests *P. crinita* and/or *P. decemlineata* are the hosts. There is no documented information about other potential host beetle relationships, or whether the wasp can host switch.

Parasitized June beetles have compromised immune systems, which ultimately compromises the survival of the developing wasp larvae. Ectoparasitic wasps produce natural anti-microbial compounds, which protect the host larva from pathogens, allow the host beetle larva to live longer, and enable the wasp larva to feed and grow without being compromised by these other factors (Dani *et al.* 2003). Adult female Yellow Scarab Hunter Wasps likely use chemical cues to both detect host beetle larva (including these anti-microbial compounds), and detect host beetle larva that have already been ectoparasitized (Hardwick and Wilson 2006). Wasp larva likely produce these same anti-microbial compounds although it is unknown if Yellow Scarab Hunter Wasps can host switch or how specific these chemical cues are for the host beetle.

Dispersal and Migration

The dispersal ability of the Yellow Scarab Hunter Wasp or any other *Dielis* species has not been measured. However, this large wasp may be a strong flyer, and may be able to disperse relatively long distances (especially males). Females spend portions of their time hunting for beetle larvae, flying and/or walking. However, gravid females may be too heavy to fly longer distances. The species is not migratory.

Interspecific Interactions

The Yellow Scarab Hunter Wasp has an ectoparasitic relationship with Ten-lined June Beetles (see Physiology and Adaptability and Biology). June beetle adults are large, robust beetles (up to 3 cm long) with distinctive wing covers (elytra) that have one short and four long white stripes. Males have large distinctive and feathered antennae, which they close up when threatened. Males also make a hissing sound when threatened. The thorax underside (both sexes) is covered with brownish hairs. June beetle larvae (Figures 3 and 4) are up to 7 cm long, and have a stiff, robust and whitish body, brown head and three pairs of legs.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

To date, Yellow Scarab Hunter Wasp surveys have focused on recording new sites, natural history and habitat information. Surveys have primarily been by wandering transects through suitable habitat (Table 2) (**see Search Effort**). Specimens are so rarely collected there is not sufficient information from which to derive population sizes and trends.

Abundance

There are few data from which to estimate Yellow Scarab Hunter Wasp abundance at extant sites. Most observations and collections are one or two individuals, per date, per site. The largest abundance of individuals was recorded in 1983 from Haynes Lease Ecological Reserve where 8 individuals were collected on May 12 (Table 1).

The abundance of Yellow Scarab Hunter Wasp is dependent on the abundance of its host scarab beetle larvae; there is likely a minimum abundance of these larvae needed for the survival of the wasp. A study that documented the parasitism rates of scarab white larvae (*Cochliotis melolonthoides*) in Tanzania by a large scoliid wasp, *Aureimeris mansueta* Gerstaecker 1857, noted that third instar larvae were targeted and the parasitism may have accounted for 20–50% mortality of that stage (Jepson 1956). The same study noted that smaller scoliid wasps, *Aureimeris* (*A. felina* (Saussure 1859 = *A. africana* Saussure 1859), *Cathimeris lachesis* (Saussure 1859) and *Campsomeriella caelebs* (Sichel 1864)), parasitized second instar larvae and accounted for 10–25% mortality (Jepsom 1956). Although unknown for Yellow Scarab Hunter Wasp, it is reasonable to suspect that parasitism rates could be similar to these scoliid wasps (i.e., 10–50%).

Fluctuations and Trends

The natural population fluctuations in scoliid wasps are a result of factors such as parasites, predators, the abundance of the host scarab beetle larvae, availability of adult nectar sources and the previous years' weather. The Yellow Scarab Hunter Wasp does not likely experience extreme fluctuations although there is insufficient information to estimate population fluctuations or trends for this species in Canada or elsewhere in the species' global range. Many sites have been visited over multiple years (Table 1 and 2); however, these sites were visited on one or two dates of a field season with the purpose of confirming the species' presence and recording the abundance on that date.

Rescue Effect

The Yellow Scarab Hunter Wasp is a large wasp although it is unknown if the species has the ability to fly longer distances and across unsuitable habitats in search of new host larva sites and new habitats to colonize. There are few databased records for the Yellow Scarab Hunter Wasp within northern Washington State, although the wasp likely occurs throughout the Antelope-brush and sagebrush ecological communities south of the international border. The closest databased record is at North Potholes Reservoir (1980) in Washington State, approximately 220 km south of the international border at Osoyoos. Natural re-establishment from Washington may be possible although given the low number of newly documented sites in Canada, other factors appear to limit the species' ability to colonize new sites.

THREATS AND LIMITING FACTORS

Threats

The threats classification for the Yellow Scarab Hunter Wasp in Canada is based on the IUCN-CMP (World Conservation Union–Conservation Measures Partnership) unified threats classification system (see Salafsky *et al.* 2008; Master *et al.* 2012). There is little information on specific threats to the Yellow Scarab Hunter Wasp and most threats are based on habitat trend information known for the south Okanagan and Similkameen valleys.

The cumulative loss, degradation, and fragmentation of the open and sandy Antelope-brush and sagebrush ecological communities are the primary threats to Yellow Scarab Hunter Wasp. The highest impact threat is habitat loss to agricultural land conversion (e.g., natural habitat conversion) or intensification (e.g., conversion of tree fruit crops to vineyards). Ongoing and cumulative threats exist from both conversion of natural areas to agricultural (particularly vineyard) use and more intensive agricultural use of those areas that are semi-natural. Additional threats include urban and commercial development; the spread and continued introduction of invasive non-native plants; the alteration to fire regimes and soil compaction resulting from overgrazing (Iverson 2012).

The overall province-wide threat impact is calculated at Very High–High. Details are discussed below under the IUCN-CMP (World Conservation Union–Conservation Measures Partnership) unified threats classification system headings and numbering scheme.

Threat 9. Pollution (High–Medium impact)

9.3 Agricultural and forestry effluents (high-medium impact)

Ten-lined June beetle larvae (both species) are considered a pest of fruit trees, particularly seedlings, nursery stock and newly transplanted trees. The larvae take 2–4 years to develop and during this time feed upon the fine root hairs and small roots of growing fruit trees. Feeding weakens the trees, weakens their roots, makes trees more susceptible to other diseases and makes the tree appear drought-stressed. Management recommendations do not currently include chemical control because chemicals are not considered effective (e.g., there is no registered chemical control). Management options to minimize beetle abundance suggest leaving former pasture fallow for at least a year before transplanting trees.

Although ten-lined June beetles may not have a specific pesticide available, there is an extensive list of additional insect and mite pests that affect grape and orchard crops throughout the Okanagan and Similkameen valleys that are controlled with pesticides. Pesticide application is the least recommended method of control (see BC Ministry of Agriculture and Lands 2010), yet pesticides are applied to most vineyards and orchards. The primary insect pests are cutworm larvae (> 20 species, consume plants), adult wasps (annoy workers and/or eat ripe fruit), leafhoppers (2 species, damage plants), Grape phylloxera (*Daktulosphaira vitifoliae*, non-native aphid, damages plants), and numerous other mealybugs, thrips, flies and fungi (BC Ministry of Agriculture and Lands 2010). Pesticides could impact adult Yellow Scarab Hunter Wasp adults when applied directly to crops or when adult wasps consume residue left on or within the fruit themselves. Chemical pesticides are typically applied during May and June, which is concurrent with the adult flight period of Yellow Scarab Hunter Wasp.

In addition, active management to control general wasp abundance on fruit crop properties is ongoing, because wasps consume and damage the fruit (BC Ministry of Agriculture 2010). Grapes mature towards the end of the growing season (August), which is later than most Yellow Scarab Hunter Wasp records (see Table 1). Social wasp control methods (e.g., knocking, breaking or destroying established nests; chemical pesticides on nests) are not applicable to Yellow Scarab Hunter Wasp because they do not build nests. Although Yellow Scarab Hunter Wasp is likely to get mistaken for other more numerous species such as the non-native European Paper Wasp (*Polistes dominula*), the probability of complete eradication due to specific targeted wasp control is unlikely. Other fruits, such as apples, pears, cherries and peaches, ripen during the Yellow Scarab Hunter Wasp flight period, but the threat of eradication is considered low.

Threat 2. Agriculture and Aquaculture(High–Medium impact)

2.1 Annual and perennial non-timber crops (high–medium impact).

The conversion of natural habitat to vineyards is a major threat to Antelope-brush ecological communities, particularly the low elevation (< 600m) Antelope-Brush / Needle-and-Thread Grass ecological community in the south Okanagan (Iverson 2012). This ecological community is targeted for acquisition by the grape production sector because it is indicative of the ideal soil conditions for grape growth (Dyer pers. comm. 2018; COSEWIC 2012). Orchard crops are also rapidly being converted to vineyards; grape crops yield a higher return on investment than orchard crops (see Habitat Trends). In general, vineyards are intensively managed and utilize higher portions of the land base than many of the older orchards in the region, and this higher intensification means less pockets of natural habitat available for native insects, such as the Yellow Scarab Hunter Wasp, amongst the agricultural fields.

Numerous private lands have small pockets of natural habitat, often too steep or rocky to plant an agricultural crop. These habitat refugia enable native insect populations to remain. Land is becoming more valuable in the Okanagan, and the demand for tourism is increasing, and thus it is becoming more economical to develop these habitat patches with either agricultural crops and/or with infrastructure such as wine tasting rooms, restaurants or bed-and-breakfasts (the infrastructure development is accounted for in Threat 1.1 and 1.2).

Ten-lined June beetle larvae are likely able to persist in areas converted from natural to agricultural, particularly because these larvae consume the fine roots of growing fruit trees, including grapes. There are records of the Yellow Scarab Hunter Wasp at four private land agricultural sites within the Okanagan Valley (#3, 4a, 5, 14), as well as the roadside adjacent to agricultural area (#8). Small patches of natural habitat within the large vineyard developments may be able to support the Yellow Scarab Hunter Wasp and host beetle larvae. However, the right combination of soft, deep, sandy soil and host beetle larvae is needed to enable the wasp female to detect the host beetle kairomones.

2.3 Livestock farming and ranching (medium–low impact).

Livestock grazing is practised widely throughout the private and crown Antelope-brush and sagebrush ecological communities of the south Okanagan and Similkameen valleys and is considered a plausible threat to the Yellow Scarab Hunter Wasp. Overgrazing leads to soil compaction and may reduce the survivorship of host beetle and developing wasp larvae. Conversely, the habitat may benefit from light grazing and keep the sandy environments open, thus allowing adult wasps to have greater opportunity to detect host larvae below the soil surface. Grazing is present at three known sites for the wasp; the provincial Wildlife Management Area along Black Sage Road (#7), the White Lake area (#9) and the Nighthawk Road-Chopaka West wildlife management area (#6). Grazing is also likely throughout portions of the Osoyoos IR (#1, 2).

Threat 7. Natural System Modifications (Medium impact)

7.1 Fire and Fire suppression (medium impact).

This threat is subdivided into two subcategories: fire and fire suppression. Fire suppression is an indirect or proximal threat to Yellow Scarab Hunter Wasp. Although partially discussed under this subheading, due in part to the contribution fire suppression makes to increasing wildfire severity, fire suppression is scored under 7.3 (Other ecosystem modifications).

Fire:

Fire and wildfire is a threat to all Yellow Scarab Hunter Wasp sites. Wildfire is considered part of the natural ecosystem processes of the southern interior grasslands and frequent, low-intensity wildfires were historically more common throughout the low elevation habitats of the Okanagan. Fires were likely ignited by First Nations peoples to improve root crops, and by lightning (Cannings and Durance 1998; Iverson 2012). Accidental fire by discarded cigarettes, unattended campfires, or vehicles (and hot engines) driving through dry vegetation is a serious threat to natural ecosystems in the Okanagan and Similkameen.

Fire suppression (discussed here but accounted for under 7.3 Other ecosystem modifications):

Over the past 100 years, fire suppression programs have altered the natural fire regime within the Okanagan and Similkameen valleys. The Okanagan Valley has experienced increased fire severity (Iverson 2012). Fire suppression has resulted in a build-up of fuels on the ground, and more intense, stand-replacing fires may result, rather than less intense patchy fires that leave some Antelope-brush ecological community patches intact. Reduced wildfire leads to tree encroachment, which also reduces the size and extent of bare soil and open sandy areas available for larvae, due to shading and competition.

It is unknown how wildfire may impact wasp populations. Wildfire may not severely impact the host beetle larvae or the larval life stage of Yellow Scarab Hunter Wasp because both are buried deep (> 30cm) within the soil and below the depth of a surface wildfire. Conversely, subsurface ground fires may severely impact both species.

7.3 Other ecosystem modifications (unknown impact).

The cumulative effects of fire suppression activities (7.1) and the spread of non-native/alien plants (8.1) have contributed to a decline in the habitat quality and quantity available to both species of Ten-lined June beetle hosts and the Yellow Scarab Hunter Wasp. These threats are discussed under their respective subheadings but scored here as unknown.

Threat 1. Residential or Commercial Development (Low impact)

1.1 Housing and urban areas (low impact); and 1.2 Commercial and industrial areas (low impact).

Human population growth and increasing land development is ongoing throughout the Okanagan valley. The human population within this area has tripled every 30 to 40 years since 1940 (Jensen and Epp 2002) and is projected to increase in the next two decades (Hobson and Associates 2006). There is potential for development at the private land sites (#3, 4, 5, 14) and portions of the Osoyoos IR (#1, 2).

Threat 6. Human Intrusions and Disturbance (Negligible impact)

6.1 Recreational activities (Negligible impact).

Hiking, off-leash dog-walking, mountain biking and all-terrain vehicle (ATV) use are some of the common recreational activities that occur within the natural habitats of the Okanagan and Similkameen valleys.

Haynes Lease Ecological Reserve (#8) and Wildlife Management Area at Road 22 (#7), White Lake (#9) and Chopaka West (#6) are frequently visited by hikers, although impacts from these recreational activities are considered negligible.

There is ongoing illegal camping at Haynes Lease Ecological Reserve (#8), particularly on the north end of the ecological reserve where there is an access road leading to a parking lot that is somewhat isolated and hidden. From April to October, there are adverse impacts to habitat within 75 metres radius to the parking lot, from extensive trampling of vegetation, garbage (including human waste), frequent campfires (in the parking lot) and discarded camping equipment at the site. All-terrain vehicle use is not an apparent threat at any one site, although there are portions of the BC crown land properties (#6) that have been subject to illegal use in the past.

Threat 8. Invasive and Other Problematic Species and Genes (Unknown impact)

8.1 Invasive non-native/alien species (unknown impact).

Many non-native plant species are found throughout the Antelope-brush and sagebrush ecological communities and open sandy habitats where Ten-lined June beetle larvae could occur and support the Yellow Scarab Hunter Wasp. Specifically, non-native invasive plants such as Cheatgrass (*Bromus tectorum*), Dalmatian Toadflax (*Linaria genistifolia* ssp*. dalmatica*), Diffuse Knapweed (*Centaurea diffusa*) and Sulphur Cinquefoil (*Potentilla recta*) have surface roots that spread horizontally and eventually cover the open sandy habitats. For example, Sulphur Cinquefoil can form monospecific stands (SIRT 2008). The spread of these plants stabilizes and covers the bare sandy soil and reduces the ability for Yellow Scarab Hunter Wasp to hover and detect burrowed host beetle larvae,

and reduces the ability for the wasp to burrow into the soil and find the host beetle larvae (e.g., dense root growth would make it difficult for adult wasps to burrow and move through the soil to reach the beetle larvae) and oviposit on the external surface of larvae. The overall understanding of this threat is unknown.

Threat 11. Climate Change and Severe Weather (Unknown impact)

11.2 Droughts (unknown impact).

Climate change is a potential but poorly understood threat to the Yellow Scarab Hunter Wasp. Climate change, particularly an increase in the frequency and intensity of extreme and periodic climatic events such as droughts, could be a long-term threat to Ten-lined June beetle larvae. Larvae are buried 10 cm below the surface, and consume the fine roots and hairs of shrubs and other plants. Extensive and prolonged drought may impact plants and lessen the forage opportunities for developing larvae. Prolonged summer drought could result in premature senescence of nectar plants and lead to a decline in the food available to adult wasps.

Limiting Factors

Limiting factors are generally not human-induced and include characteristics that make the species more vulnerable to ongoing threats. The main limiting factors for Yellow Scarab Hunter Wasp are likely a combination of the following.

Host beetle:

The Yellow Scarab Hunter Wasp depends on *P. crinita* and/or *P. decemlineata* and without these beetle larvae the wasp cannot complete its life cycle (**see Life Cycle and Reproduction**). Host beetles have a two-year life cycle, and wasps may only be able to detect the larvae after their first year when the larvae are larger.

Host and wasp larval substrate.

Ten-lined June beetle larvae are able to develop in a wide range of soil substrates. However, wasp larvae appear to have more specific soil substrate requirements: soft, deep, sandy soil that is sparsely vegetated. Adult wasps need to be able to detect June beetle larval kairomones through the soil, and then be able to dig through the soil in order to find the beetle larvae, which can then be up to 0.6 m in depth. Host larvae detection combined with drought, predation and other abiotic factors may play a role in this detectability.

Small population size.

Yellow Scarab Hunter Wasps are within small, isolated, and limited habitat patches that remain within the low elevation grasslands of the south Okanagan and Similkameen valleys. There are fewer than 70 specimens or observations since the first record in 1945 and based on low collection records, the species likely occurs at small or localized sites,

although genetic exchange likely occurs across sites.

Natural parasitic enemies.

Parasites are known to attack scoliid wasps during all life stages; however, no species-specific information is available for Yellow Scarab Hunter Wasp.

Vulnerability to weather patterns.

Seasonal weather patterns affect the abundance and distribution of wasps and beetles at all life stages. Humidity and extreme winter temperatures affect host beetle larval survival, particularly if the temperature and rainfall impact the species' growth and adult movement. All these factors contribute to the degree days and subsequent emergence of the next year's generation.

Number of Locations

There are 8–14 known locations proposed for Yellow Scarab Hunter Wasp, based on the threat of agricultural pesticides to control grape/orchard pests and land development across different land ownership and management regimes (Table 2, Figure 6). However, with greater search effort it is expected that additional sites and locations would be found, and the actual number of plausible locations is likely greater than the proposed range of known locations (i.e., it is reasonable to expected more than 10 locations at a minimum).

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Yellow Scarab Hunter Wasp and its scarab beetle host are not specifically listed or protected under provincial or federal legislation.

The Yellow Scarab Hunter Wasp is known from two provincial protected areas in BC: Haynes Lease Ecological Reserve (approximately 10 km north of Osoyoos on the west side of the valley) and South Okanagan Grasslands Protected Area – West Chopaka (along Nighthawk Road, approximately 19km south of Cawston in the Similkameen Valley). The BC *Park Act* protects invertebrate species at risk (provincially assessed as Red or Blue-listed by the BC Conservation Data Centre) in provincial parks and protected areas. When species at risk and the habitats they require are known to occur within a protected area, provisions for management are incorporated into the park master plan (if the park has a written and approved Master Plan). Provincial parks staff within the range of Yellow Scarab Hunter Wasp are aware of the species and possible presence within the low elevation Antelope-brush ecological communities. When scientific research permits and other activities within parks and protected areas are proposed, parks staff consider adverse impacts from proposed activities on the wasp and its habitat (Bunge pers. comm. 2017; Safford pers. comm. 2017; Weston pers. comm. 2017).

Yellow Scarab Hunter Wasp is not listed as Identified Wildlife under the BC *Forest and Range Practices Act;* however, it is possible to list the species under this act. This act is applicable to provincial crown forest and grazing land. Under this act, species that are adversely impacted by forestry or range activities can be listed as Identified Wildlife and known sites and habitat are spatially protected within Wildlife Habitat Areas. Yellow Scarab Hunter Wasp could be protected under the BC *Oil and Gas Activities Act*.

Non-Legal Status and Ranks

The conservation status ranks for Yellow Scarab Hunter Wasp (Natureserve 2017) are:

Global Status: GNR (Not Yet Ranked).
Canada National Status: NNR (Not Yet Ranked).
BC provincial status: SNR (Not Yet Ranked)
United States: NNR (Not Yet Ranked)

Non-government conservation organizations, such as The Land Conservancy, The Nature Trust and the South Okanagan Similkameen Conservation Program (and affiliated organizations) work with private landowners towards protecting arthropod species at risk on private lands (White pers. comm. 2017). Should additional information become available on Yellow Scarab Hunter Wasp, these organizations may be willing to initiate stewardship actions within their current management and outreach planning.

Habitat Protection and Ownership

The Yellow Scarab Hunter Wasp has been collected from at least four private properties in the Okanagan Valley (#3, 4a, 5, 14). Each landowner has been informed of the unique assemblage of pollinating insects in the Okanagan Valley and stewardship opportunities for maintaining these populations. There is a record from the roadside verge of Black Sage Road (#4b), south of Oliver. This roadside is managed by the regional government, although the site is also likely within the adjacent private property.

The Yellow Scarab Hunter Wasp has been recorded from the Inkameep Reserve (federal) governed by the Osoyoos First Nation. There is one site recorded from the federal property at White Lake, west of Oliver. Portions of this property have a grazing lease to The Nature Trust, a non-government conservation organization. The sites at Haynes Lease Ecological Reserve (approximately 10km north of Osoyoos in the Okanagan Valley; #7), the Wildlife Management Area along Road 22 (#8) and South Okanagan Grasslands Protected Area – West Chopaka (along Nighthawk Road, approximately 19km south of Cawston in the Similkameen Valley; #9) are on provincial land.

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The cover photograph of the Yellow Scarab Hunter Wasp resting on Alfalfa (*Medicago sativa*) was taken by Jennifer Heron on June 15, 2017 at Haynes Lease Ecological Reserve (BC Parks and Protected Areas), Osoyoos, BC. Specimen was not collected.

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Jennifer M. Heron is the provincial invertebrate conservation specialist with the BC Ministry of Environment and Climate Change Strategy. She directs and manages the provincial approach to invertebrate conservation, including the development and implementation of provincial legislation, policy, procedures, and standards for the conservation, and recovery of invertebrate species at risk, their habitats and ecosystems, and to keep these species from becoming at risk. She has authored/co-authored eleven COSEWIC status reports. Her interests include the native bees of BC and thermal springs invertebrates.

Cory S. Sheffield has been studying bees and pollination since 1993, starting with his undergraduate thesis project at Acadia University in Nova Scotia. His Master's research studied insect-plant interactions at Acadia followed by a PhD at the University of Guelph, Ontario. These studies focused on the bee fauna of Nova Scotia, including their diversity and contributions to crop pollination. Cory then worked on post-doctoral studies of bee taxonomy and DNA barcoding, followed by a research associate position in bee taxonomy with the Canadian Pollination Initiative (CANPOLIN) at York University, Ontario. Since 2012, Cory has been a research scientist and curator of invertebrate zoology at the Royal Saskatchewan Museum. His research continues to focus on bees: he has published on the taxonomy of Canadian/North American bees, the utility of DNA barcoding for bees, bee physiology, pollination contributions and diversity of the Canadian bee fauna.

ONLINE DATA SOURCES AND COLLECTIONS EXAMINED

University of Calgary, Insects & Invertebrate Zoology Museum, Department of Biological Sciences, Calgary, AB (John Swann 2017)

Northern Forestry Centre, Natural Resources Canada, Edmonton, AB (Greg Pohl 2017)

Strickland Entomological Museum, Department of Biology, University of Alberta, Edmonton, AB (Danny Shpeley 2017)

Invertebrate Zoology, Royal Alberta Museum, Edmonton, AB (Matthias Buck 2017)

Pacific Forestry Centre, Natural Resources Canada, Victoria, BC (Meghan Noseworthy 2017)

Royal British Columbia Museum, Victoria, BC (Claudia Copley 2017)

Spencer Entomological Collection, Beaty Biodiversity Museum, University of British Columbia, Vancouver, BC (Karen Needham and Chris Ratzlaff 2017)

Manitoba Museum of Man and Nature, Winnipeg, MB (Randall Mooi 2017)

Wallis Roughley Museum of Entomology, Department of Entomology, University of Manitoba, Winnipeg (Jason Gibbs 2017)

Canadian National Collection of Insects, Arachnids and Nematodes, Agriculture and Agri-Food Canada, Ottawa, ON (online database 2017)

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Table 4. Results for the Yellow Scarab Hunter Wasp threats assessment in Canada. The classification below is based on the IUCN-CMP (World Conservation Union–Conservation Measures Partnership) unified threats classification system. For a detailed description of the threat classification system, see the CMP web site (CMP 2010). Threats may be observed, inferred, or projected to occur in the near term. Threats are characterized here in terms of scope, severity, and timing. Threat "impact" is calculated from scope and severity. For information on how the values are assigned, see Master *et al.* (2009) and footnotes to this table.

Scientific Name	Yellow Scarab Hunter Wasp, *Dielis pilipes*			
Assessment Date	2018-08-31			
Assessors:	Jennifer Heron (status report writer), Cory Sheffield (status report writer), Orville Dyer (BC Ministry of Environment and Climate Strategy), Paul Grant (Arthropods SSC Co-chair), David Fraser (BC Ministry of Environment and Climate Change Strategy) with advice from Sara Bunge (BC Parks), Lea Gelling (BC Conservation Data Centre) and Dawn Marks (BC Conservation Foundation).			
			Level 1 Threat Impact Counts	
	Threat Impact		**high range**	**low range**
	A	Very High	0	0
	B	High	2	0
	C	Medium	1	3
	D	Low	1	1
	Calculated Overall Threat Impact:		Very High	High

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	
1.1	Housing & urban areas	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	Potentially applicable to private land sites (#3, 4, 5, 14) with natural habitat patches, for housing expansion; and on the Osoyoos Indian Reserve (#1, 2).
1.2	Commercial & industrial areas	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	Possibly applicable to natural habitat patches (for commercial buildings for crop storage, wine tasting or fruit shops) on agricultural land (#3, 4, 5, 14) and places on the Osoyoos Indian Reserve (#1, 2).
1.3	Tourism & recreation areas		Unknown	Unknown	Moderate (11-30%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Conversion of natural grasslands to golf courses and other forms of recreation. This doesn't currently apply to any known sites, applies to potential habitat.
2	Agriculture & aquaculture		High - Medium	Large (31-70%)	Serious - Moderate (11-70%)	High (Continuing)	
2.1	Annual & perennial non-timber crops		High - Medium	Large (31-70%)	Serious - Moderate (11-70%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Applicable to private properties (#1, 2, 3, 4, 5, 14) (further development on the property).
2.3	Livestock farming & ranching		Medium	Large (31-70%)	Moderate (11-30%)	High (Continuing)	#6,8,9
6	Human intrusions & disturbance		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	
6.1	Recreational activities		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	Applicable to 3 sites (#6, 7, 8, 9). Illegal camping at Haynes Lease Ecological Reserve (#8).
7	Natural system modifications		Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	
7.1	Fire & fire suppression		Medium	Pervasive (71-100%)	Moderate (11-30%)	Moderate (Possibly in the short term, < 10 yrs)	Applicable to all sites. Scored for the threat of wildfire only.
7.3	Other ecosystem modifications		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Applicable to all sites. Fire suppression and invasive non-native plants are cumulative threats because they are indirect threats to the wasp. This threat is applicable to all sites.
8	Invasive & other problematic species & genes		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
8.1	Invasive non-native/alien species/diseases		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Applicable to all sites. Affects wasp's ability to detect host species (non-native plants fill in the open sandy areas).

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9	Pollution		High - Medium	Large (31-70%)	Serious - Moderate (11-70%)	High (Continuing)	
9.3	Agricultural & forestry effluents		High - Medium	Large (31-70%)	Serious - Moderate (11-70%)	High (Continuing)	#1,2,3,4,5,8,7,14
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
11.2	Droughts		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Applicable to all sites. Not a well understood threat

[1]**Impact** – The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of each stress is based on Severity and Scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. The median rate of population reduction or area decline for each combination of scope and severity corresponds to the following classes of threat impact: very high (75% declines), high (40%), medium (15%), and low (3%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity is unknown).

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

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

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