COSEWIC
Assessment and Status Report

on the

Grappletail
Octogomphus specularis

in Canada

SPECIAL CONCERN
2021

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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Grappletail — Photo by John D. Reynolds.

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COSEWIC
Assessment Summary

Assessment Summary – April 2021

Common name
Grappletail

Scientific name
Octogomphus specularis

Status
Special Concern

Reason for designation
This dragonfly is known from only seven fast-flowing, warm streams that drain small lowland lakes in the mountains of the lower Fraser Valley in southwestern British Columbia. Here, the species is at the northern edge of a range that extends south to Mexico. Larvae forage for three years in streams while adults forage for only a few weeks in nearby forests. There are no estimates of population trends from about 150 observations in the past 90 years. Most streams where it occurs are in forested watersheds with few threats. However, local threats include roadkill at stream crossings and disturbance to the stream habitat by recreational vehicles.

Occurrence
British Columbia

Status history
Designated Special Concern in May 2021.

COSEWIC
Executive Summary

Grappletail
Octogomphus specularis

Wildlife Species Description and Significance

Grappletail (*Octogomphus specularis*) is a slender dragonfly, 51 to 53 mm long. The top and sides of the thorax are yellow or pale green with a broad black stripe between them. The abdomen is black with a fine pale stripe on the top and between the abdominal segments. In males, the abdomen widens posteriorly and has two distinctive, yellow, eight-branched appendages (cerci) at the tip.

Distribution

Grappletail's global range extends from southwestern British Columbia along the Pacific coast of the United States and into northernmost Mexico. The United States range is mostly west of the Sierra Nevada and Cascade Mountains. In Canada it is known from seven streams in the Lower Fraser River valley in southwestern British Columbia in an area extending over 514 km^2.

Habitat

Grappletail larvae inhabit sand and gravel or organic debris in slow to moderately flowing sections with boulder and cobble substrates, usually in fast-flowing streams. All known Canadian subpopulations are immediately downstream from lakes, where stream water is warmer and food availability is greater compared to other streams.

Biology

Like all dragonflies, Grappletails have an aquatic larval stage and terrestrial adult stage. The larvae (nymphs) inhabit streams where they feed on aquatic invertebrates. They spend three years in the larval stage. When mature, the nymphs climb onto boulders, banks, and overhanging trees where they emerge as adults. Males typically remain near the stream while females often move up to about 100 m into the surrounding forest. Adults feed on flying insects. Males perch on sunny rocks, twigs, and leaves on the stream bank and forage up and down the stream. Females return to the stream when ready to mate. They oviposit by flying in loops over a pool and dipping the tip of the abdomen into the water. The flight dates are mid-June to early September in British Columbia, with about 70% of adult records in July.

Population Sizes and Trends

Population size and trends of Grappletail in Canada are poorly known. There are a total of 154 specimens and observations since 1936, but no population estimates or trend data are available. Grappletail was found at four of the six previously known subpopulations during 2019 and 2020 surveys but its status could not be confirmed at the remaining two subpopulations. A new subpopulation was documented in 2020.

Threats and Limiting Factors

Most of the habitat where the seven subpopulations occur is relatively intact within mainly forested watersheds with little habitat conversion along the streams where larvae would likely reside. Sweltzer Creek has been subject to shoreline development and water quality changes caused by recreational, agricultural, and urban runoff. Other potential threats include roadkill (streams flow under bridges or through culverts at most sites), invasive species, water quality changes, and stream sedimentation related to logging.

Protection, Status and Ranks

Grappletail is not protected under the Canadian *Species at Risk Act* or the U.S. *Endangered Species Act* list. River and stream habitats in Canada receive some protection under the federal *Fisheries Act* where fish habitat is present. Grappletail is on the provincial Red List in British Columbia with a rank of S2 (Imperilled), but not specifically protected by legislation. The Jacobs Creek, Loon Creek, and Blaney Creek subpopulations are in the Malcolm Knapp Research Forest, owned by the University of British Columbia. The site is managed as a working forest where research, logging, and other activities take place. The Davis Creek subpopulation is in Davis Lake Provincial Park. The Rolley Creek subpopulation is in the Mission Municipal Forest and on a provincial road allowance. Its headwaters include Rolley Lake Provincial Park, Crown land, and privately owned land. Elbow Creek and its upstream watershed are on Crown Land. The land surrounding the Sweltzer Creek subpopulation consists of a municipal park in the community of Cultus Lake. The upstream watershed includes Cultus Lake Provincial Park, Crown land, and private land. This watershed extends into the US.

TECHNICAL SUMMARY

Octogomphus specularis

Grappletail

Gomphe spéculaire

Range of occurrence in Canada: British Columbia

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	3 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. Unknown b. Unknown c. Unknown
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	514 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	28 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)	Possibly as many as 7, but threats low, so locations may not apply
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of “locations”*?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	No, decline of habitat historical at Sweltzer Creek
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**
	Unknown
Total	

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	Unknown

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

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

Was a threats calculator completed for this species? Yes. A threats conference call was held on 3 April 2020. The overall threat impact was rated as Low. Known threats include: 1.1 Housing & urban areas (Low Impact) 1.3 Tourism & recreation areas (Low Impact) 4.1 Roads & railroads (Low Impact) 5.3 Logging & wood harvesting (Low Impact) 6.1 Recreational activities (Low Impact) What additional limiting factors are relevant? • Dependence on unusual habitat type • Northern limit of global range

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Apparently stable in the United States (N4) and Washington (S4)
Is immigration known or possible?	Unknown but unlikely. Non-migratory. Nearest known United States occurrence is 150 km from Canadian occurrences
Would immigrants be adapted to survive in Canada?	Likely
Is there sufficient habitat for immigrants in Canada?	Likely
Are conditions deteriorating in Canada?[+]	Probably at Sweltzer Creek. Unknown at other subpopulations
Are conditions for the source (i.e., outside) population deteriorating?[+]	No
Is the Canadian population considered to be a sink?[+]	No
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species?	No

Status History:

COSEWIC: Designated Special Concern in May 2021.

Status and Reasons for Designation:

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

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

Reasons for designation:
This dragonfly is known from only seven fast-flowing, warm streams that drain small lowland lakes in the mountains of the lower Fraser Valley in southwestern British Columbia. Here, the species is at the northern edge of a range that extends south to Mexico. Larvae forage for three years in streams while adults forage for only a few weeks in nearby forests. There are no estimates of population trends from about 150 observations in the past 90 years. Most streams where it occurs are in forested watersheds with few threats. However, local threats include roadkill at stream crossings and disturbance to the stream habitat by recreational vehicles.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Population trends unknown.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. Although both EOO (514 km^2) and IAO (28 km^2) are below the thresholds for Endangered, no other sub-criteria are met and there is little evidence of decline or threats to base locations on.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Population size unknown and little evidence of decline.
Criterion D (Very Small or Restricted Population): Not applicable. Population size unknown, and little evidence of decline.
Criterion E (Quantitative Analysis): Not applicable. No data to conduct analyses.

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 (2021)

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

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TABLE OF CONTENTS

List of Figures

List of Tables

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Phylum Arthropoda – arthropods
Class Insecta – insects
Order Odonata - damselflies and dragonflies
Suborder Anisoptera - dragonflies
Family Gomphidae – clubtails
Genus *Octogomphus* Selys, 1873
Species *Octogomphus specularis* – Grappletail

Synonyms : Neogomphus specularis Hagen in Selys, 1859

French common name: Gomphe spéculaire
English common name: Grappletail

Grappletail is the sole member of the genus *Octogomphus*. The species was described in Selys-Longchamps (1859) as *Neogomphus specularis* but later assigned to *Octogomphus* (Selys-Longchamps 1873). No subspecies have been described. *Octogomphus* is most closely related to *Stylogomphus* and *Lanthus* (Paulson 2009). The type locality is “California” (Paulson and Dunkle 2016).

Morphological Description

Grappletail is a slender dragonfly, 51 to 53 mm long (Needham *et al*. 2000). The top and sides of the thorax are yellow or pale green with a broad black stripe between them. The abdomen is black with a fine pale stripe on the top and between the abdominal segments (Cannings 2002; Paulson 2009) (Figure 1). In males, the abdomen widens near the end and has two distinctive, yellow, eight-branched appendages (cerci) at the tip (Needham *et al*. 2000). Similar dragonflies within its range include Pale Snaketail (*Ophiogomphus severus*) and Sinuous Snaketail (*O. occidentalis*), both of which lack the black abdomen and yellow cerci of Grappletail (Cannings 2002).

Mature larvae are 18 to 24 mm long with a mottled brown pattern on the abdomen (Figure 2). The third antennal segment is widened and the wing buds are parallel rather than divergent (Walker 1958; Tennessen 2019). The egg has not been described.

Figure 1. Adult male Grappletail at Rolley Creek, 12 July 2019. Photo: Robert Foster.

Figure 2. Grappletail exuvia (female). Collected at Blaney Creek, 26 June 1990. Photo by Don Griffiths, courtesy Spencer Entomological Collection, Beaty Biodiversity Museum, University of British Columbia.

Population Spatial Structure and Variability

Spatial structure and variability of Grappletail populations have not been studied in Canada or the US. DNA barcodes are available for five Grappletail specimens in the Barcode of Life Datasystem (Ratnasingham and Hebert 2007), four of which are from Rolley Creek, British Columbia (the origin of the other is not provided). The five samples constitute one Barcode Index Number (BIN).

Designatable Units

No subspecies are recognized. The species occurs entirely in the Pacific National Ecological Area (COSEWIC 2011a) and there is no information on population genetic structure among sites. There also are no data on discreteness or evolutionary significance among populations. Grappletail has one designatable unit within Canada.

Special Significance

Grappletail is the only member of the genus *Octogomphus* and is endemic to North America. Dragonflies are popular among amateur naturalists with a growing number of field guides, atlases and web-based resources. There is no specific Aboriginal Traditional Knowledge for Grappletail available. However, this species is part of Canadian ecosystems that are important to Indigenous people, who recognize the interconnectedness of all species within the ecosystem.

DISTRIBUTION

Global Range

The global range of Grappletail extends from southwestern British Columbia south along the Pacific coast of the United States, mostly west of the Sierra Nevada and Cascade Mountains, and into northernmost Mexico (Paulson 2009) (Figure 3). In Washington, Grappletail is locally distributed in the western lowlands, along the Columbia River, and as far north as King County, about 150 km from the nearest Canadian population (Paulson 2017). There are no records north of King County, but the species is probably more widespread in the state (Paulson 2017). It is known from 15 counties in Oregon, including a disjunct record in the northeastern corner of the state, east of the Cascade Range (Paulson 2009; Valley 2019). Most California records are from the west slope of the Sierra Nevada to the Pacific. There is a single record in Esmeralda County, Nevada, east of the Sierra Nevada (Paulson 2009; Johnson 2016). Reports from Montana are probably in error (Bachen pers. comm. 2019).

The global range covers 769,000 km^2, less than 1% of which is in Canada[1] (Figure 3).

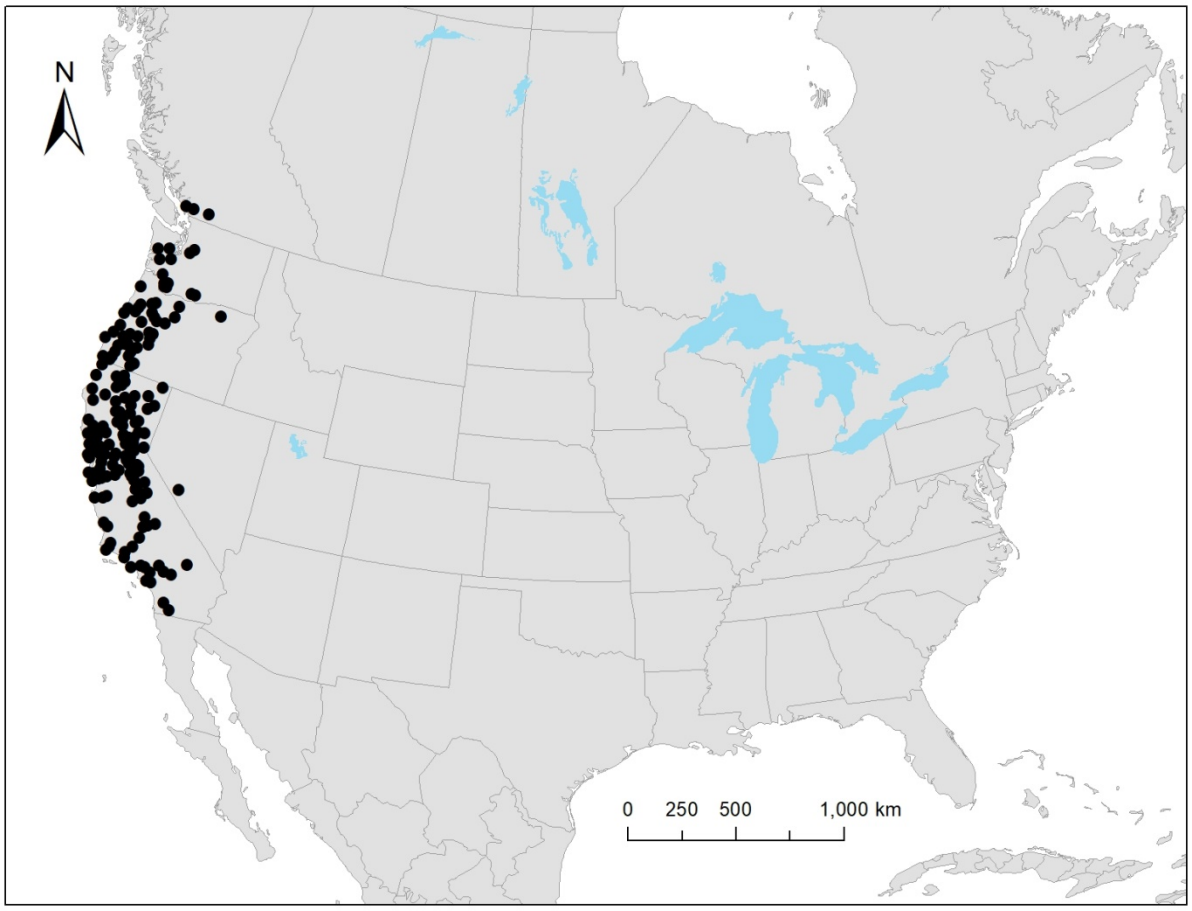

Figure 3. Global range of Grappletail (*Octogomphus specularis*) (data from Odonata Central 2019, iNaturalist 2019). (map by A. Harris).

Canadian Range

Grappletail has seven subpopulations[2] (Table 1) in the lower Fraser River Valley, British Columbia (Figure 4). All but one are north of the Fraser River.

[1] Calculated by the writer using Arc Map

[2] Subpopulations are defined as geographically or otherwise distinct groups in the population between which there is little demographic or genetic exchange (typically one successful migrant individual or gamete per year or less) (IUCN 2001)

Table 1. Known records of Grappletail in Canada. Sources: British Columbia Conservation Data Centre (CDC), Canadian National Collection (CNC), E-Fauna BC, Royal British Columbia Museum (RBCM), Spencer Entomological Collection, Beaty Biodiversity Museum, UBC (SEC). Refer to Figure 4 for map.

Site	Subpopulation	Source	Search Effort (minutes)	First Detected	Most recent survey	# Individuals	Notes	Observer
Blaney Creek	1	E-Fauna BC		1983	Apr 19 1983	1 larva	larva	J. Richardson
Blaney Creek	1	SEC		1983	July 27 1985	5 m, 2 f	Ovipositing, copulating	S.G. Cannings
Blaney Creek	1	CDC		1983	Sep 14 1988	1 m		H. Nadal
Blaney Creek	1	E-Fauna BC		1983	Aug 25 1989	1 larva	Outlet of lake at logging road	R.A. Cannings, S.G. Cannings
Blaney Creek	1	SEC		1983	June 26 1990	5 exuviae		J. Lancaster
Blaney Creek	1	2019 fieldwork	90*	1983	July 11 2019	0		R.F. Foster, A.G. Harris
Blaney Creek	1	2019 fieldwork	45	1983	July 15 2019	3 ad		R.F. Foster
Loon Creek	1	SEC		1985	July 29 1985	2 m, 1 f	Ovipositing in shallow water at sandy edge of stream, 1300 h	S.G. Cannings
Loon Creek	1	SEC		1985	July 23 1998	1 m		R.D. Kenner
Loon Creek	1	2019 fieldwork	65*	1985	July 11 2019	0		R.F. Foster, A.G. Harris
Loon Creek	1	2019 fieldwork	20*	1985	July 15 2019	0		R.F. Foster, A.G. Harris
Jacobs Creek	2	SEC		1985	July 29 1985	1 m	Above Jacobs Lake	S. G. Cannings
Jacobs Creek	2	SEC, CDC		1985	July 23 1996	2 m	South of Jacobs L. Seven males observed, two collected	R.D. Kenner
Jacobs Creek	2	2019 fieldwork	85*	1985	July 11 2019	0	South of Jacobs L.	R.F. Foster, A.G. Harris
Jacobs Creek	2	2019 fieldwork	40	1985	July 15 2019	2 ad, 1 exuvia	South of Jacobs L.	R.F. Foster
Elbow Creek	3	Whitehouse 1941		1936	Aug 12 1936	9 m, 2 f	“Headwaters”	F.C. Whitehouse
Elbow Creek	3	Whitehouse 1941		1936	Aug 14-18 1936	11 m, 9 f		F.C. Whitehouse
Elbow Creek	3	2019 fieldwork	27	1936	July 13 2019	0		A.G. Harris
Davis Creek	4	Rob Cannings pers. comm.		1980	July 29 1980	1 m	Outlet of Davis L. Photograph in RBCM collection	G. Doerksen

Site	Subpopulation	Source	Search Effort (minutes)	First Detected	Most recent survey	# Individuals	Notes	Observer
Davis Creek	4	Rob Cannings pers. comm.		1980	Sep 16 1980	1 f	Outlet of Davis L. Photograph in RBCM collection	G. Doerksen
Davis Creek	4	2019 fieldwork	50	1980	July 12 2019	0	900 m downstream from outlet of Davis L.	R.F. Foster, A.G. Harris
Davis Creek	4	2020 fieldwork	60	1980	July 27 2020	20 ad	Many individuals of both sexes seen, including mating pairs and ovipositing females	B.M.Starzomski, J. Heron, J. Reynolds
Sweltzer Creek	5	Whitehouse 1941		~1936	prior to 1936	?	Outlet of Cultus L. Collected prior to 1936 by Ricker (Whitehouse 1941)	W. Ricker
Sweltzer Creek	5	Whitehouse 1941, CNC		~1936	June 16 - late July 1936	27 m	Outlet of Cultus L. 27 males collected over 5 weeks. No females observed.	F.C. Whitehouse
Sweltzer Creek	5	2019 fieldwork	70	~1936	July 13 2019	0	Outlet of Cultus L.	A.G. Harris
Sweltzer Creek	5	2019 fieldwork	75	~1936	July 16 2019	0	Outlet of Cultus L.	R.F. Foster
Rolley Creek	6	CDC		1996	July 24 1996	1 m		S.G. Cannings
Rolley Creek	6	CDC		1996	July 31 2000	2 m, 1 f		G. Hutchings
Rolley Creek	6	Gatten pers. comm.		1996	July 28 2017	4 to 6		J. Gatten
Rolley Creek	6	2019 fieldwork	162*	1996	July 12 2019	20 ad, 1 exuvia	Ovipositing, copulating	R.F. Foster, A.G. Harris
Rolley Creek	6	2020 fieldwork	30	1996	July 27 2020	2 m, 1 f	Ovipositing	J. Gatten
Devil's Creek	7	2020 fieldwork	60	2020	July 27 2020	10 ad	Many individuals of both sexes seen, including ovipositing females	B.M. Starzomski, J. Gatten, J.D. Reynolds
Devil's Creek	7	2020 fieldwork	110	2020	July 27 2020	8 ad		C.D. Eckert, J.D. Reynolds

*Includes larval searches

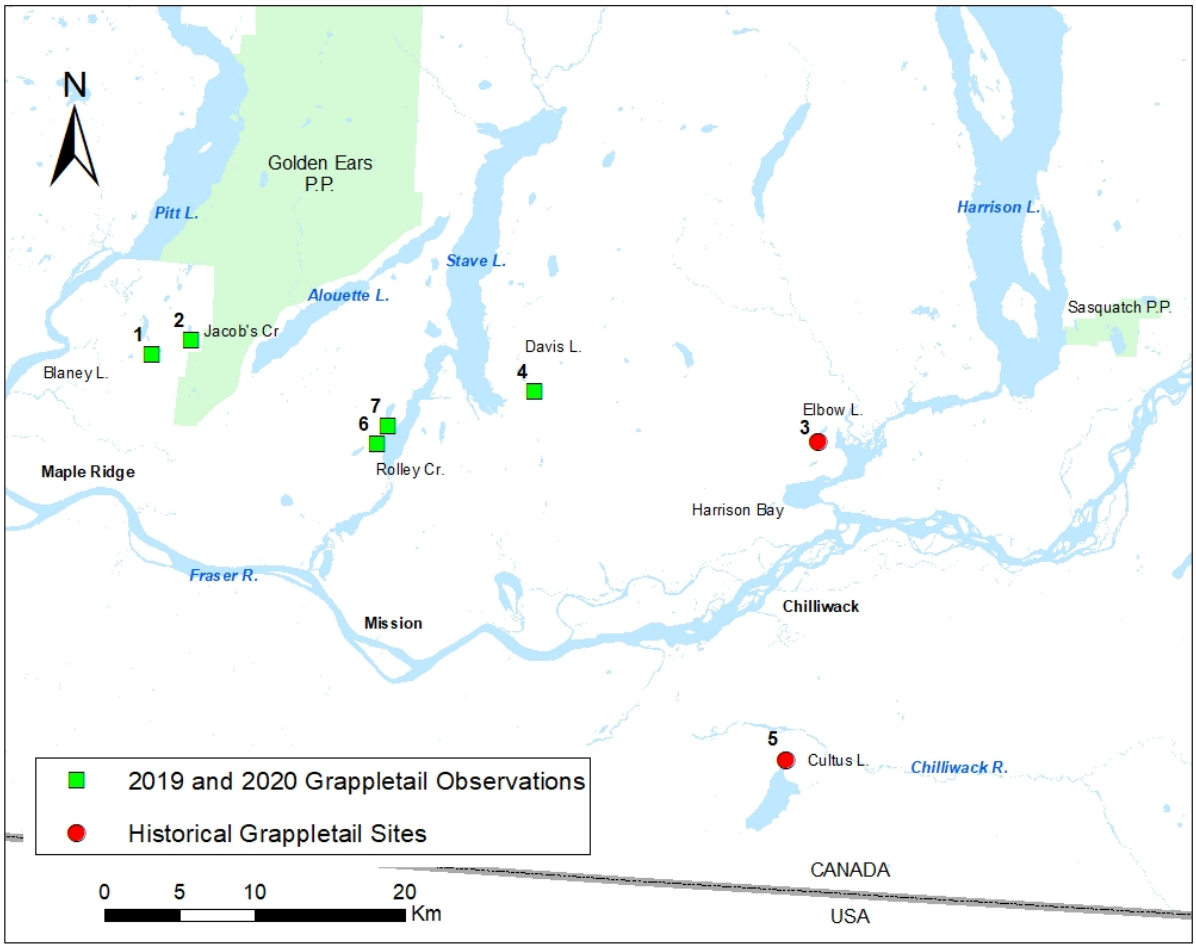

Figure 4. Map of southern British Columbia showing Grappletail range. Numbers refer to subpopulations in Table 1. (map by A. Harris).

All Canadian subpopulations are considered to be extant. Grappletails were confirmed to be present at five of the seven subpopulations in 2019 and 2020 and the lack of consistent survey effort at the others means that their status cannot be confirmed.

Given the restricted habitat (streams draining from lakes), the popularity of dragonflies among naturalists, and the availability of field guides and regional checklists, the mapped range is reasonably complete, although additional subpopulations may exist in less accessible areas within the known range in southern British Columbia.

The reported presence of Grappletail at Harrison Bay in 1936 (e.g., British Columbia Conservation Data Centre) is apparently a misinterpretation of Walker (1957) who describes the distribution in Canada as “Cultus Lake, Chilliwack dist. and Elbow Lake, Harrison Bay” but makes no further mention of Harrison Bay. Grappletail range is incorrectly mapped in Donnelly (2004) as extending into northern British Columbia.

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EOO) of Grappletail in Canada is 514 km^2 as measured by a convex polygon encompassing all known Canadian subpopulations[3], assuming it still occurs at all historical sites. The index of area of occupancy is 28 km^2, based on 2 km X 2 km grids. Both the EOO and IAO are minimum estimates and could increase if additional subpopulations are found.

Search Effort

Grappletail was first reported in Canada at Sweltzer Creek prior to 1936 and the most recent records are from Rolley Creek, Davis Creek, and Devil's Lake in 2020 (Table 1). Within the Canadian range, there are 154 known sight and museum records from seven subpopulations. Survey methods have typically consisted of collecting adults and exuviae (shed larval exoskeletons) along streams (e.g., Cannings *et al*. 2007).

Seven subpopulations were surveyed for this report. The six known Grappletail subpopulations were surveyed 11-16 July 2019. In 2020, Rolley Creek, Davis Creek, and a previously undocumented site at Devil's Lake (subpopulation 7) were surveyed between 27 July and 13 August (Gatten pers. comm. 2020; Heron pers. comm. 2020; Reynolds pers. comm. 2020; Starzomski pers. comm. 2020). Methods included visual surveys for flying and perched adults, kick-and-sweep surveys for larvae, and searches for exuviae on streambanks, boulders, and logs (Table 1). Survey sites include Loon Creek (subpopulation 1 on Figure 4), Blaney Creek (subpopulation 1), Jacobs Creek (also known as Marion Creek) (subpopulation 2), Elbow Creek (subpopulation 3), Davis Creek (subpopulation 4), Sweltzer Creek (subpopulation 5), and Rolley Creek (subpopulation 6). Additional sites surveyed in 2019 included points downstream from historical records and suitable habitat at the outflow of Hicks Lake (Sasquatch Provincial Park) and Chilliwack Lake (Figure 4). About 19 other sites not situated below lakes were surveyed opportunistically in 2019. Search effort totaled 829 minutes at known sites and 553 at other sites. No larvae were observed in 2019. Two creeks, connecting Cannell Lake and Sayres Lake with Stave Lake, were considered potential habitat. They were searched on 13 August 2020 (Reynolds pers. comm. 2020). The habitat was not as good as perceived on Google Earth and no Grappletail were found.

The species is easily recognized with the male's distinctive yellow claspers. However, adult flight activity is sensitive to weather conditions; no adults were observed at Blaney or Jacobs Creek during cool (20°C), damp conditions on 11 July 2019 (although other dragonfly species were flying) but several adults were observed at the same sites several days later when it was warmer (23°C) and sunny (Table 1).

British Columbia is one of the better surveyed parts of Canada for odonates (Ramsay and Cannings 2000; Cannings 2019). These have been general surveys for odonates rather than targeted searches for Grappletail.

[3] Calculated by the writer using ArcMap

Dragonfly surveys date back to those of E.R. Buckell prior to 1938 covering areas mostly north and east of the Lower Fraser (Buckell 1938); the Cultus Lake area by W.E. Ricker (Walker and Ricker 1938); and surveys by Whitehouse between 1934 and about 1941, covering wide areas of the southern and central parts of the province (Whitehouse and Walker 1947).

Concentrated surveys for dragonfly species at risk were undertaken by the Royal British Columbia Museum and the British Columbia Conservation Data Centre between 1996 and 2003, covering several regions of the province (Cannings and Ramsay 2005; Cannings 2019). These included northern British Columbia (Cannings *et al*. 2006), the Montane Cordillera ecozone (Cannings and Cannings 2011), the Columbia Basin (Cannings *et al*. 2000), and the Fraser Valley (Kenner 1996).

No Grappletail larvae were reported from over 300 Canadian Aquatic Biomonitoring Network (CABIN) monitoring sites in British Columbia, seven of which are in the Lower Fraser River Valley (ECCC 2109a).

Null search effort for Grappletail prior to 2019 is poorly documented. There are over 20,000 dragonfly records up to 2004 (the most recent update) in E-Fauna BC, a GIS-based biogeographic atlas of the wildlife of British Columbia (Klinkenberg 2020). Dragonfly records are distributed over much of the province but most concentrated in road accessible areas in the south (Cannings and Scudder 2005). Records from Grappletail sites were queried in E-Fauna BC for species with similar flight periods and using similar habitat on the assumption that Grappletail would have been reported if collected. The species included Emma's Dancer (*Argia emma*), Shadow Darner (*Aeshna umbrosa*), and Pacific Spiketail (*Cordulegaster dorsalis*) (Cannings, R. pers. comm. 2019a; Cannings, S. pers. comm. 2019). Null surveys included Blaney Creek (subpopulation 1) (three additional dates), Loon Creek (subpopulation 1) (two additional dates), Sweltzer Creek (subpopulation 5) (two additional dates), and Jacobs Creek (subpopulation 2) (one additional date) (Table 2). There are also about 200 Odonata records in iNaturalist between 2010 and 2019 within the Canadian extent of occurrence, including a single record of Grappletail (iNaturalist 2019).

Grappletail has not gone through the formal Aboriginal Traditional Knowledge Gathering process (Davis pers. comm. 2019).

Table 2. Additional null surveys at or near Grappletail sites (E-Fauna BC data; Cannings and Scudder 2005). Refer to Figure 4 for sites.

Site	Date	Species Observed	Observer
Jacobs	Sep 2 1996	Emma's Dancer	G.E. Hutchings
Sweltzer	Aug 14 2013	Emma's Dancer	A. Manweiler
Sweltzer	Aug 21 1984	Emma's Dancer	S.G. Cannings
Blaney (Loon)	Aug 16 1970	Pacific Spiketail	G. Doerksen
Blaney	Sep 2 1996	Shadow Darner	G.E. Hutchings
Blaney	Aug 14 1988	Shadow Darner	S.G. Cannings
Blaney	Jul 23 1998	Shadow Darner	R.D. Kenner
Blaney (Loon)	Aug 17 1999	Shadow Darner	R.D. Kenner

HABITAT

Habitat Requirements

In British Columbia, Grappletail has been recorded from moist low-elevation (< 200 m above sea level [asl]) deciduous and mixed-wood forests within the Coastal Western Hemlock biogeoclimatic zone (Meidinger and Pojar 1991). The species has an aquatic and terrestrial life stage and uses these two habitat types over the course of its life cycle.

Terrestrial foraging habitat includes forest stands with a large component of Bigleaf Maple (*Acer macrophyllum*), alders (*Alnus* sp.) or cottonwoods (*Populus* sp.). The riparian areas where Grappletail has been recorded include an understory of Sword Fern (*Polystichum munitum*), Salmonberry (*Rubus spectabilis*), and other shrubs and herbs characteristic of moist, rich sites and riparian areas.

Grappletail larvae live in streams draining from lakes, usually moderately fast (Cannings 2002; Paulson 2009; Walker 1958). Streams typically have rocky substrates and flow through forests (Figure 5). Devil's Creek is the slowest moving stream that Grappletail have been found in Canada (Figure 6) (Reynolds pers. comm. 2020). Grappletail streams surveyed in 2019 (Table 1) had boulder and cobble substrate with small deposits of sand and organic debris and were generally less than 10 m wide and less than 1 m deep (Foster and Harris pers. obs. 2019). Larvae inhabit relatively slower reaches, burrowing shallowly in mixed sand and gravel (Tennessen 2019) and loose detritus that collects in pools (Kennedy 1917).

Figure 5. Grappletail habitat at Rolley Creek, 12 July 2019. Photo: Allan Harris.

Figure 6. Grappletail habitat at Devil's Creek, 27 July 2020. Photo Brian Starzmoski.

Sweltzer Creek (subpopulation 5) is the largest stream among the Canadian Grappletail sites. It has a mean annual discharge of 3.54 m^3/s with the highest mean flow in February (5.12 m^3/s) and the lowest mean flow in August (1.46 m^3/s) (station 08MH033, at Cultus Lake) (1947 – 1964 data; ECCC 2019a). Jacobs Creek (subpopulation 2) is a smaller stream with mean annual discharge of 0.95 m^3/s and the highest mean flow in December (1.85 m^3/s) and the lowest mean flow in August (0.18 m^3/s) (station 08MH108, above Jacobs Lake) (1965 – 1979 data; ECCC 2019a). Data are unavailable for other streams that are similar in size or smaller than Jacobs Creek.

Water conductivity values measured during fieldwork in July 2019 were less than 20 µS/cm, indicating low concentrations of dissolved electrolyte ions (Foster and Harris pers. obs. 2019), characteristic of these highly oligotrophic streams (Richardson pers. comm. 2019). The exception was Sweltzer Creek (subpopulation 5) where conductivity was 189 µS/cm. Stream water pH values ranged from 7.0 to 8.7 and were also greatest at Sweltzer Creek (Foster and Harris pers. obs. 2019). Water temperatures measured in July 2019 ranged from 15.7 °C (Davis Creek) to 21.2 °C (Sweltzer Creek) (Foster and Harris pers. obs. 2019). Grappletail was not found in streams cooler than 13°C in July 2019 (Foster and Harris pers. obs. 2019).

All known Grappletail sites in Canada are less than 1000 m downstream from a lake (Table 1, Figure 4). Lake outlet streams tend to be warmer and have higher density of filter-feeding invertebrates (i.e., potential food for Grappletail larvae) than other streams (Richardson and Mackay 1991). The density of filter feeders decreases with distance downstream probably due to decreasing food particle quantity, quality, and size. Lakes also buffer downstream habitat from rapid changes in temperature and flows (Richardson and Mackay 1991).

Habitat Trends

Most watersheds supporting Grappletail subpopulations in Canada remain primarily forested with little or no urbanization, industry, or agriculture. There are few data for the streams supporting Grappletail, but water quality in streams in this region is generally “fair to good” (ECCC 2019b). Long-term monitoring (1972–2008) at East Creek in the Malcolm Knapp forest found considerable yearly variation in precipitation and streamwater chemistry but few consistent temporal trends (Feller 2010). In contrast, Sweltzer Creek has experienced substantial changes to the aquatic environment caused by human activity since the 1930s. Agricultural runoff and urbanization in the Cultus Lake watershed have increased nutrient loading, leading to lake eutrophication and decreased dissolved oxygen (Shortreed 2007; Sumka 2017). Cultus Lake has also warmed by about 2°C to 4°C over the last 85 years (Shortreed 2007). Habitat alteration in built up areas (e.g., Abbotsford) likely reduced stream habitat many decades ago.

BIOLOGY

Grappletail biology is well-known based on studies and observations from British Columbia (Whitehouse and Walker 1941; Walker 1958) and the western United States (e.g., Kennedy 1917; Paulson 2009).

Life Cycle and Reproduction

Like all dragonflies, Grappletails have an aquatic larval stage and terrestrial adult stage.

The larvae (nymphs) inhabit sand and gravel or organic debris in slow to moderately flowing sections of streams (Kennedy 1917; Tennessen 2019) where they feed on aquatic invertebrates. The size class distribution of larvae in California indicates that they spend three years in the larval stage before emerging as adults (Kennedy 1917; Tennessen 2019). Larvae have been observed in British Columbia but the duration of the larval stage has not been studied.

When mature, nymphs climb onto boulders, banks, and overhanging trees where they emerge as adults. Males typically remain near the stream while females often move up to about 100 m into the surrounding forest (Kennedy 1917). Both males and females will perch up to 10 m high in trees (Paulson 2009). Adults feed on flying insects.

Adults have a prolonged flight period compared to many other dragonflies (Kennedy 1917) but die in late summer. The flight dates are mid-June to early September in British Columbia with 70% of adult records 12 to 31 July (Walker 1958; Table 1). Flight dates in Oregon are mid-May to early September (Johnson 2018).

Males perch on sunny rocks, twigs, and leaves on the stream bank and forage up and down the stream (Kennedy 1917; Paulson 2009). They hold small territories (~3 m long) where they are aggressive to other males (Paulson 2009).

Females return to the stream when ready to mate, where they may be chased by multiple males. When being chased by numerous males, females may fly into the surrounding forest or hide under fallen trees (Donnelly 2008). Copulating pairs sometimes hang in trees (Paulson 2009).

Females oviposit (lay eggs) by flying in loops over a pool and dipping the tip of the abdomen into the water at intervals of about 1 to 2 m (Kennedy 1917). One female perched at the edge of a stream and oviposited by releasing a stream of eggs onto a wet rock (Lyons 2013).

Physiology and Adaptability

Little is known about the physiology and adaptability of Grappletail. Adults are tame and easily approached (Paulson 2009).

Dispersal and Migration

Little is known of dispersal in Grappletail. Females have been observed about 100 m ("several hundred feet") inland from the streams where they emerged (Kennedy 1917). In general, dragonflies move less than 200 m between reproductive and foraging sites, but sometimes move over 1 km (Corbet 1999). Dispersal between Blaney Creek (subpopulation 1) and Jacobs Creek (subpopulation 2) and between Rolley Creek (subpopulation 6) and Devil's Creek (subpopulation 7) seems feasible. These streams are 1-3 km apart with potential stream habitat in the intervening forest. The other subpopulations are separated by at least 10 km and dispersal between them is less likely. Migration is not known to occur.

The Canadian Grappletail range is not severely fragmented because all sites appear to be in habitat patches that are large enough to support viable populations. Grappletail has persisted at Rolley Creek, Jacobs Creek, and Blaney Creek for at least 23, 34, and 36 years respectively (Table 1).

Interspecific Interactions

Grappletail larvae are likely eaten by fish, amphibians, and possibly American Dipper (*Cinclus mexicanus*) and waterfowl. Adults are likely prey of larger dragonflies, amphibians, and birds (Corbett 1999). Western Toad (*Anaxyrus boreas*) were observed on mid-stream rocks at Jacobs Creek where they would be well-positioned to eat emerging larvae and adults landing to perch (Foster and Harris pers. obs. 2019).

Grappletail shares aquatic and terrestrial habitat with Pacific Spiketail (*Cordulegaster dorsalis*) and darners (*Aeshna* spp.) at Rolley Creek, Blaney Creek, Jacobs Creek, and probably other locations (Foster and Harris pers. obs. 2019). Interspecific competition for food is likely, but has not been documented.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Most records of Grappletail in Canada have come from general odonate surveys rather than targeted surveys. None of the sites has been adequately surveyed to estimate population size or detect population changes.

Abundance

Data are insufficient to estimate the abundance of Grappletail in Canada. There are 154 specimens and observations since 1936 (Table 1). In 2019, a total of 25 adults and two exuviae were observed in three subpopulations. High counts include 27 adults collected over five weeks at Sweltzer Creek (subpopulation 5) in 1936, 20 adults collected at Elbow

Creek (subpopulation 3) 14 to 18 August 1936, and 20 adults observed at Rolley Creek (subpopulation 6) on 12 July 2019. In 2020, about 20 adults were observed at Davis Lake (subpopulation 4) and about 10 adults at Devil's Lake (subpopulation 7) (Starzomski pers. comm. 2020; Reynolds pers. comm. 2020).

The larval stage lasts for three years and would logically make up at least three-quarters of the total population. However, larvae are poorly represented in Canadian collections with only two records of Grappletail larvae.

Fluctuations and Trends

There are insufficient data to determine Canadian Grappletail population fluctuations or trends. None of the subpopulations has been repeatedly surveyed in a manner to detect population changes. Grappletail were found at three historical sites in 2019 (Blaney/Loon Creek, Jacobs Creek, and Rolley Creek) but not at Davis Creek, Elbow Creek, or Sweltzer Creek, nor at any of the potential sites. Grappletails were observed at Davis Creek in 2020 (Starzomski pers. comm. 2020; Reynolds pers. comm. 2020) and may continue to inhabit Elbow and Sweltzer creeks. There has been very little documented search effort at those streams (e.g., no documented searches at Elbow Creek between 1941 and 2019). Adult Grappletails are sensitive to weather, only flying when it is warm and sunny, and null surveys do not necessarily indicate absence.

Rescue Effect

Rescue from Grappletail subpopulations in the United States is unlikely. The nearest United States records are in central Washington, about 150 km south of the Canadian range (Odonata Central 2019) (Figure 3). Although Grappletail is probably more widespread in Washington (Paulson 2017), it does not migrate and is not known to disperse more than a few hundred metres from natal streams (Kennedy 1917).

THREATS AND LIMITING FACTORS

The threats classification for Grappletail 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).

Threats to Grappletail are poorly understood but general threats to dragonflies and their habitat in British Columbia have been assessed based on the literature (especially Cannings *et al*. 2000) and from input from species experts. The overall calculated threat impact was Medium, based on four Low threats. Assigned threat was reduced to Low. The threats are Low Impact and most at low end of Low and there is likely some duplicate accounting. The following main categories of potential threats to this species are discussed starting with Low threats, then the Unknown. Refer to Tables 3 and 4 for details.

Table 3. Summary of threats for Grappletail (*Octogomphus specularis*). An "X" indicates that a potential threat applies to that subpopulation. Refer to Table 4 and Figure 4 for details. Devil's Creek (7) subpopulation was first noted in 2020 and is not included in this table.

	Threat										
Subpopulation	**1.1**	**1.3**	**4.1**	**5.3**	**6.1**	**7.2**	**7.3**	**8.2**	**9.1**	**9.3**	**11.1**
Blaney Cr (1)			X	X							X
Jacobs Cr (2)			X	X							X
Elbow Cr (3)			X	X							X
Davis Cr (4)			X	X	X						X
Rolley Cr (6)			X	X							X
Sweltzer Cr (5)	X	X	X	X	X	X	X	X	X	X	X

Table 4. Threat classification table for Grappletail (*Octogomphus specularis*) across its geographic range in Canada 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 Conservation Measures Partnership website (CMP 2006). For information on how the values are assigned, see Master *et al.* (2009).

Species or Ecosystem Scientific Name	*Octogomphus specularis*, Grappletail			
Element ID			**Elcode**	
Date:	2020-04-02			
Assessor(s):	Allan Harris (report writer), Rosie Nobre-Soares (COSEWIC Secretariat), Jennifer Heron (Arthropods SSC Co-chair and moderator), Dave McCorquodale (Arthropods SSC Co-chair), Syd Cannings (Canadian Wildlife Service), Colin Jones (Arthropods SSC), John Richardson (Arthropods SSC), Robert Longair (Arthropods SSC), Leah Ramsay (Arthropods SSC), Greg Wilson (BC COSEWIC Representative), Lea Gelling (BC Conservation Data Centre), Jeff Ogden (Arthropods SSC), Tracy Hueppelsheuser (BC Ministry of Agriculture), Ross Vennesland (Canadian Wildlife Service), Rob Cannings (Royal British Columbia Museum).			
References:	COSEWIC Draft Status Report on Grappletail Dragonfly			
Overall Threat Impact Calculation Help:			**Level 1 Threat Impact Counts**	
	Threat Impact		**high range**	**low range**
	A	Very High	0	0
	B	High	0	0
	C	Medium	0	0
	D	Low	4	4
Calculated Overall Threat Impact:			Medium	Medium
Assigned Overall Threat Impact:	**C = Low**			
Impact Adjustment Reasons:	The four scored threats are Low and at the low end of Low, all slight severity. Adjusted to Low from Medium: because there is some duplicate accounting, and given the slight severity of all threats.			
Overall Threat Comments	Grappletails were seen at 5 of 7 subpopulations in 2019 and 2020 and the other 2 are considered extant due to lack of consistent search effort over the years.			

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	
1.1	Housing & urban areas	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	Potential for development and cottage development on Cultus Lake. There is a reasonable riparian area around Cultus and the riparian area and critical habitat for the Cultus Lake Sculpin, *Cottus aleuticus*. Restricted to the one location and potential for future development elsewhere is minimal.
1.2	Commercial & industrial areas						Not applicable, there aren't any planned commercial developments at known sites
1.3	Tourism & recreation areas	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	Tourism development and ongoing recreational activity at Sweltzer Creek.
2	Agriculture & aquaculture						
2.1	Annual & perennial non-timber crops						Agricultural effluents scored under 9.3. Not applicable, these areas aren't within agricultural zones.
2.2	Wood & pulp plantations						Not applicable. Livestock grazing is not at any of these subpopulations.
2.3	Livestock farming & ranching						Not applicable.
2.4	Marine & freshwater aquaculture						Not applicable.
3	Energy production & mining						
3.1	Oil & gas drilling						Not applicable.
3.2	Mining & quarrying						Active quarry within 50 m of Sweltzer Creek. Impacts unknown. Score under other ecosystem modifications. Mitigation in place for quarry.
3.3	Renewable energy						Not applicable.
4	Transportation & service corridors	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
4.1	Roads & railroads	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Roads within 50 m of all known locations. Roadkill a potential threat especially bridges at Sweltzer Creek and Rolley Creek. Overall, the threat of road mortality is likely low because the threat has been ongoing for many years. It's certainly chronic and is likely to take out parts of the population, but it's hard to determine.
4.2	Utility & service lines						Not applicable.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.3	Shipping lanes						Not applicable.
4.4	Flight paths						Not applicable.
5	Biological resource use	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals		Unknown	Unknown	Unknown	Unknown	Probably not a threat.
5.2	Gathering terrestrial plants						Not applicable.
5.3	Logging & wood harvesting	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Logging occurs in all watersheds where Grappletail occurs. Potential changes to stream environment include altered water quality, temperature and discharge. Lakes tend to reduce downstream impacts.
5.4	Fishing & harvesting aquatic resources						Not applicable. Fish stocking is scored under 8.2.
6	Human intrusions & disturbance	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	Four wheel drive vehicles causing soil damage and erosion at Davis Creek but larvae probably adapted to erosion and sedimentation by storms. Potential for direct mortality of emerging adults. Popular recreational area at Sweltzer Creek but no evidence of habitat changes. At Sweltzer Creek exposure to sunscreen from swimmers upstream.
6.2	War, civil unrest & military exercises						Not applicable. The subpopulations are not within military/DND properties.
6.3	Work & other activities						Not applicable.
7	Natural system modifications		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
7.1	Fire & fire suppression						Not applicable. Fires are infrequent in the riparian areas (which are wetter ecosystems).
7.2	Dams & water management/use		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	Low head weir at headwater of Sweltzer Creek and elsewhere upstream in the watershed. Creek is run of the river. Impacts unknown. Also some historical dredging and smolt fence in outlet stream, perceived impacts slight. Restricted to Sweltzer.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.3	Other ecosystem modifications		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Didymo and milfoil and increased algal blooms coat the bottom of the stream and potentially prevent larvae from burrowing into the substrate and/or emerging from the substrate. Decreased oxygen and impaired feeding are also possible. Probably just in Sweltzer Creek, but potentially all streams. Not known now, but potential. There are some invasive shrubs and other species that are impacting the floodplain habitat.
8	Invasive & other problematic species & genes		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
8.1	Invasive non-native/alien species/diseases		Negligible	Negligible (<1%)	Serious (31-70%)	High (Continuing)	Smallmouth Bass, Eurasian Milfoil, and other spp. in Cultus Lake. Not yet observed in Sweltzer Creek but no barriers limiting their access. No other invasives reported from Grappletail streams but several fish spp. spreading in southern BC.
8.2	Problematic native species/diseases		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Stocking native fish into previously fishless lakes and stream. Potentially eating larvae, but unlikely.
8.3	Introduced genetic material						Not applicable.
8.4	Problematic species/diseases of unknown origin						Not applicable.
8.5	Viral/prion-induced diseases						Not applicable.
8.6	Diseases of unknown cause						Not applicable.
9	Pollution		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	
9.1	Domestic & urban waste water		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	Domestic and agricultural runoff probably contributed to eutrophication and decreased dissolved oxygen in Cultus Lake. Road salt and road maintenance impacts likely minimal given location and stream flow. Salt load probably small and rapidly diluted.
9.2	Industrial & military effluents						Not applicable.
9.3	Agricultural & forestry effluents		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	Domestic and agricultural runoff probably contributed to eutrophication and decreased dissolved oxygen in Cultus Lake.
9.4	Garbage & solid waste						Not applicable.
9.5	Air-borne pollutants						Not applicable.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.6	Excess energy						Not applicable. Light pollution isn't thought to be a threat, this species isn't crepuscular or nocturnal, so light shouldn't affect their habits.
10	Geological events						
10.1	Volcanoes						Not applicable.
10.2	Earthquakes/tsunamis						Not applicable.
10.3	Avalanches/landslides						Not applicable.
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
11.1	Habitat shifting & alteration		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Warming of Cultus Lake has contributed to eutrophication. Earlier peak runoff and decreased late summer minimum flows in Fraser River Warming may allow Grappletail to expand range in BC.
11.2	Droughts						Not applicable. Lake will buffer to some extent but low flow could constrain habitat in late summer.
11.3	Temperature extremes						Not applicable.
11.4	Storms & flooding						Not applicable.
11.5	Other impacts						Not applicable.
Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).							

1. Residential & commercial development (Low Impact)

1.1 Housing & urban areas

Housing development is unlikely to be a significant threat at most Grappletail sites due to the protected status and/or unsuitable terrain adjacent to occupied habitat and in most of the upstream watershed. The Sweltzer Creek site is surrounded by the community of Cultus Lake, where there is a subdivision covering about 26 ha, 250 m south of the creek outlet and a 2 ha subdivision at the creek mouth. Further development is a potential future threat to the streamside habitat. Urban waste water is discussed under 9.1.

1.3 Tourism & recreation areas

As with housing and urban development, tourism developments are unlikely at most Grappletail sites. There is a municipal park at Sweltzer Creek with a public beach, picnic area and parking immediately upstream from Grappletail habitat, a waterpark about 150 m from the creek, and a campground about 1.6 km downstream. Changes in land use within the park could damage the streamside habitat.

4. Transportation & service corridors (Low Impact)

4.1 Roads & railroads

Road kill is a potential threat to Grappletail for most Canadian subpopulations. Bridges or culverts cross Grappletail habitat at Rolley Creek (subpopulation 6), Blaney Creek (subpopulation 1), Loon Creek (subpopulation 1), Jacobs Creek (subpopulation 2), and Sweltzer Creek (subpopulation 5), and a road follows the bank of Elbow Creek (subpopulation 3) less than 50 m from the stream. Traffic is apparently low on most of these roads but probably greater on the Florence Lake Forest Service Road (Burma Street) at Rolley Creek, which provides access to forestry activities as well as recreational and residential use. Grappletails were observed flying across the road on several occasions in 2019 (Foster and Harris pers. obs.). The bridge at Sweltzer Creek also has relatively busy traffic.

Large numbers of dragonflies can be killed where traffic exceeds 50 km/hour near suitable habitat (Riffell 1999; COSEWIC 2008). Forest access roads with high speeds and narrow rights-of-way may be particularly dangerous for dragonflies (COSEWIC 2011b).

5.Biological resource use (Low Impact)

5.3 Logging & wood harvesting

Logging takes place in all the watersheds where Grappletail occurs in Canada. Potential impacts of logging include altered stream temperatures, nutrient inputs, and increased winter stream discharge. These changes can lead to eroding banks, sedimentation, and reduced availability of woody debris (Gregory *et al*. 1987; Sullivan *et al*. 1987). Loss of streamside tree cover may also reduce cover for adults. Females disperse up to 100 m into forests after emergence and logging could impact the emergence and foraging habitat.

6. Human intrusions & disturbance (Low Impact)

6.1 Recreational activities

Excessive recreational use by four-wheel drive vehicles at Davis Lake has resulted in soil damage and erosion (Pynn 2018), potentially causing siltation in Grappletail habitat. However, larvae are probably adapted to erosion and sedimentation caused by winter storms and this effect is unknown. Direct mortality of emerging adults by collisions with recreation vehicles is another potential threat.

Swimmers at the beach at Cultus Lake may be causing sunscreen to wash downstream to the Sweltzer Creek subpopulation (5). Benzophenone-3, an ingredient in sunscreen, has been shown to cause endocrine disruption in some species (Sujin and Choi 2014), but the impacts on Grappletail are unknown.

There is little evidence of damage caused by recreational activities at other subpopulations (Foster and Harris pers. obs. 2019) but the large and growing human population in the Fraser Valley and increasing recreational use of public lands suggest that this threat may increase.

7. Natural system modifications (Unknown Impact)

7.2 Dams & water management/use

Dams and other water control structures can modify dragonfly habitat by changing the flow, temperature, and timing of water discharge. A low head weir at the outflow of Cultus Lake at Sweltzer Creek (subpopulation 5) is used to maintain lake levels (Sumka 2017) but apparently operates as “run of the river” without significantly altering the Sweltzer Creek environment. Several other low weirs are also present upstream of Sweltzer Creek (Sumka 2017) but probably have little effect on Grappletail habitat.

7.3 Other Ecosystem Modifications

Eurasian Watermilfoil (*Myriophyllum spicatum*) has been recorded in Cultus Lake since the 1970s and now covers much of the shallow-water habitat (Shortreed 2007). Other invasive aquatic plant species observed at Sweltzer Creek (subpopulation 5) in 2019 include cattail (*Typha* spp.) and Creeping Jenny (*Lysimachia nummularia*) (Foster and Harris pers. obs. 2019) could alter aquatic invertebrate communities. Impacts on Grappletail are unknown.

8. Invasive & other problematic species & genes (Unknown Impact)

8.2 Problematic native species/diseases

Grappletail coexists with native trout and salmon in many streams throughout its range, but introducing fish into previously fishless lakes and streams or artificially increasing fish populations through stocking could impact Grappletail through direct predation on larvae or emerging adults or altering the food supply or the aquatic environment (COSEWIC 2011b).

Elbow and Rolley lakes were stocked with triploid Rainbow Trout (*Onchorhynchus mykiss*) between the 1970s and 2019 (Ministry of Environment and Climate Change Strategy 2019). Sweltzer Creek (subpopulation 5) was stocked with Rainbow Trout and Cutthroat Trout (*Oncorhynchus clarkii*) in the 1950s and Cultus Lake was stocked with Rainbow and Cutthroat trout and Lake Whitefish (*Coregonus clupeaformis*) (Ministry of Environment and Climate Change Strategy 2019a).

Didymo (*Didymosphenia geminata*) or “Rock Snot” is a freshwater diatom native to high elevation streams in North America (Invasive Species Council of British Columbia 2019; Ministry of Environment and Climate Change Strategy 2019a). Since the late 1980s it has spread rapidly to lower, warmer streams on Vancouver Island and in southern mainland

British Columbia, possibly on boats and fishing gear. Didymo blooms form when the soluble reactive phosphorus concentration is low or is reduced to low levels through various anthropogenic processes (Bothwell *et al*. 2014). Although not yet known to occur in Grappletail habitat, Didymo can form dense mats that can cause changes in the composition of aquatic invertebrate communities (Gillis and Chalifour 2010).

9. Pollution (Unknown Impact)

9.1 Domestic & urban waste water

At Sweltzer Creek (subpopulation 5), septic fields and fertilizers from urban runoff are thought to have contributed to increased nutrient loading in Cultus Lake, leading to ongoing lake eutrophication and decreased dissolved oxygen (Shortreed 2007; Sumka 2017). The impacts on Grappletail and its habitat are unknown but could include reduced larval survival.

9.3 Agricultural & forestry effluents

As is the case with urban runoff, agricultural runoff in the Cultus Lake watershed is thought to have contributed to lake eutrophication and decreased dissolved oxygen (Shortreed 2007; Sumka 2017).

11 Climate change & severe weather (Unknown Impact)

11.1 Habitat shifting & alteration

Southern British Columbia has warmed 0.8°C per century, primarily due to warmer winter temperatures (British Columbia Ministry of Environment 2016). Cultus Lake has warmed substantially since the early 1900s, and there are indications that the warming climate is contributing to eutrophication of Cultus Lake (Shortreed 2007; Sumka 2017).

Long-term monitoring data indicate that the Fraser River is experiencing earlier peak runoff and decreased late summer minimum flows (British Columbia Ministry of Environment 2016).

The implications of climate change for Grappletail are unknown. Warming temperatures may allow the species to expand its range at the northern limit of its distribution but reduced stream flow and eutrophication are potential threats to its habitat.

Limiting Factors

Grappletail is at the northern limit of its range in southern British Columbia and restricted to an uncommon habitat: warmer than average streams draining from lakes.

Number of Locations

Grappletail is known from six or seven locations in Canada. The locations are largely defined by potential threats acting at the watershed level. Agriculture, urban development, and industry are unlikely to be significant threats at most locations given the rugged terrain and existing protection status. Sweltzer Creek is the exception, where there is significant agriculture and other development within the watershed.

Location 1 includes Loon and Blaney Creeks in the Blaney Creek watershed. The watershed is mainly forested with little or no upstream development and few invasive species, but potentially vulnerable to water quality changes related to logging in the Malcolm Knapp Research Forest.

Location 2 includes Jacobs Creek in the North Alouette River watershed, also in the Malcolm Knapp Research Forest. This watershed faces similar threats as Location 1 and could be considered part of one location. At Locations 4 (Davis Creek) and 6 (Rolley Creek) much of the stream and upstream watershed are protected in provincial parks where logging does not occur but recreational use and invasive species are potential threats.

Locations 3 (Elbow Creek) and 7 (Devil's Creek) are potentially threatened by invasive species and logging in the watershed.

Threats are more imminent at Location 5 where eutrophication and invasive species in Cultus Lake could threaten Grappletail in Sweltzer Creek. The Sweltzer Creek watershed has significant agriculture and urban development.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Grappletail is not protected under the *Species at Risk Act* in Canada. It is not covered by the Committee for International Trade in Endangered Species of Wild Fauna and Flora (CITES). River and stream habitats in Canada receive some protection under the federal *Fisheries Act* where fish habitat is present.

Grappletail and other invertebrates are not specifically protected under British Columbia's *Wildlife Act* or *Wildlife Amendment Act* (Province of British Columbia 2019). The species could be listed as "Identified Wildlife" under the British Columbia *Forest and Range Practices Act* (Province of British Columbia 2002) and the *Oil and Gas Activities Act* (Province of British Columbia 2008). These acts are applicable to provincial Crown forest and grazing land. Under these acts, "Identified Wildlife" and their habitat are protected from adverse impacts from forestry or range activities, or oil and gas activities within Wildlife Habitat Areas (Heron pers. comm. 2019). To date, Grappletail has not been listed as Identified Wildlife.

The *British Columbia Park Act* protects invertebrate species at risk (provincially assessed as Red or Blue-listed by the British Columbia 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 Grappletail are aware of the species and subpopulations within their aquatic and terrestrial habitats.

Non-Legal Status and Ranks

Grappletail is on the British Columbia provincial Red List (including species "at risk of being lost: extirpated, endangered, or threatened") with a rank of S2 (Imperilled) (B.C. Conservation Data Centre 2020). It is classified as "Least Concern" on the IUCN Red List of Threatened Species (IUCN 2019). It is ranked as G4 (Apparently Secure) Globally by NatureServe (2019) and N2 (Imperilled) in Canada by Wild Species 2015 (Canadian Endangered Species Conservation Council 2016).

Grappletail is ranked N4 (Apparently Secure) in the United States and S4 (Apparently Secure) in Washington State; it is not ranked in other states within its range (NatureServe 2019).

Habitat Protection and Ownership

Blaney and Loon Creeks (subpopulation 1), and Jacobs Creek (subpopulation 2) subpopulations are in the Malcolm Knapp Research Forest, owned by the University of British Columbia. The site is managed as a working forest where research, logging and other activities take place (UBC 2019). The forest is managed to conserve and protect fish, water, soil, wildlife, and biodiversity.

Elbow Creek (subpopulation 3) and its upstream watershed are on Crown land.

The Davis Creek subpopulation (4) is in Davis Lake Provincial Park. The upstream watershed consists of Crown land.

The land surrounding the Sweltzer Creek subpopulation (5) consists of a municipal park in the community of Cultus Lake. The upstream watershed includes Cultus Lake Provincial Park surrounding much of Cultus Lake, Crown land, and private land. The watershed extends into the US.

The Rolley Creek subpopulation (6) is in the Mission Municipal Forest and on a provincial road allowance. Rolley Lake and its headwaters include Rolley Lake Provincial Park, Crown land, and privately owned land.

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