

**COSEWIC**  
**Assessment and Status Report**

on the

**Pygmy Snaketail**  
*Ophiogomphus howei*

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. 2008. COSEWIC assessment and status report on the Pygmy Snaketail *Ophiogomphus howei* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 34 pp. ([www.sararegistry.gc.ca/status/status\\_e.cfm](http://www.sararegistry.gc.ca/status/status_e.cfm)).

Production note:

COSEWIC would like to acknowledge John Klymko for writing the status report on Pygmy Snaketail, *Ophiogomphus howei*, 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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## COSEWIC Assessment Summary

### Assessment Summary – November 2018

**Common name**

Pygmy Snaketail

**Scientific name**

*Ophiogomphus howei*

**Status**

Special Concern

**Reason for designation**

One of Canada's smallest dragonflies, this globally-rare species is a habitat specialist, restricted to a few rivers in New Brunswick and a single river in northwestern Ontario. While the overall level of threats is currently low, potential dam construction threatens at least one site across the range, and invasive aquatic species may impact this dragonfly during its larval stage.

**Occurrence**

Ontario, New Brunswick

**Status history**

Designated Special Concern in November 2008. Status re-examined and confirmed in November 2018.



**COSEWIC**  
**Executive Summary**

**Pygmy Snaketail**  
*Ophiogomphus howei*

**Wildlife Species Description and Significance**

The Pygmy Snaketail (*Ophiogomphus howei*) is a small (total length of 31–34 mm; wing length of 19–21 mm) dragonfly in the family Gomphidae, commonly referred to as the clubtails. This species is associated with clean fast-moving water. Adults are black in colour, with vivid yellow markings on the abdomen and wings, and with bright green markings on the thorax. The larvae are aquatic, small and cryptic.

**Distribution**

The Pygmy Snaketail ranges in eastern North America. It is known from two geographic areas: the Appalachian Mountains from northern New Brunswick to northeastern Georgia, and the Midwest from Minnesota, Wisconsin, Michigan, and northwestern Ontario.

In Canada it is known from seven large river systems: the Saint John, St. Croix, Magaguadavic, Southwest Miramichi, Cains, and Salmon Rivers in New Brunswick, and the Namakan River in northwestern Ontario. Some snaketails are quite rare, and exuviae (cast-off larval skins left behind after emergence) are the most often found evidence supporting the presence of a species.

**Habitat**

The Pygmy Snaketail larvae occur in larger, swiftly flowing, and moderate gradient rivers with unpolluted water and significant areas of fine sand or pea gravel substrate. Adults are believed to primarily reside in forest canopies near natal rivers. Searches for exuviae at many seemingly appropriate waters, and at the appropriate time of the year, have generally yielded no results for the species; suggesting that suitable habitat, including factors influencing larval success, is more narrowly defined than we currently realize.

## **Biology**

The length of time required for larvae to develop and emerge from their aquatic habitats is believed to take at least two years. In Canada, emergence occurs from late May or early June to late June and is largely associated with the synchronous emergence of other members of its genus. After emerging, adults survive for four to six weeks and are rarely encountered at water, but likely spend much of their time in the forest canopy.

## **Population Sizes and Trends**

Population estimates of abundance or trends for the Pygmy Snaketail in Canada are unknown, but the US population is considered stable.

## **Threats and Limiting Factors**

Overall impact of threats to the Pygmy Snaketail are considered low. Potential dam construction is a threat to the Ontario subpopulation. Invasive species can also alter the biota to the detriment of the Pygmy Snaketail; however, the impact of this threat is unknown. Water pollution due to excessive nutrient input from sewage, or sedimentation due to agricultural or forestry run-off are believed to have a negligible impact on the species.

## **Protection, Status and Ranks**

The Pygmy Snaketail was assessed as Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 2008, and is listed Special Concern under Schedule 1 of *Species at Risk Act*. It is listed as Special Concern under the *New Brunswick Species at Risk Act* and Endangered under the *Ontario Endangered Species Act*. It is ranked N2 in Canada, S1 in Ontario, and S2 in New Brunswick.

## TECHNICAL SUMMARY

*Ophiogomphus howei*

Pygmy Snaketail

French name: Ophiogomphe de Howe

Range: Ontario, New Brunswick

### 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)	2 to 4 years.
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) partially understood; c) no
Are there extreme fluctuations in number of mature individuals?	No

### Extent and Occupancy Information

Estimated extent of occurrence (EOO)	162,904 km <sup>2</sup>
Index of area of occupancy (IAO) (Always report 2x2 grid value).	92 km <sup>2</sup>
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)	The criteria necessary to define "locations" are not met as >50% of the Canadian population is not under threat and therefore the concept of locations does not apply.
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Yes. Proposed dam construction threatens to alter the habitat of the single Ontario site. Loss of the Ontario occurrence would decrease the known EOO from 162,904 km <sup>2</sup> to 22,777 km <sup>2</sup>
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes.
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Yes.
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?	Possible inferred decline based on pollution and invasive species which could cause decline in quality of habitat.
Are there extreme fluctuations in number of subpopulations?	No.
Are there extreme fluctuations in number of "locations"*?	No.
Are there extreme fluctuations in extent of occurrence?	No.
Are there extreme fluctuations in index of area of occupancy?	No.

#### Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	N Mature Individuals
St. Croix River	Unknown
Magaguadavic River	Unknown
Saint John River	Unknown
Salmon River	Unknown
Southwest Miramichi/Cains River	Unknown
Namakan River	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 completed.
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\* See Definitions and Abbreviations on [COSEWIC website](#) 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

- i. 7.2 Dams & water management/use: Low impact
- ii. 1.1 Housing and urban areas: Negligible impact
- iii. 9.3 Agricultural and forestry effluents: Negligible impact
- iv. 9.4 Garbage and solid waste: Negligible impact
- v. 8.1 Invasive non-native/alien species/diseases. Unknown impact

What additional limiting factors are relevant?  
 The Ontario population is potentially very isolated. The nearest known population is 165 km to the southwest on the Mississippi River downstream of Grand Rapids Minnesota. Such isolation makes the population inherently vulnerable to extirpation.

**Rescue Effect (immigration from outside Canada)**

Status of outside population(s) most likely to provide immigrants to Canada.	The US subpopulation in Maine is similar to the status of New Brunswick subpopulation.
Is immigration known or possible?	Yes, possible.
Would immigrants be adapted to survive in Canada?	Yes.
Is there sufficient habitat for immigrants in Canada?	Yes.
Are conditions deteriorating in Canada?+	Possibly.
Are conditions for the source population deteriorating?+	Possibly.
Is the Canadian population considered to be a sink?+	No.
Is rescue from outside populations likely?	Possible, but unlikely.

**Data Sensitive Species**

Is this a data sensitive species? No

**Status History**

COSEWIC Status History: Designated Special Concern in November 2008. Status re-examined and confirmed in November 2018.

**Status and Reasons for Designation:**

<b>Status:</b> Special Concern	<b>Alpha-numeric codes:</b> Not Applicable
<b>Reasons for designation:</b> One of Canada’s smallest dragonflies, this globally-rare species is a habitat specialist, restricted to a few rivers in New Brunswick and a single river in northwestern Ontario. While the overall level of threats is currently low, potential dam construction threatens at least one site across the range, and invasive aquatic species may impact this dragonfly during its larval stage.	

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



### **Applicability of Criteria**

Criterion A (Decline in Total Number of Mature Individuals): Not applicable, insufficient data
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. While IAO is very small (92 km <sup>2</sup> ) and meets the threshold for Endangered, this species is not severely fragmented, the concept of locations does not apply, nor are there extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small or Restricted Population): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

## PREFACE

The Pygmy Snaketail was first assessed by COSEWIC as Special Concern in 2008, and it was listed as Special Concern under Schedule 1 of the *Species at Risk Act* in 2011. The species was listed Endangered under Ontario's *Endangered Species Act* in 2012. A national management plan was released in 2013, and in that same year it was listed Special Concern under the New Brunswick *Species at Risk Act*.

Since 2008, additional surveys for the species have been conducted in Ontario, New Brunswick, and Nova Scotia. Additional specimens have been collected, resulting in minor changes to EOO and IAO, but it is still rare and still known from the same river systems: the Saint John, St. Croix, Magaguadavic, Southwest Miramichi, Cains, and Salmon Rivers in New Brunswick, and the Namakan River in northwestern Ontario.



### 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.

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

# **COSEWIC Status Report**

on the

## **Pygmy Snaketail** *Ophiogomphus howei*

**in Canada**

2018

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## WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

### Name and Classification

Kingdom Animalia - animals  
Phylum Arthropoda - arthropods  
Subphylum Hexapoda - hexapods  
Class Insecta - insects  
Subclass Pterygota - winged insects  
Order Odonata - damselflies and dragonflies  
Suborder Anisoptera - dragonflies  
Family Gomphidae - clubtails  
Genus *Ophiogomphus* Selys, 1854  
Species *Ophiogomphus howei* Bromley, 1924

English Common Name: Pygmy Snaketail (Paulson and Dunkle 1996; Catling *et al.* 2005), Midget Snaketail ((United States Environmental Protection Agency 2017), Howe's Midget Snaketail Dragonfly (World Conservation Union, IUCN (Baillie and Groombridge 1996)). The generic name, snaketail, refers to the snake-like appearance of the abdomen, wherein the swollen apex resembles a snake's head. The common name refers to the fact that this is the smallest of the snaketail dragonflies.

French Common Name: Ophiogomphe de Howe (COSEWIC 2008)

The Pygmy Snaketail (*Ophiogomphus howei*) is distinct, and there are no proposed subspecies or species forms. The genus has been taxonomically stable since its description by Selys Longchamps (1854). Carle (1986, 1992) proposed three subgenera; with the Pygmy Snaketail falling into the subgenus *Ophionuroides*. The species is considered native in all places where it occurs (NatureServe 2017) and does not appear to be expanding its range.

The adult female was described by Bromley (1924) and the adult male was described by Calvert (1924). The larvae was described by Kennedy and White (1979). Although early instars of the larvae can be difficult to identify, medium to late instars, exuviae, and adults are distinctive for this species.

### Morphological Description

The Pygmy Snaketail's general morphology is typical of other snaketails except in size and wing markings (Figure 1). It is the smallest of the snaketails, and one of the smaller dragonflies in North America, with a total length of 31–34 mm and a hindwing length of 19–21 mm (Needham *et al.* 2014). The flare at the end of the abdomen is relatively wide for the genus. Females have a thicker abdomen and reduced flare compared to the males. The wings of both sexes are tinged yellow in the basal half, though the extent and opacity of this pigmentation is greater in females (Needham *et al.* 2014). This wing colour pattern is unique in the Gomphidae, and rare among other North American odonates, the exception being some species of *Sympetrum* (Catling 2007), notably *Sympetrum semicinctum* (Say) in the east.





Figure 1. Dorsal and lateral view of the male Pygmy Snaketail. Photograph by Paul M. Brunelle.

The Pygmy Snaketail's background body colouring is dark brown and black, with extensive vivid yellow markings on the dorsal abdomen and bright green on the thorax. Thoracic markings of teneral are yellow for up to seven days (Kennedy and White 1979).

Final instar of Pygmy Snaketail larvae (Figure 2) are 19–22.5 mm long (Kennedy and White 1979). They are similar in size to early instar larvae of other *Ophiogomphus* species, and can be distinguished from them by the absence of dorsal abdominal hooks, although small bumps are present. The lateral spines of abdominal segment 7 are vestigial or absent. Final instar Pygmy Snaketail larvae will also have wing cases reaching (laterally) the middle of abdominal segment 4. Similarly sized early instars of other snaketails will have wing cases proportionately much shorter for the same total length.

Detailed descriptions of larvae can be found in Kennedy and White (1979). Adult descriptions are available in Bromley (1924, adult female), Calvert (1924, adult male), and Needham *et al.* (2014, adults).



Figure 2. Exuvia of the Pygmy Snaketail. Photograph taken by John Klymko on July 6, 2016 on the Magaguadavic River, New Brunswick.

## **Population Spatial Structure and Variability**

There has been no genetic analysis of individuals across the species' range. There are two North American population centres, one ranging along the Appalachian Mountains from Georgia and South Carolina north to New Brunswick, and one in the northeastern American Midwest, with populations in Michigan, Wisconsin, Minnesota, and adjacent northwestern Ontario. There are no reported morphological differences between the two population centres, as evidenced by the lack of named subspecies, and genetic differences have not been researched. The genetic sequence of the DNA Barcode region has been sequenced for 11 specimens of Pygmy Snaketail (Hebert, pers. comm. 2018). All specimens originated in New Brunswick, so genetic divergence between the two population centres can not be assessed with this data, and no other studies on genetic divergence between the population centres has been conducted.

## **Designatable Units**

Pygmy Snaketail is considered to have one designatable unit. Designatable units represent discrete and evolutionarily significant populations. There are likely two discrete subpopulations (one in Ontario and one in New Brunswick); however, there is no evidence that they are evolutionarily significant.

### Discreteness:

The entire range of this species falls in two areas: the western subpopulations are in Wisconsin, Minnesota and northwestern Ontario, the eastern subpopulations occupy the Appalachian region extending from New Brunswick to South Carolina (Figure 3). These regions are separated by approximately 800 km (from northern Kentucky to central Wisconsin). A recent Michigan record of an adult Pygmy Snaketail on the Grand River, south of Lansing, posted on Odonata Central (Abbot 2017, record 463346) falls outside the two population centres. If it is considered part of the western group, to which it is closest, then the difference between the eastern and western regions is approximately 500 km.

### Evolutionary significance:

Throughout its North American range the Pygmy Snaketail is not known to differ morphologically, or differ in genetic characteristics, although detailed genetic studies have not been conducted. The Pygmy Snaketail exists in similar ecological settings across its range, and there is no evidence of local adaptation. Therefore, there is currently no evidence to support more than one designatable unit.

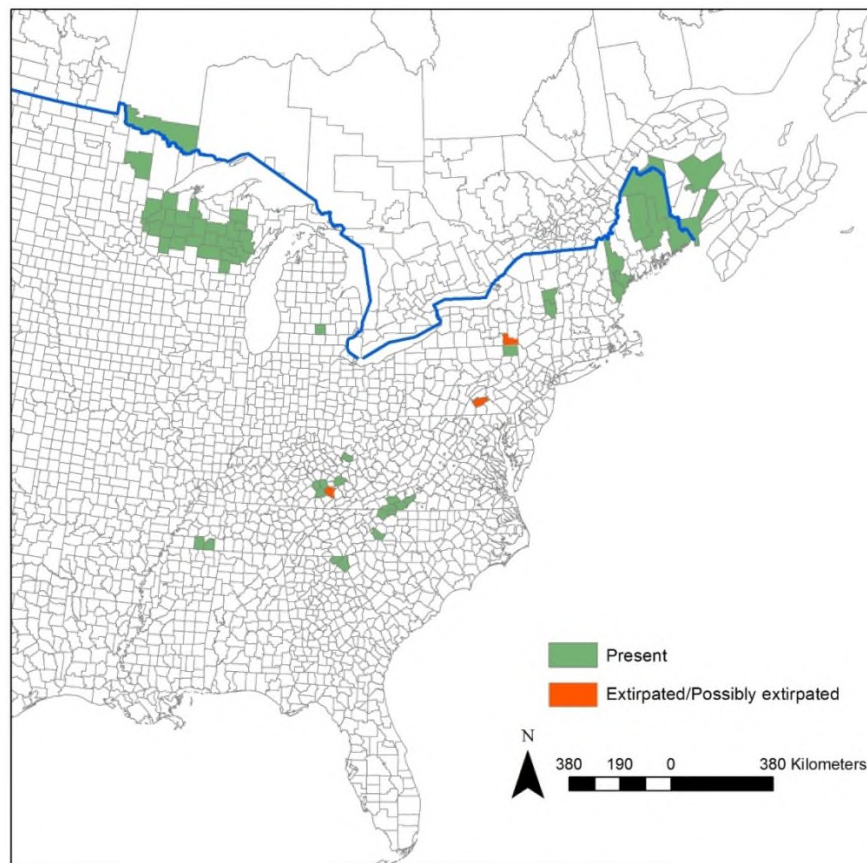


Figure 3. Global distribution of *Ophiogomphus howei* (based on NatureServe 2017, ACCDC 2018, Odonata Central 2017, Steffens and Smith 1999, ADIP 2015, Daigle pers. comm. 2017).

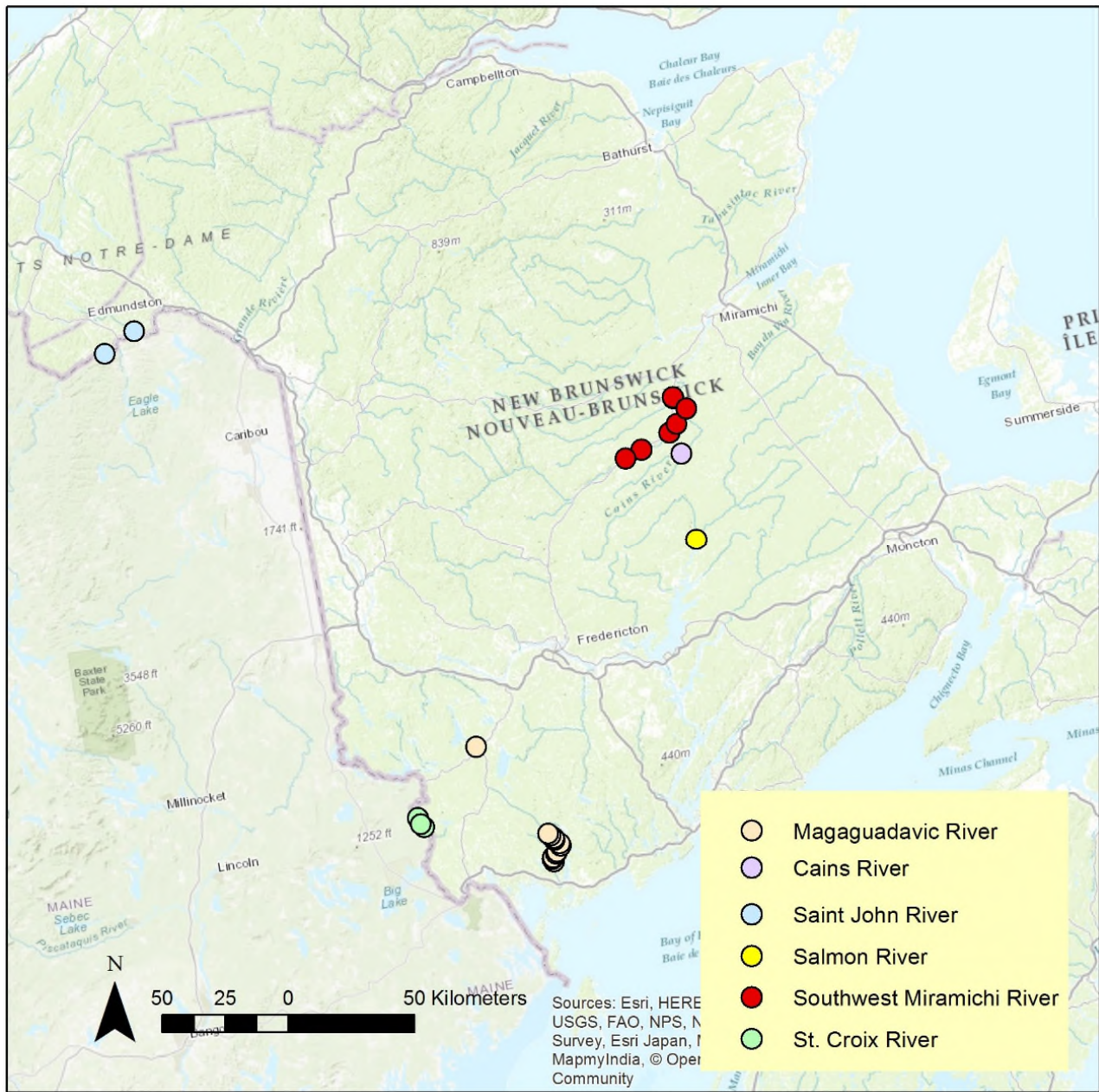


Figure 4. Distribution of *Ophiogomphus howei* in New Brunswick. The Cains River and Southwest Miramichi River occurrences are considered one subpopulation. All other river populations are considered separate subpopulations.

## **Special Significance**

Pygmy Snaketail is widely reported as a species limited to relatively pristine running water habitat (Brunelle 2010; Paulson 2011; Dunkle 2000; White *et al.* 2010). It is considered rare through most of its range in North America. This species reaches its northern extreme in Canada.

## **DISTRIBUTION**

### **Global Range**

The global range of Pygmy Snaketail is split into two geographic areas. The species ranges in eastern North America along the Appalachian Mountains from northern New Brunswick to western South Carolina and northern Georgia. South of New England the species appears to be confined to the Appalachian Mountains; however, it is found in lowland areas of Massachusetts and Maine up to southwest New Brunswick. The second centre of distribution is west and south of the Great Lakes in Michigan, Minnesota, and Wisconsin.

The global range is approximately 1.86 million square kilometres.

### **Canadian Range**

In Canada, Pygmy Snaketail occurs in New Brunswick and northwestern Ontario. There are six subpopulations: five in New Brunswick and one in Ontario (Figure 5). Subpopulations are defined as geographically or otherwise distinct groups in the population between which there is little demographic or genetic exchange. Each river in which Pygmy Snaketail has been documented is considered to have its own subpopulation, with the exception of the Cains River in New Brunswick; it drains into the Southwest Miramichi and is therefore considered part of the Southwest Miramichi subpopulation. All subpopulations are considered extant, although, as discussed below, the only evidence of the Ontario subpopulation is an exuvia collected in 2007.

Approximately 30% of the species' global range is in Canada, although this includes a vast swath between northwestern Ontario and New Brunswick where the species has not been recorded.

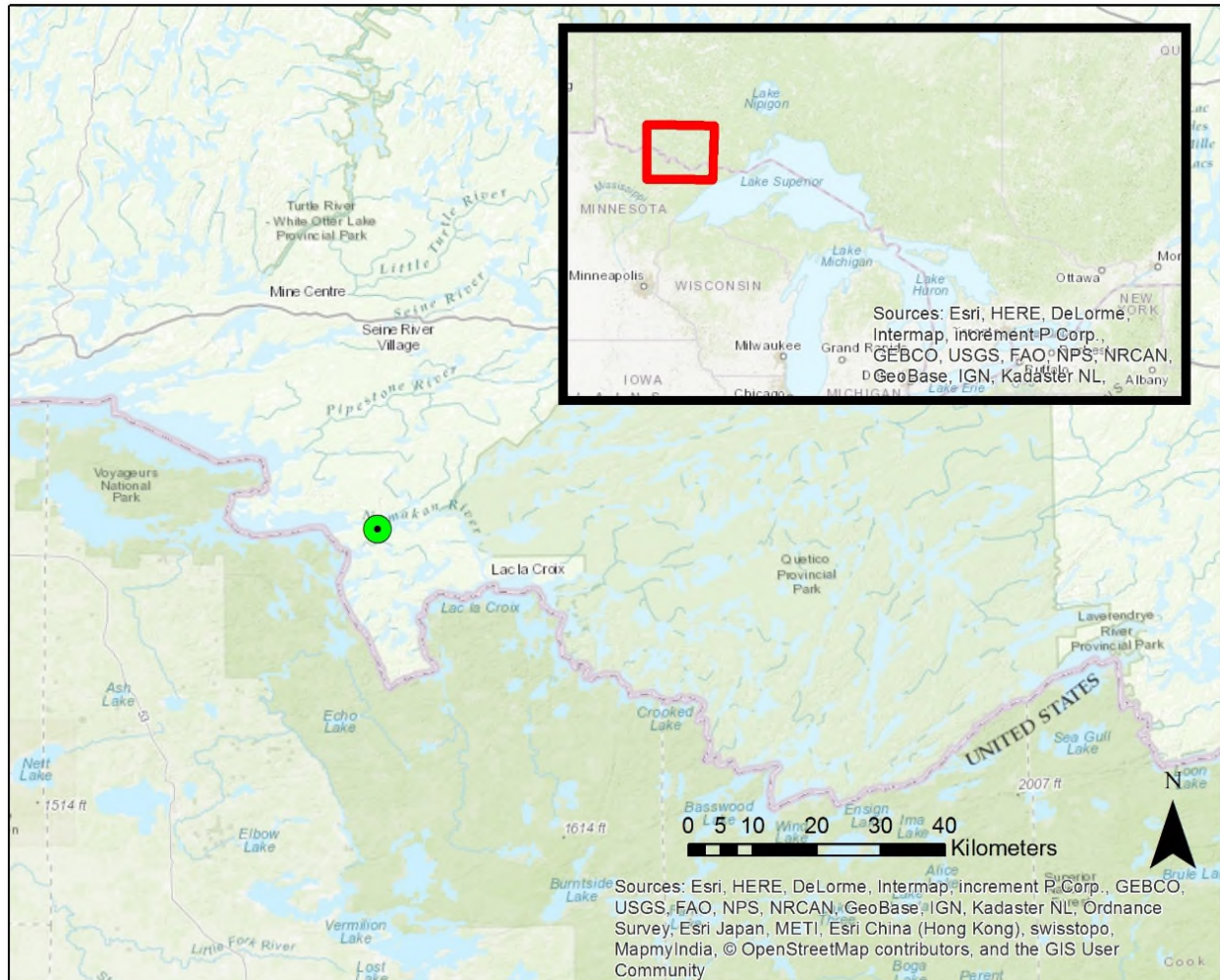


Figure 5. Distribution of *Ophiogomphus howei* in Ontario.

### Northwestern Ontario

On June 23, 2007, Ilka Milne discovered a single Pygmy Snaketail exuvia on the Namakan River, Rainy River district, in northwestern Ontario (see Table 1). It is possible the species could be found elsewhere in northwestern Ontario. Several rivers in the region, including the Pigeon River, the Maligne River, and Rainy River appear to have suitable habitat, although habitat, including factors influencing larval success and emergence, are likely more narrowly defined than we currently realize. None of these rivers have been extensively surveyed for exuviae (**see Search Effort**).

The Namakan River is in the Thunder Bay-Quetico Ecozone, within the Boreal Shield Ecoregion.

**Table 1. Canadian Pygmy Snaketail Records. River width calculated on Google Earth. If a large island was present at the collecting site, the width is taken from below the island.**

Prov.	River	River width (m)	Date	Collector/Observer	Life stage	Evidence	Museum
NB	Cains	60	13 Jun 2007	D.A. Doucet, J. Edsall	Exuvia	Specimen	New Brunswick Museum
NB	Cains	60	25 Jun 2007	D.A. Doucet, J. Edsall	Adult	Specimen	New Brunswick Museum
NB	Magaguadavic	65	6 Jul 2016	J. Klymko, S.L. Robinson	Exuvia	Specimen	New Brunswick Museum
NB	Magaguadavic	75	6 Jul 2016	J. Klymko, S.L. Robinson	Exuvia	Specimen	New Brunswick Museum
NB	Magaguadavic	130	2 Jul 2008	D.A. Doucet, D.V. Sawyer	Exuvia	Specimen	New Brunswick Museum
NB	Magaguadavic	120	6 Jul 2016	S.L. Robinson	Exuvia	Specimen	New Brunswick Museum
NB	Magaguadavic	65	29 Jun 2016	J. Klymko, S.L. Robinson	Exuvia	Specimen	New Brunswick Museum
NB	Magaguadavic	75	29 Jun 2016	J. Klymko, S.L. Robinson	Exuvia	Specimen	New Brunswick Museum
NB	Magaguadavic	100	29 Jun 2016	J. Klymko, S.L. Robinson	Exuvia	Specimen	New Brunswick Museum
NB	Magaguadavic	70	29 Jun 2016	J. Klymko, S.L. Robinson	Exuvia	Specimen	New Brunswick Museum
NB	Magaguadavic	70	29 Jun 2016	J. Klymko, S.L. Robinson	Exuvia	Specimen	New Brunswick Museum
NB	Magaguadavic	110	29 Jun 2016	J. Klymko, S.L. Robinson	Exuvia	Specimen	New Brunswick Museum
NB	Magaguadavic	65	29 Jun 2016	J. Klymko, S.L. Robinson	Exuvia	Specimen	New Brunswick Museum
NB	Magaguadavic	110	29 Jun 2016	S.L. Robinson	Exuvia	Specimen	New Brunswick Museum
NB	Magaguadavic	115	17 Jun 2003	S.I. Tingley	Exuvia	Specimen	New Brunswick Museum
NB	Magaguadavic	30	1 Jul 2003	D.L. Sabine	Teneral	Observation	-
NB	Saint John	170	5 Jul 2018	J. Klymko, M. Weigensberg	Exuvia	Specimen	New Brunswick Museum
NB	Saint John	210	28 Jun 2018	J. Klymko, M. Weigensberg	Exuvia	Specimen	New Brunswick Museum
NB	Saint John	180	22 Jun 2002	P.M. Catling	Teneral, Exuvia	Specimen	Canadian National Collection
NB	Salmon	50	27 Jun 2007	D.A. Doucet, J. Edsall	Exuvia	Specimen	New Brunswick Museum
NB	Southwest Miramichi	140	16 Jun 2008	D.A. Doucet, D.V. Sawyer	Exuvia	Specimen	New Brunswick Museum
NB	Southwest Miramichi	90	20 Sep 2007	G.H. Stairs	Exuvia	Specimen	New Brunswick Museum

Prov.	River	River width (m)	Date	Collector/ Observer	Life stage	Evidence	Museum
NB	Southwest Miramichi	100	17 Jun 2007	D.A. Doucet, J. Edsall	Exuvia	Specimen	New Brunswick Museum
NB	Southwest Miramichi	100	25 Jun 2007	D.A. Doucet, J. Edsall	Adult	Specimen	New Brunswick Museum
NB	Southwest Miramichi	100	15 Jul 2007	D.A. Doucet	Adult	Observation	-
NB	Southwest Miramichi	100	14 Sep 2007	D.A. Doucet, J. Edsall	Exuvia	Specimen	New Brunswick Museum
NB	Southwest Miramichi	100	16 Jun 2008	D.A. Doucet, D.V. Sawyer	Exuvia	Specimen	New Brunswick Museum
NB	Southwest Miramichi	105	17 Jun 2007	P.M. Brunelle	Exuvia	Specimen	New Brunswick Museum
NB	Southwest Miramichi	105	25 Jun 2007	D.A. Doucet, J. Edsall	Adult	Specimen	New Brunswick Museum
NB	Southwest Miramichi	105	17 Jun 2007	D.A. Doucet, J. Edsall	Exuvia	Specimen	New Brunswick Museum
NB	Southwest Miramichi	90	18 Jun 2003	S.I. Tingley	Exuvia	Specimen	New Brunswick Museum
NB	Southwest Miramichi	90	20 Jun 2007	D.A. Doucet, J. Edsall	Exuvia	Specimen	New Brunswick Museum
NB	Southwest Miramichi	90	25 Jun 2007	D.A. Doucet, J. Edsall	Adult, Exuvia	Specimen	New Brunswick Museum
NB	Southwest Miramichi	90	4 Jul 2007	S.I. Tingley	Adult	Observation	-
NB	Southwest Miramichi	90	9 Jul 2007	D.A. Doucet, J. Edsall	Exuvia	Specimen	New Brunswick Museum
NB	Southwest Miramichi	90	15 Jul 2007	D.A. Doucet	Exuvia	Specimen	New Brunswick Museum
NB	Southwest Miramichi	90	7 Aug 2007	D.A. Doucet, J. Edsall	Exuvia	Specimen	New Brunswick Museum
NB	Southwest Miramichi	90	21 Aug 2007	D.A. Doucet, J. Edsall, G.H. Stairs	Exuvia	Specimen	New Brunswick Museum
NB	Southwest Miramichi	90	22 Aug 2007	G.H. Stairs	Exuvia	Specimen	New Brunswick Museum
NB	Southwest Miramichi	90	18 Sep 2007	D.A. Doucet, J. Edsall	Exuvia	Specimen	New Brunswick Museum
NB	Southwest Miramichi	90	16 Jun 2008	D.A. Doucet, D.V. Sawyer	Teneral, Exuvia	Specimen	New Brunswick Museum
NB	Southwest Miramichi	90	3 Jul 2011	J. Klymko, S.L. Robinson	Exuvia	Specimen	New Brunswick Museum
NB	St. Croix	100	12 Jul 2017	J. Klymko, M. Weigensberg	Exuvia	Specimen	New Brunswick Museum
NB	St. Croix	100	12 Jul 2017	J. Klymko, M. Weigensberg	Exuvia	Specimen	New Brunswick Museum
NB	St. Croix	85	12 Jul 2017	J. Klymko, M. Weigensberg	Exuvia	Specimen	New Brunswick Museum



Prov.	River	River width (m)	Date	Collector/ Observer	Life stage	Evidence	Museum
NB	St. Croix	80	12 Jul 2017	J. Klymko, M. Weigensberg	Exuvia	Specimen	New Brunswick Museum
ON	Namakan	80	27 Jun 2007	I. Milne, H. Van Ael, H. Verhoef, M. Lysne, B. Morgenstern	Exuvia	Specimen	Natural Heritage Information Centre, OMNR

## New Brunswick

The Pygmy Snaketail was first recorded in Canada on June 22, 2002, on the banks of the Saint John River at Baker Brook, Madawaska County, New Brunswick (Catling 2002). Since then it has been recorded on the St. Croix River, the Southwest Miramichi River, the Cains River, the Salmon River, the Magaguadavic River, and at another site on the Saint John River upstream of Edmundston (ADIP 2015, ACCDC 2018). All New Brunswick records are presented in Table 1.

New Brunswick is entirely in the Atlantic Maritime Ecozone. Within this Ecozone, Pygmy Snaketail is found in the Northern New Brunswick Highlands, Maritime Lowlands, and Southern New Brunswick Uplands Ecoregions.

## **Extent of Occurrence and Area of Occupancy**

The extent of occurrence (EOO) for Pygmy Snaketail is 162,904 km<sup>2</sup> within Canada's extent of jurisdiction. Based on known occurrences, the index of area of occupancy (IAO) in Canada is 92 km<sup>2</sup> using a 2X2 km<sup>2</sup> grid. In New Brunswick, the IAO is 88 km<sup>2</sup>, and 4 km<sup>2</sup>. In Ontario (single record).

## **Search Effort**

### New Brunswick, Nova Scotia, and Prince Edward Island

In total, there are 32,737 Odonata records in the Atlantic Dragonfly Inventory Program database to 2015 (ADIP 2015). These records, plus 2288 records from the Atlantic Canada Conservation Data Centre (ACCDC 2018) and Dwayne Sabine (Sabine, unpublished data), are mapped by Ecoregion in Figure 8. Most records (53%) are from the Maritime Lowlands Ecoregion (7529, 21% of total), Southern New Brunswick Uplands (6232, 18% of total), and Prince Edward Island Ecoregions (4756, and 14% of total).

Of the 35,025 ADIP, ACCDC, and Sabine records, 6303 are immature (18% of total), including 4230 records from running water (12% of total). Nearly all of these immatures are exuviae. Most records from running water are from the Maritimes Lowlands (1799 records, 43% of total), the Southern New Brunswick Uplands (968 records, 23% of immature records total), and South-central Nova Scotia Uplands Ecoregions (434 records, 10% of total). See Figure 9 for the number of immature records from running water per ecoregion.

Many Maritimes rivers, or sections of them, have been subject to intensive exuvia sampling, often done specifically in pursuit of the Pygmy Snaketail. The 22 best surveyed sites are identified in Table 2, and mapped in Figure 10.

All major river systems in the Maritimes have been subject to some level of search effort, and as outlined above many have been extensively surveyed; however, there are still some river stretches that have not been well-sampled, like most of the Saint John River and its tributaries upstream of Fredericton.

**Table 2. Rivers and locations in the Maritimes that have been intensively surveyed for exuviae.**

River No.	Location	No. survey localities	No. records with exuviae and larvae	No. exuviae collected	No. larvae collected	Pygmy Snaketail detected	Notable efforts
1	Upper Saint John River, Madawaska County	43	~120	562	18	Yes	Dwayne Sabine, Paul Brunelle, Denis Doucet (ADIP 2015), Klymko and Weigensberg (ACCDC unpublished data) ( <i>note that Klymko and Weigensberg data have not been fully tabulated; they examined thousands of exuviae in the field but collected a small percentage of them</i> )
2	Restigouche River	34	17	3188	0	No	Klymko and Robinson 2011
3	Northwest Miramichi River	4	26	341	0	No	Doucet and Edsall 2008, Dwayne Sabine (ADIP 2015)
4	Little Southwest Miramichi River	4	45	458	0	No	Doucet and Edsall 2008 and ADIP volunteers
5	Renous River	3	28	149		No	Doucet and Edsall 2008
6	Southwest Miramichi (including Cains River)	14	259	1606	0	Yes	Doucet and Edsall 2008
7	Eel River	7	72	245	53	No	Paul Brunelle, Dwayne Sabine (ADIP 2015)
8	St. Croix River	6	127	342	177	Yes	Brunelle (ADIP 2015)
9	Canoose Stream	2	130	492	641	No	Paul Brunelle (ADIP 2015)
10	Digdeguash River	10	85	315	28	No	Klymko and Robinson 2017
11	Magaguadavic River	23	237	1654	33	Yes	Klymko and Robinson 2017, Dwayne Sabine, Denis Doucet (ADIP 2015)
12	Oromocto River	8	62	391	2	No	Klymko and Robinson 2017, Dwayne Sabine, Denis Doucet (ADIP 2015)
13	Lower Saint John River*	15	913	13125	14	No	Dwayne Sabine (ADIP 2015, unpublished data)
14	Salmon River	5	59	312	0	Yes	Doucet and Edsall 2008

River No.	Location	No. survey localities	No. records with exuviae and larvae	No. exuviae collected	No. larvae collected	Pygmy Snaketail detected	Notable efforts
15	Petitcodiac River	15	79	310	6	No	Klymko and Robinson 2017
16	New River	6	41	111	23	No	Klymko and Robinson 2017
17	Lepreau River	8	67	156	38	No	Klymko and Robinson 2017
18	Tusket River	10	27	243	1	No	Klymko 2011
19	Medway	13	65	264	43	No	Klymko 2011
20	LaHave River	14	35	200	3	No	Klymko 2011
21	Shubenacadie River	32	188	1311	273	No	Klymko and Robinson 2013, Paul Brunelle (ADIP 2015)
22	St. Mary's River	82	336	2616	0	No	Klymko and Robinson 2011

\*One site, the Princess Margaret Bridge in Fredericton, has been exceptionally well surveyed by Dwayne Sabine. It accounts for 787 of the records, 12,395 of the exuviae, and 14 of the larvae collected on the Lower Saint John River.

## Ontario

In total, there are 77,066 Odonata records in the Ontario Odonata Atlas Database (OOAD 2017).<sup>1</sup> These records, plus an additional 30 exuviae records from Mike Oldham from northwestern Ontario (Oldham, pers. comm. 2017), are mapped by ecoregion in Figure 6. More than 80% of records are from the Algonquin-Lake Nipissing Ecoregion (24,590 records, 32% of total), the Lake Erie Lowland Ecoregion (24,191 records, 31% of total), and the Manitoulin-Lake Simcoe Ecoregion (13,686 records, 18% of total).

As the Pygmy Snaketail is so difficult to detect as an adult, and because the species appears to only occur in medium to large rivers (**see BIOLOGY**), this immature dataset from running water offers a reasonable survey effort proxy for the Pygmy Snaketail. Of the 77,096 records, 3,153 are immatures (4% of total). Most of these immatures are exuviae. Of these, 1535 are from flowing water (2% of total) and a date appropriate for detecting the Pygmy Snaketail. Records were assigned to flowing water based on description of survey site; the 184 records for which site conditions were unreported are considered to be from running water for the analysis. Pygmy Snaketail larvae can be found throughout the year, and exuviae can be collected after approximately May 24. Therefore, exuvia records dated earlier than May 25 were excluded.

Most records of immatures from running water are from the Algonquin-Lake Nipissing Ecoregion (450 records, 29% of immature record total). The Abitibi Plains and Manitoulin-Lake Simcoe Ecoregions have the second and third most immature records (373 records, 24% of immature total and 210 records, 14% of immature total, respectively). See Figure 7 for the number of immature records from running water per ecoregion.

<sup>1</sup> 'Records' refer to the encounter with a particular species at a particular place on a particular date. Different lifestages of the same species are included in the same record, as are multiple voucher specimens.

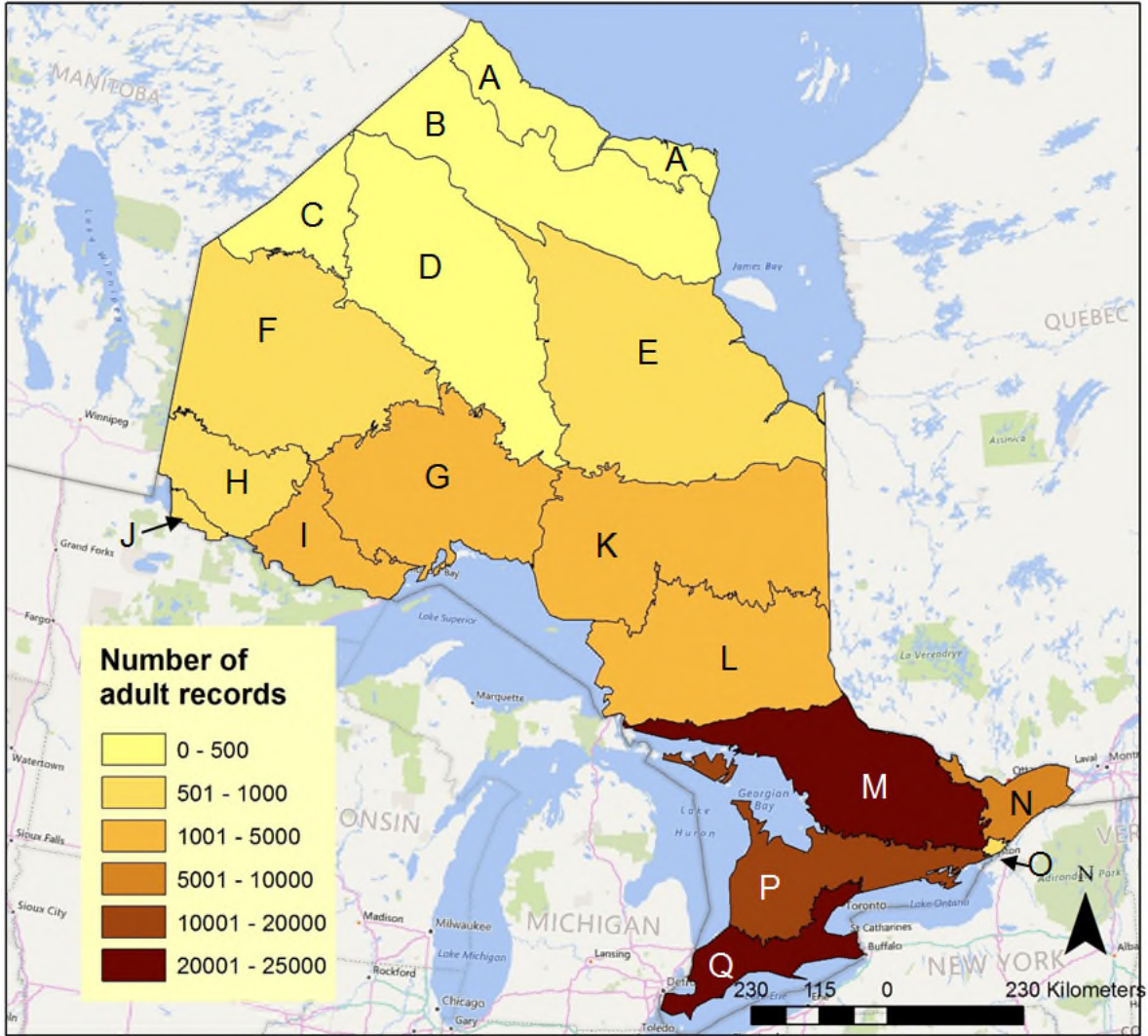


Figure 6. Search effort in Ontario as assessed by total number of Odonata records per ecoregion. A) Coastal Hudson Bay Lowland; B) Hudson Bay Lowland; C) Hayes River Upland; D) Big Trout Lake; E) James Bay Lowlands; F) Lac Seul Upland; G) Lake Nipigon; H) Lake of the Woods; I) Thunder Bay-Quetico; J) Rainy River; K) Abitibi Plains; L) Lac Temiscamingue Lowland; M) Algonquin-Lake Nipissing; N) St-Laurent Lowlands; O) Frontenac Axis; P) Manitoulin-Lake Simcoe; Q) Lake Erie Lowland. Odonata data from the Ontario Odonata Atlas Database (2017) and M. Oldham (pers. comm. 2017).

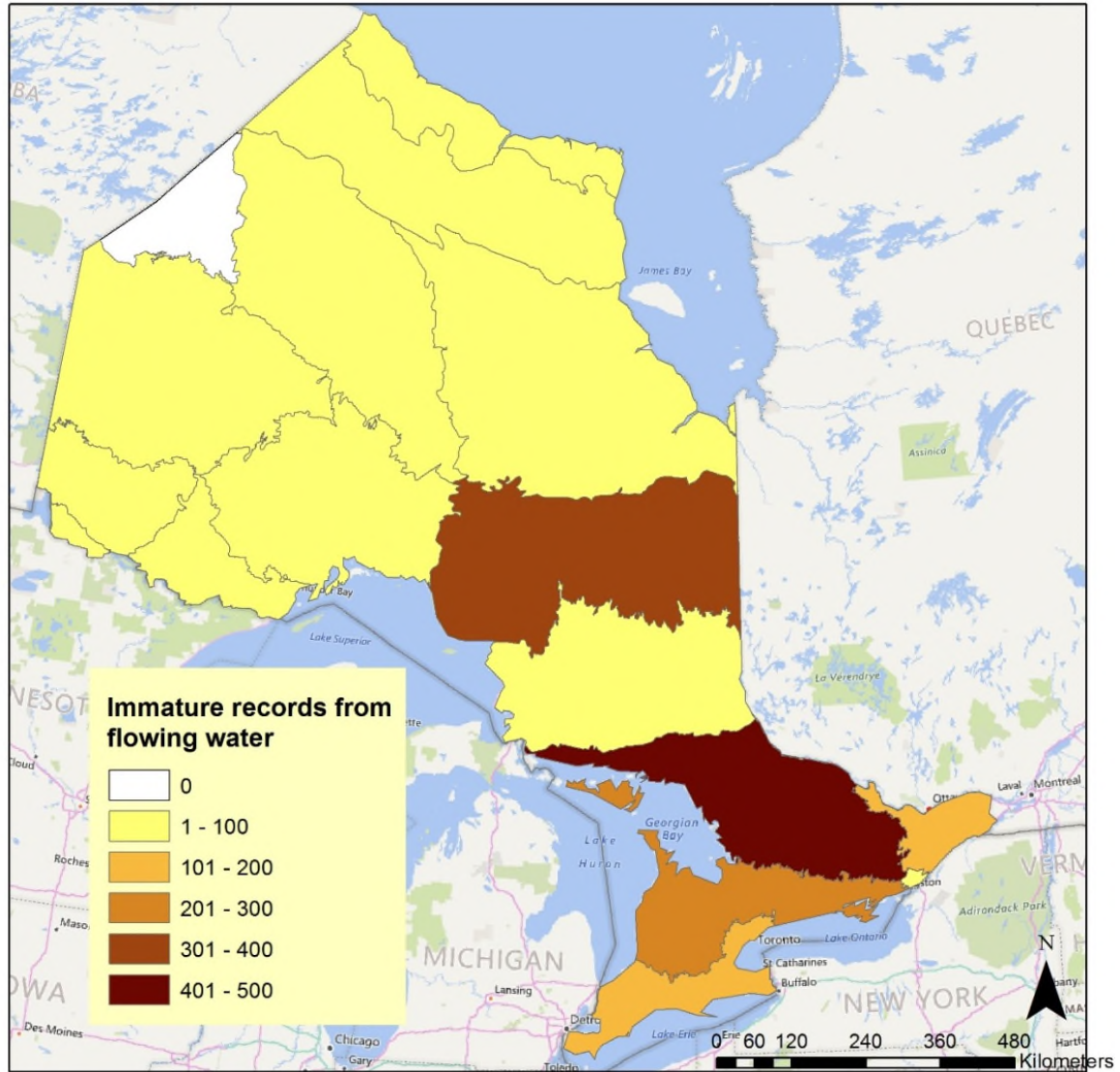


Figure 7. Search effort in Ontario as assessed by total number of immature Odonata records from running water per ecoregion. Odonata data from the Ontario Odonata Atlas Database (2017) and M. Oldham (pers. comm. 2017).

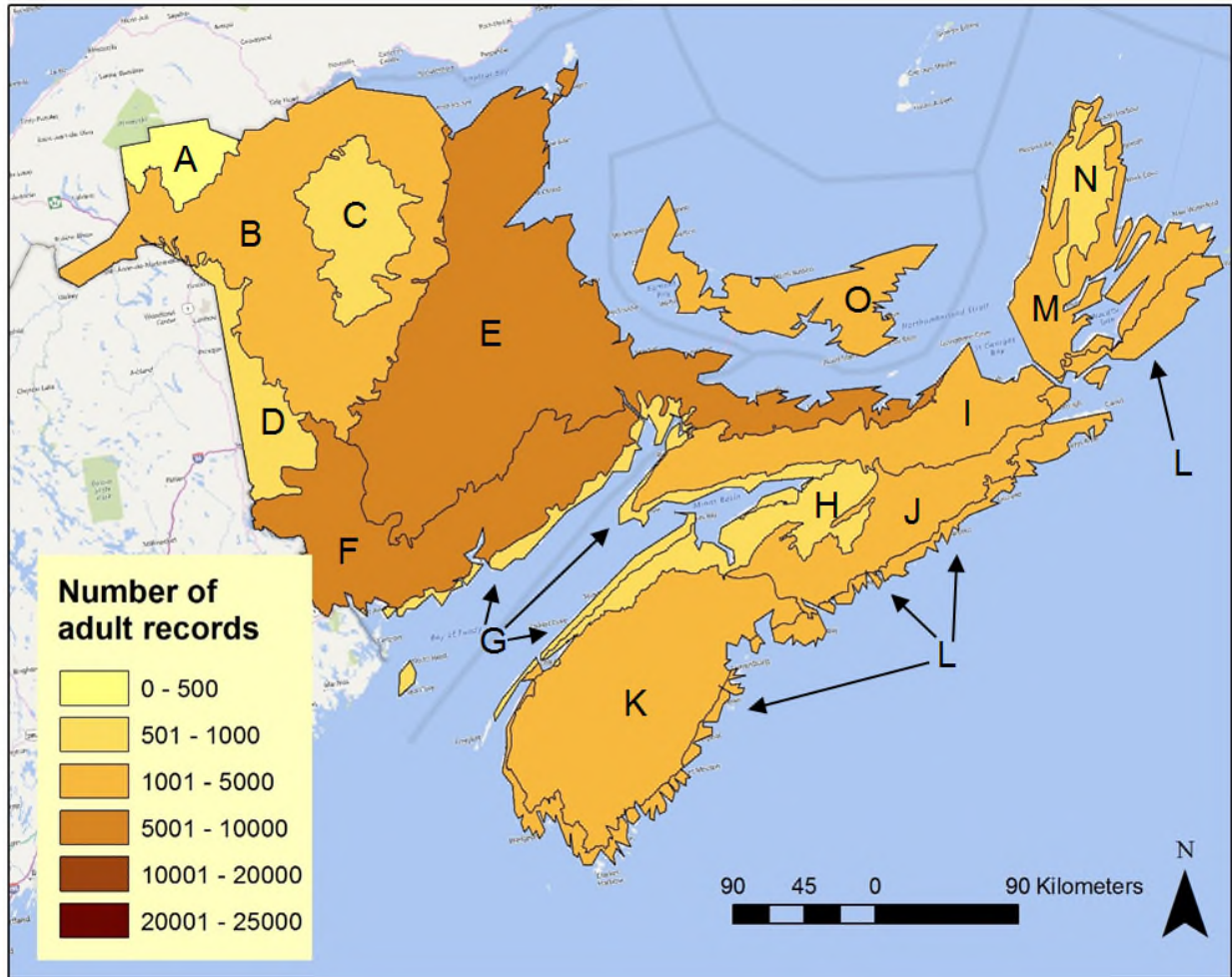


Figure 8. Search effort in the Maritimes as assessed by total number of Odonata records per ecoregion. A) Appalachians; B) Northern New Brunswick Highlands; C) New Brunswick Highlands; D) Saint John River Valley; E) Maritime Lowlands; F) Southern New Brunswick Uplands; G) Fundy Coast; H) Annapolis-Minas Lowlands; J) South-central Nova Scotia Uplands; K) Southwest Nova Scotia Uplands; L) Atlantic Coast; M) Nova Scotia Highlands; N) Cape Breton Highlands; O) Prince Edward Island. Odonata data from ADIP (2015), ACCDC (2018), and Dwayne Sabine (pers. comm. 2017).

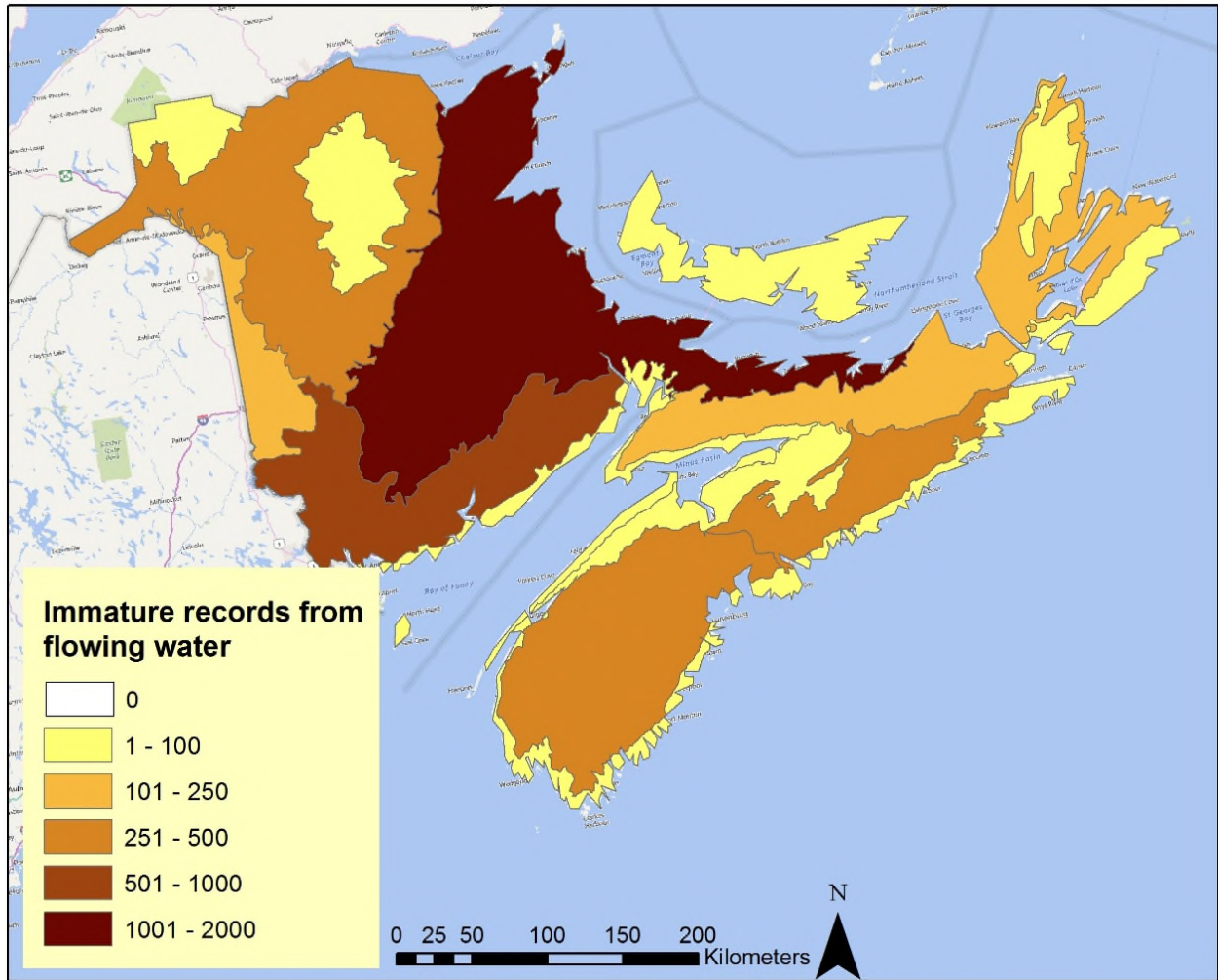


Figure 9. Search effort in the Maritimes as assessed by total number of immature Odonata records from running water per ecoregion. Odonata data from ADIP (2015), ACCDC (2018), and Dwayne Sabine (pers. comm. 2017).

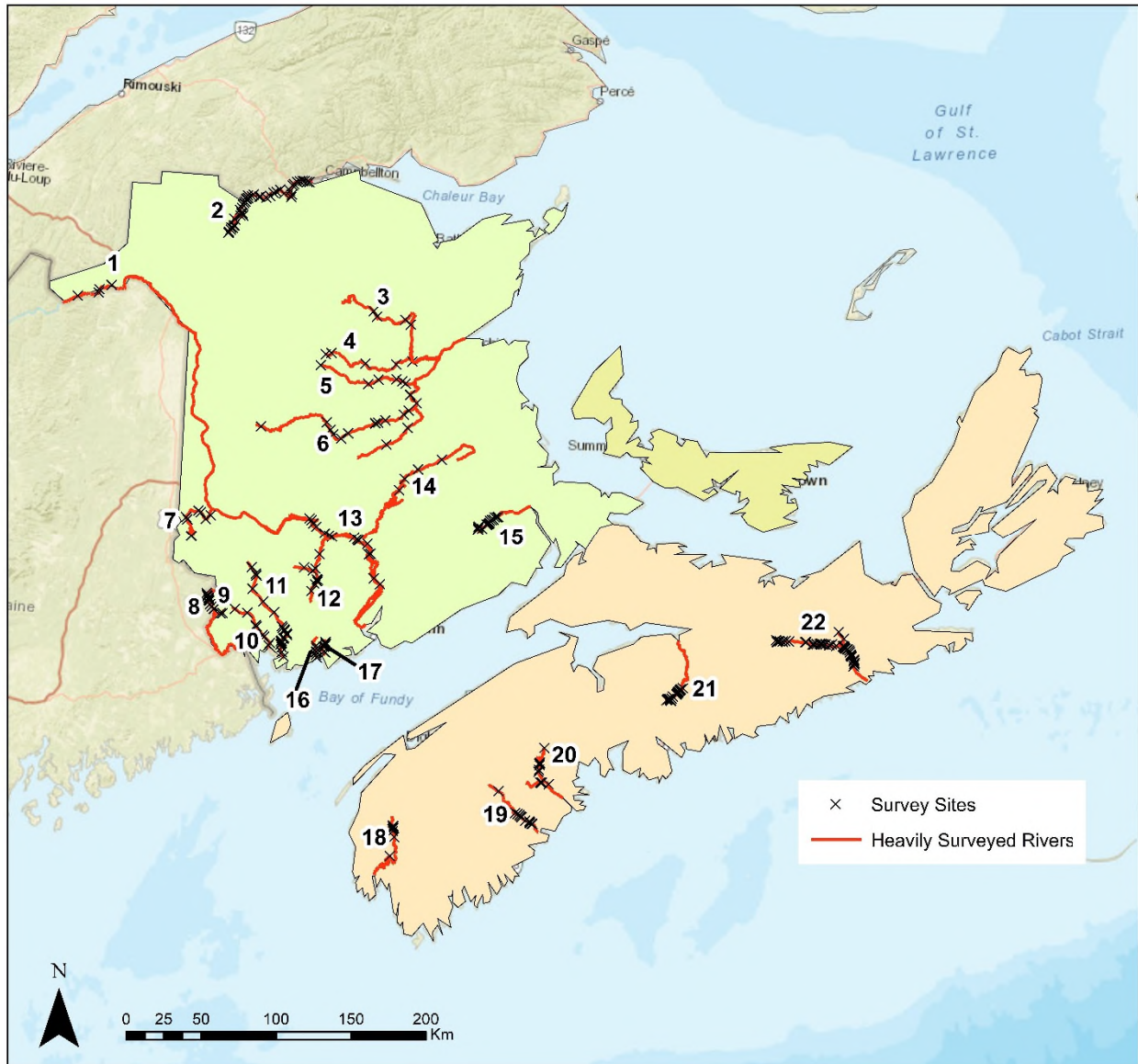


Figure 10. Well surveyed rivers in the Maritimes, with survey sites on those rivers. See Table 2 for river names. Odonata data from ADIP (2015), ACCDC (2018), and Dwayne Sabine (pers. comm. 2017).

A follow-up survey of the single known site on the Namakan River on June 24, 2008 failed to detect any more adults or exuviae. The conditions (extremely high water levels) and timing (in 2008 very late spring may have delayed emergence until after the survey) may have made finding more evidence of a resident subpopulation less likely (COSEWIC 2008).

A more thorough survey of the Namakan River was conducted by the Ontario Ministry of Natural Resources in 2009 and 2010. In 2009, 12 sites on the river were surveyed for exuviae and four sites were surveyed for larvae using driftnets. Crews of two to five people collected hundreds of exuvia over eight days from June 15 to June 25, but none were the



Pygmy Snaketail. Driftnets run from June 18–22 also failed to detect the Pygmy Snaketail (Van den Broeck and Jones 2009). A survey of similar scope was also conducted in 2010, but again the Pygmy Snaketail was not found (Jones, pers. comm. 2017).

A more recent follow-up survey in 2016 was hampered by poor weather and very high water levels. On July 3–5, three surveyors spent 12.5 hours searching the shoreline for exuviae and adjacent meadows for adults at the known site but the Pygmy Snaketail was not found. From July 6–8 the same observers surveyed the 35 km of Namakan River from Lac la Croix to Namakan Lake for adults and exuviae. In total, there were 24.75 hours of surveying with three people without detecting the Pygmy Snaketail (Poropat and Boxall 2016).

Note that the Pygmy Snaketail can be difficult to detect at sites where it is known to occur, so it can not be assumed it no longer occurs on the Namakan River. For example, the St. Croix River in New Brunswick was surveyed intensively for five days in 2006 but the species was not found (COSEWIC 2008). This was done to confirm the species occurred on the Canadian side of the river; it had been found on the US shore of this border waterway in 1996 and 2005. In 2017 the species was found along the Canadian shoreline of the St. Croix River for the first time.

Surveys elsewhere in the vicinity of Namakan River have been limited. The Namakan River is in the Thunder Bay-Quetico Ecoregion, which stretches from Thunder Bay in the east to Rainy Lake in the west and has an area of 29,567 km<sup>2</sup>. This region has other rivers, like the Pigeon River and Maligne River, that appear suitable. In the analyzed dataset, there are 1,116 records from this ecoregion, 38 of which are immatures from running water (all exuviae) (note that intensive surveys on the Namakan River have not been incorporated into the Ontario Odonata Ontario Atlas Database). Four of these records are from the Pigeon River, none are from the Maligne River. Rainy River, which is in the Rainy River Ecoregion, also has seemingly suitable habitat. There are only 10 records of immature dragonflies from it.

The areas where Pygmy Snaketail may occur in Ontario away from Northwestern Ontario are the Algonquin-Lake Nipissing, St. Lawrence Lowlands, Abitibi Plains, and Lac Temiscamingue Lowland ecoregions. This assumption is based on the distributions of all other *Ophiogomphus* species known to occur in the Maritimes and the Midwest (*O. colubrinus*, *O. carolus*, *O. rupinsulensis*, and *O. anomalus* – see Paulson (2011) for maps). All of those species with the exception of *O. rupinsulensis*, which is more widespread than other eastern *Ophiogomphus* species, occur across central Ontario but have not been recorded from southwestern Ontario, western Ohio, Indiana, or Illinois. Given the relatively low level of development in most areas of these ecoregions, it is unlikely that Pygmy Snaketail would have occurred there only historically. Historic and recent Odonata searches in that area have produced no records for Pygmy Snaketail, despite there being 32,971 Odonata records from the combined ecoregions in the Ontario Odonata Atlas, including 1,103 records of immatures from running water, primarily exuviae (Ontario Odonata Atlas Database 2017).

A recent Michigan record of an adult Pygmy Snaketail on the Grand River, south of Lansing, posted on Odonata Central (Abbot 2017, record 463346) is noteworthy as it is close to extreme southwestern Ontario. Given that no immatures were found it is not certain a breeding subpopulation exists on the Grand River, but that is very likely; the nearest known subpopulations are more than 300 km to the west, on the other side of Lake Michigan. Given this disjunction from known records it is hard to know if the Grand River record represents an isolated occurrence, or is part of a larger metapopulation, be it historic or extant. The Lake Erie Lowland Ecoregion, which covers extreme southwestern Ontario, has the second most Odonata records of any ecoregion; however, just 141 immatures have been collected there from running water. That said, landscape is heavily modified, especially Kent and Essex counties, and most rivers there are likely too turbid for Pygmy Snaketail.

## Québec

The species has not been recorded in Québec; however, it is known from the Saint John River system, the upper reaches of which extend into Québec, given the habitat parameters are similar. The two rivers of highest potential in Québec are the major Saint John River tributaries: the Southwest Branch Saint John River and the Daaquam River.

Savard (2011) searched literature for Québec Odonata records. In total, 263 documents yielded Odonata 7,520 records. The area of greatest survey intensity is southern Québec, south of 47°N. Savard found no Odonata records from the Southwest Branch Saint John River or the Daaquam River, suggesting these rivers have not been surveyed for dragonflies.

## **HABITAT**

### **Habitat Requirements**

Habitat requirements for the Pygmy Snaketail are described for their aquatic and terrestrial life stages. Although this rare species is difficult to detect, it is important to note that habitat, including factors influencing larval success and emergence are likely more narrowly defined than we currently realize.

Pygmy Snaketail nymphs require larger, relatively pristine rivers with significant areas of sand or gravel substrate (Tennessen 1993; Dunkle 2000). The average approximate river width at Pygmy Snaketail collection sites in New Brunswick and Maine is 74 m (n = 128). The smallest river was only 5 m wide; however, this site, which is less than 700 m from its outflow into the Saco River and is known to host a Pygmy Snaketail subpopulation, is anomalous. The next smallest river was 20 m wide, and 90% of records are from sites where rivers are 40 m or wider. The Southwest Miramichi at Blackville, New Brunswick, where the species is more often detected, is approximately 90 m wide (Figure 11). Pygmy Snaketail has not been found in eutrophic rivers in Canada or Maine. It is described as occurring in clean rivers in Wisconsin (Wisconsin Department of Natural Resources 2013), so it may be intolerant of eutrophication.



Figure 11. Typical habitat of Pygmy Snaketail on the Southwest Miramichi River, Blackville, New Brunswick. Photograph by John Klymko on 3 July 2011.

If it is proven that a Pygmy Snaketail subpopulation occurs in Michigan's Grand River then our understanding of the species' tolerance of eutrophication and general disturbance would have to be re-examined. The catchment of that river has been almost completely converted to cropland or more intensive development.

When mature, Pygmy Snaketail nymphs emerge from water and metamorphose into adults. This emergence occurs on shorelines, generally within 1 m of the water's edge (J. Klymko, pers. obs). Emergence sites have been documented adjacent to forest and riparian meadows and thickets (J. Klymko, pers. obs). Exuviae are typically found on erosional banks on bare earth or exposed roots; however, they are easier to find there than in more obstructed habitat like dense vegetation. Adults are rarely encountered, but they have been found resting on low vegetation near rivers, and flying into forest canopy, and it is assumed they spend most of their adult lives in forest canopy (**see BIOLOGY**). It is unknown if adults have specific habitat requirements, such as forest of particular age or composition. The watersheds in which Pygmy Snaketail is found in Canada are almost entirely forested. For example, the St. Croix River watershed is 81% forested (Oblak 2011), the Miramichi River watershed is 90% forested (MREAC 2007), and the Magaguadavic River watershed is 83.7% forested (Killorn 2014).

## Habitat Trends

Water quality within rivers is important to the immature life forms of the Pygmy Snaketail. Environment and Climate Change Canada monitors water quality, with parameters relevant to ecosystem health, at stations across southern Canada (ECCC 2018). There are five index categories that range from excellent (water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels) to poor (water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels) (CCME 2017).

Water quality index values are available from stations in or near river stretches with subpopulations on the Saint John, Cains, Southwest Miramichi, Magaguadavic, and St. Croix rivers from 2002–2016, these are presented in Table 3. Index values varied at some stations; however, no stations exhibited a strong trend of increasing or decreasing water quality over the sample period. All rivers were in the “good” category for the last reporting period (2014–2016). The Salmon river and Namakan rivers were not featured in ECCC 2018 report.

**Table 3. Water quality index values for sampling sites on the Saint John, Southwest Miramichi, Cains, St. Croix, and Magaguadavic rivers. Sampling site data from ECCC 2018. Index categories are defined in CCME 2017.**

		Sampling sites					
		Saint John River below St. Basile (Site No. 00BR01AF0084)	Southwest Miramichi River above Blackville Bridge (Site No. 00BR01BO0041)	Cains River mouth (Site No. 00BR01BN0001)	St. Croix River above Milltown Bridge (Site No. 00BR01AR0092)	St. Croix River below St. Croix Bridge (Site No. 00BR01AR0067)	Magaguadavic River St. George (Site No. 00BR01AQ0024)
Sampling period	2002-2004	-	Good	-	Good	-	Fair
	2003-2005	-	Good	-	Good	-	Fair
	2004-2006	Good	Good	-	Good	-	Fair
	2005-2007	Good	Good	Good	Excellent	-	Fair
	2006-2008	Good	Good	Good	Fair	Good	Fair
	2007-2009	Good	Good	Good	Fair	Excellent	Fair
	2008-2010	Good	Good	Good	Fair	Excellent	Fair
	2009-2011	Good	Good	Good	Good	Excellent	Good
	2010-2012	Good	Good	Good	Good	Excellent	Good
	2011-2013	Good	Good	Good	Good	Excellent	Good
	2012-2014	Good	Good	Good	Good	Excellent	Good
	2013-2015	Good	Good	Good	Good	Good	Good
	2014-2016	Good	Good	Good	Good	Good	Good

Kidd *et al.* (2011) reported that the water quality index for aquatic life, as measured by pH and concentrations of aluminum, iron, and dissolved oxygen, were “fair” for the Saint John River in New Brunswick upstream of Edmundston for their last measurement period (2000–2008). The index value was better in the 1960s, but worse in the 1970s, 1980s, and 1990s. They also report that eutrophication is not considered a concern. This stretch of the Saint John River has relatively low concentrations of nitrogen, phosphorus, and chlorophyll *a* (a pigment from plants and algae used to indirectly measure primary production), and that eutrophication has decreased since the 1960s.

The terrestrial landscape around natal rivers provide habitat to adult Pygmy Snaketails. Adults are assumed to live primarily in forest canopy. All sites where the Pygmy Snaketail has been documented in Canada are in forested landscapes. There is wood harvesting in all watersheds where the species occurs, so forest available to adults at most sites is a dynamic patchwork of forest stands of varying ages.

## BIOLOGY

### Life Cycle and Reproduction

As with all clubtails, eggs are laid by adult females by dipping the end of the abdomen into water to release them. In one observed instance this was done in the current in the middle of the river (Donnelly, pers. comm. 2007), and in another in the slower but still active current margins (Brunelle, pers. comm. 2017). Presumably these eggs sink to the bottom while carried along by the current, and development of the larvae is on or inside the substrate.

Larvae burrow during the day, and reach depths of 20 cm (Donnelly, pers. comm. 2007). Larvae come to the substrate surface at night, and like many riverine Odonata, Pygmy Snaketail larvae are known to drift downstream at night (DuBois and Pratt 2017).

In New Brunswick the Pygmy Snaketail begins emerging in late May or the first half of June and continues throughout June. The earliest collection date of an exuvia in Canada is June 13, 2007 (ADIP 2015). In Maine exuviae have been collected as early as May 25 (ADIP 2015). The latest date of emergence observed in Canada was in New Brunswick on July 1, 2003 (ADIP 2015). It is likely that emergence begins with drifting of the larvae, and hence larvae leaving the water to emerge will be concentrated where strong current slows abruptly (Brunelle, pers. comm. 2017). Typical emergence sites will be the head of pools into which rapids are emptying, and generally below structures along the erosional banks of the rivers. Gibbs *et al.* (2004) suggest that the Pygmy Snaketail emerges synchronously towards the end of the emergence of other species such as the Extra-striped Snaketail (*O. anomalus* Harvey), the Riffle Snaketail (*O. carolus* Needham), and the Maine Snaketail (*O. mainensis* Packard), and more or less during the same period as the Brook Snaketail (*O. aspersus* Morse).

Pygmy Snaketail exuviae are usually taken on erosional banks near where the current is strong, suggesting that larvae either live in the fast but even current adjacent to those banks, or that they drift prior to emerging, in which case they would tend to end up at those banks. They generally emerge within 1 m of the water's edge (J. Klymko, pers. obs.).

Following emergence, the teneral fly from the river for an extended period of maturation. While most Odonata species return frequently to rivers to establish territories and breed, the Pygmy Snaketail seems to spend little time at its larval waters. It is likely that it spends the bulk of its adult life in the surrounding forest, usually in the canopy, where virtually no observation has been done. Kennedy and White (1979) noted that they flew high in the trees in the late afternoon until dusk. The Pygmy Snaketail is abundant on some rivers in Wisconsin; however, adults are seldom observed (Tennessee, pers. comm. 2017). In New Brunswick and Maine, only 11 of the 114 records of the species are based solely on adults (ADIP 2015, ACCDC 2018). Adults that have been found are typically on low vegetation near water, though several have been seen on bushes in fields a substantial distance from any potential larval habitat (Daigle, pers. comm. 2017). Adults have also been seen flying rapidly very low over water for brief periods (Tennessee, pers. comm. 2017).

The latest adult record in Canada is July 15, 2007 (ADIP 2015).

Emergence and flight period are presumably similar in northwestern Ontario. The Wisconsin flight period is similar to the that of New Brunswick and Maine, with the earliest record of May 19 and the latest record is July 16 (DuBois, pers. comm. 2017).

As with other riverine clubtails, Pygmy Snaketail larvae likely eat whatever small creatures are also present in their substrate habitat, but the burrowing behaviour of the larvae suggests there may be some specialization in prey. Kennedy and White (1979) recorded water mites (Arachnida), mayflies (Ephemeroptera), and midge larvae (Diptera) from the foregut of Pygmy Snaketail larvae. Little is known of the food preferences of Pygmy Snaketail adults. Presumably they feed on whatever flying insect species is present, as do most Odonata species. They have not been reported to glean from solid surfaces.

Kennedy and White (1979) posit the species has a two year life cycle based on there being two distinctive size classes of larvae in the New River in Virginia. Gibbs *et al.* (2004) and DuBois and Pratt (2017) found that a wide variety of larval instars can be collected on a given collection day in Maine and Wisconsin, respectively, suggesting a life cycle potentially greater than two years.

## **Physiology and Adaptability**

Physiological requirements of the Pygmy Snaketail are not documented. The species is consistently found in relatively large, clean, medium gradient rivers, but the adaptability of this species is unknown.

## Dispersal and Migration

The Pygmy Snaketail is not a migratory species. The dispersal capabilities of the Pygmy Snaketail have not been studied. In general, Odonata species associated with lentic habitats, like ponds, have a greater capability of dispersal than species associated with lotic habitats, because lentic habitats are less predictable spatially and temporally (Hof *et al.* 2006). The dispersal distances of individuals are not well known for lotic Odonata species, but it is estimated that adults can disperse 1–13 km (Collins and McIntyre 2017). Hickling *et al.* (2005) studied the poleward range shifts of 37 species of nonmigratory British Odonata between 1960–1970 and 1985–1995. Their study included one Gomphidae species, the Common Clubtail (*Gomphus vulgatissimus* (Linnaeus)), a species of moderate to slow-flowing water (British Dragonfly Society 2018). Hickling *et al.* (2005) found that the northern margin of the Common Clubtail's range had shifted 74 km northward over the study period.

## Interspecific Interactions

Little is known about interspecific interactions in Pygmy Snaketail. It co-occurs with the Extra-striped Snaketail, the Maine Snaketail, the Rusty Snaketail (*Ophiogomphus rupinsulensis* (Walsh)), the Riffle Snaketail, and the Brook Snaketail at all known new Brunswick sites. On the Namakan River, the Extra-lined Snaketail, the Rusty Snaketail and the Boreal Snaketail (*O. colubrinus* Sélys) have been collected (Poropat and Boxall 2016, Oldham, pers. comm. 2017, Ontario Odonata Atlas Database 2017).

Dragonfly larvae are the prey of fish, aquatic birds, and large predaceous aquatic insects (Walker 1953). Spinycheek Crayfish (*Orconectes limosa* (Rafinesque)) consume surface-dwelling dragonfly larvae in riverine and aquarium settings (Brunelle, pers. comm. 2017). The burrowing behaviour of the Pygmy Snaketail larvae may limit their exposure, but they are at the surface at night when they drift, and when they crawl to shore to emerge. Adult dragonflies are preyed on by a variety of birds, including hawks, falcons, and Eastern Kingbird (*Tyrannus tyrannus*), frogs, and large dragonfly species, particularly the Dragonhunter (*Hagenius brevistylus* Sélys) (Walker 1953).

Although the Pygmy Snaketail is a small species, it may actively defend territory. A male has been seen pursuing and harassing the Illinois River Cruiser (*Macromia illinoensis* Walsh), one of the larger species to fly along rivers (Brunelle, pers. comm. 2017).

## POPULATION SIZES AND TRENDS

### Sampling Effort and Methods

There have been no attempts to quantify any Pygmy Snaketail subpopulations in Canada, and it is difficult to approximate population sizes, especially with rare, difficult to detect species.

## **Abundance**

There are many factors that make estimating abundance or density problematic, including detectability and timing of surveys to align with emergence. Exuvia are not easily detectable and can be destroyed by wind, rain, or fluctuating water levels. Therefore, abundance estimates cannot be accurately made for subpopulations.

However, there is some information on the number of exuviae detected on specific surveys. The species is known from single exuvia on the Namakan and Salmon Rivers. On the St. Croix River, six exuviae were collected in 2017; however, a systematic survey of the river was not completed.

In 2007, the Southwest Miramichi River was surveyed for Pygmy Snaketail exuviae (Doucet and Edsall 2008). Eleven sites, each consisting of both banks of 100 m long stretches of river, were surveyed. The Pygmy Snaketail was at all five sites surveyed between Blissfield and Blackville and nowhere else, and in total 76 exuviae were collected.

In 2016, the Magaguadavic River was surveyed for Pygmy Snaketail (Klymko and Robinson 2017). Twenty-four sites were surveyed, and a total of 26 exuviae were found at 10 sites.

In 2018, the entire Saint John River upstream of Edmundston was surveyed (ACCDC unpublished data). Surveys were done at 44 sites for a total of 7.4 km of shoreline, along a 58.9 km stretch of river. Two exuviae were found, one at Kennedy Island, and one at Baker Brook.

## **Fluctuations and Trends**

The data available are insufficient to speculate on fluctuations or trends of the population. The only river that has been subject to intensive survey in more than one year is the Namakan River, and from there just one record exists. It is known that the Pygmy Snaketail has persisted on the Saint John River from 2002 to 2018, on the Magaguadavic River from 2003 to 2016, on the Southwest Miramichi River from 2003 to 2011, and on the St. Croix River from 1996 (earliest US record (ADIP 2015)) and 2017.

Globally, the population trend is considered stable over the short-term (10 years) and unknown over the long-term (200 years) (NatureServe 2018).

## **Rescue Effect**

As far as is known, the adults generally do not wander far from the rivers where they have developed as larvae and are associated with forest close to the river banks. Snaketail species are generally closely associated with larval sites, unlike some other genera of dragonflies that wander widely. Given likely similar population trends, rescue is considered possible for New Brunswick, but unlikely.



The nearest known site in Minnesota is approximately 165 km distant from the Ontario site, further than adults are likely to wander (**see Dispersal and Migration**). Based on current knowledge, rescue from outside subpopulations is not possible in Ontario in the short term.

There are several Maine subpopulations close to the New Brunswick border, and rescue may be possible. The Pygmy Snaketail is known from the Saint John River in Northern Maine 19 km upstream of where the river begins to form the international border. A subpopulation on the Aroostook River is also less than 17 km from the New Brunswick border, but with unsuitable habitat between due to the Beechwood Dam. A subpopulation on St. Croix Stream near Houlton Maine is approximately 38 km northwest of the Meduxnekeag River in New Brunswick. There is also a subpopulation on the West Branch Mattawamkeag River near Haynesville, Maine, that is approximately 20 km from the New Brunswick border.

## THREATS AND LIMITING FACTORS

The International Union for the Conservation of Nature–Conservation Measures Partnership (IUCN- CMP) threats calculator (Salafsky *et al.* 2008; Master *et al.* 2009) was used to classify and list threats to the Pygmy Snaketail (Appendix 1). A draft threats calculator was completed. Overall threat impact for the Pygmy Snaketail is considered Low–Low. Potential or suspected threats below are listed in order of highest to lowest threat.

### Threats

#### 7.2 Dams & water management/use (Low impact)

The greatest perceived threat is the impoundment of running waters. Head ponds<sup>2</sup> destroy larval habitat outright by eliminating lotic habitat, and there is the potential of a negative impact on populations below dams if the altered flow regime renders the substrate composition unsuitable for larvae (e.g. a dam that releases large volumes of water at regular intervals could create stronger than normal currents that wash away sand and gravel substrate).

Damming likely had a profound influence on the distribution and abundance of the species in the 1800s and early 1900s when that practice occurred throughout northeast North America for industrial and hydroelectric purposes.

The Ontario subpopulation may be negatively impacted by hydroelectric construction proposed for the Namakan River (Gemini Power Corp. 2010). The proposed dam is a run-of-the-river dam, so there is no head pond, but the outflow could result in rapid water fluctuations and periodic peak flows that exceed current flow levels. This could alter the

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<sup>2</sup> The pond, reservoir, or lake created above a dam.

river substrate where larvae reside. The project has been impeded by cost (see Brennan 2014) and its future is unclear. There are no major hydroelectric projects proposed in New Brunswick.

### 1.1 Housing and urban areas (Negligible impact)

Adjacent to the site on the upper Saint John River, a significant proportion of the shoreline is developed, much of it a low density residential area. On the Magaguadavic River, most of the shoreline is undisturbed, but there are some cottages, and new lots are being cleared for development (J. Klymko, pers. obs.). On the Southwest Miramichi River, most shoreline is undeveloped, but there are rural homes along much of the shoreline, and one emergence site is in the town of Blackville. Regulations prevent extensive shoreline clearing and the impact of forest cover loss adjacent to rivers is unclear. Near all emergence sites there is extensive forest, so forest cover may not be a limiting factor. At all other sites development is minimal or non-existent.

### 5.3 Logging & wood harvesting (Negligible impact)

Forest harvesting may exert a negative impact on adult subpopulations, which are thought to spend much of their time in the forest canopy. Harvesting, generally in the form of clearcutting, occurs around all New Brunswick sites. In Ontario, harvesting occurs within 2 km to the north of the Namakan River at the known collection site. Mandated setbacks around waterways (e.g., strips of riparian forest cover left by foresters) may mitigate the impact. It is unknown how far Pygmy Snaketail adults wander from watercourses, and it is possible that adults use forest further from rivers than mandated setbacks protect.

### 9.3 Agricultural & forestry effluents (Negligible impact)

Pygmy Snaketail larvae, like other Odonata larvae, are probably sensitive to pesticides, especially organochlorides and organophosphates (Corbet 1999). Effects of pollutants on odonate larvae include slow growth, developmental deformities, and behavioural abnormalities (Corbet 1999). Pollution is a potential threat, particularly by broadcast pesticides used in agriculture or forestry management. However, there are 30 m buffers between waterways and forest activities and under the NB *Clean Water Act*, people with development plans need permits to do the work, mitigating the impact of this potential threat. Direct and indirect impacts of pollution on adults in forest canopies and larvae in aquatic environments are not completely known.

### 8.1 Invasive non-native/alien species/diseases (Unknown impact)

Exotic crayfish may pose direct and indirect threats to the Pygmy Snaketail. Generally, crayfish are omnivorous, and their broad diets simultaneously affect multiple trophic levels (Dorn and Wojdak 2004). Because of this, their impacts on various taxa are not easily predicted. When Virile Crayfish (*Orconectes virilis* (Hagen)) was reintroduced to a lake in northwestern Ontario, it altered the composition of the damner (Odonata: Aeshna spp.) larval community: large, presumably late-instar larvae decreased in abundance, whereas small,

presumably early-instar larvae increased in abundance, and overall *Aeshna* biomass increased (Phillips *et al.* 2009). In a lake in Wisconsin, the introduction of Rusty Snaketail (*O. rusticus* (Girard)) caused a significant decline in the abundance of snails, but had little or no effect on macroinvertebrate densities, including Odonata (Lodge *et al.* 1994). In Japan, the introduction of an exotic crayfish, Red Swamp Crayfish (*Procambarus clarkia* (Girard)), was concomitant with the decline of an endangered dragonfly (*Libellula angelina* Selys) (Miyake and Miyashita 2011).

In New Brunswick, two exotic crayfish occur within Pygmy Snaketail subpopulations: Spinycheek Crayfish on the St. Croix River (McAlpine *et al.* 2007), and Virile Crayfish on the Saint John River (McAlpine *et al.* 1999). Virile Crayfish is also known from the Bartholemew River (based on a single specimen collected dead, McAlpine pers. comm. 2017), which drains into the Southwest Miramichi River at Blackville.

In the Namakan River system, Rusty Crayfish (*O. rusticus* (Girard)) and Northern Clearwater Crayfish (*O. propinquus* (Girard)) are present as exotic species. Both were introduced upstream of the Namakan River Pygmy Snaketail site into Basswood, Knife and Sucker lakes decades ago (Jackson, pers. comm. 2017). Currently, Rusty Crayfish appears to be limited to Basswood Lake, more than 60 km southeast of the Pygmy Snaketail site, whereas Northern Clearwater Crayfish is spreading, and has been detected in Crooked Lake, approximately 50 km southeast of the Pygmy Snaketail site (Jackson, pers. comm. 2017). Another exotic species, Calico Crayfish (*O. immunis*), has recently been detected at Atikokan 65 km to the northeast of the Pygmy Snaketail site (Jackson, pers. comm. 2017). In Namakan Lake, downstream of the Pygmy Snaketail site, Calico Crayfish is present (Kallemeyn *et al.*, 2003). It is debated whether that species is native to the watershed (Maki, pers. comm, 2017). Rusty Crayfish is not yet in Namakan Lake, but it is present in Crane and Sand Point Lakes, which are part of the Namakan Lake reservoir (Maki, pers. comm. 2017). It seems unlikely Calico Crayfish and Rusty Crayfish could colonize the Namakan River from Namakan Lake because the rapids present would be serious obstacles.

The Smallmouth Bass (*Micropterus dolomieu* Lacépède) was introduced to the St. Croix River around 1870 (Catt 1949). There they are voracious predators on the benthos (Brunelle, pers. obs. in situ (pers. comm. 2017)). They possibly represent a threat to Pygmy Snaketail larvae during nocturnal emergence from substrate, as the bass feed at night (Gilhen, pers. comm. 2007). The Smallmouth Bass was introduced to the Magaguadavic River system in 1925 (Catt 1949). It was also introduced historically to the Namakan River system (Jackson, pers. comm. 2017).

The Chain Pickerel (*Esox niger* Lesueur) was introduced to New Brunswick in the 1800s (Cox 1896). It is established in the St. Croix River (Anon. 1988), the Saint John River (ACCDC 2018), and the Magaguadavic River (COSEWIC 2008). Young Chain Pickerel feed primarily on immature aquatic insects. As adults they are largely piscivorous, but larger invertebrates are still consumed (Scott and Crossman 1998). The impact this species has on the New Brunswick Odonata fauna is unknown.

## Limiting Factors

Limiting factors are generally not human-induced and include characteristics that make the species more vulnerable to ongoing threats. Limiting factors for Pygmy Snaketail include habitat specificity and the geographic isolation of the Ontario subpopulation.

### Habitat specificity

The Pygmy Snaketail occurs in relatively large clean rivers with a moderate gradient. Its distribution is much more patchy than sympatric riverine congeners (ADIP 2015), suggesting that some unknown habitat requirements prevent it from occurring in unoccupied areas of seemingly suitable habitat.

### Geographic isolation

The known Ontario subpopulation is potentially very isolated. The nearest known occurrence is 165 km to the southwest on the Mississippi River downstream of Grand Rapids Minnesota. Such isolation makes subpopulations inherently vulnerable to extirpation.

## Number of Locations

It is not possible to calculate the number of locations for this species. The term 'location' defines a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present. This species is mobile and the threats to this species remain low or are absent. In absence of clearly defined threats over its range, the term 'location' cannot be used and the subcriteria that refer to the number of locations will not be met.

There is one site in Ontario, the Namakan River. There are 5 sites in New Brunswick consisting of the St. Croix River, Magaguadavic River, Saint John River, and Salmon River. The Cains River and Southwest Miramichi River are considered a single site, as the Cains is a tributary of the Southwest Miramichi.

## PROTECTION, STATUS AND RANKS

### Legal Protection and Status

Pygmy Snaketail was assessed as Special Concern by COSEWIC in 2008 (COSEWIC 2008) and listed as Special Concern under Schedule 1 of the *Species at Risk Act* (SARA) in 2011. Pygmy Snaketail is listed as Special Concern under the New Brunswick *Species at Risk Act* and Endangered under the Ontario *Endangered Species Act*.

General prohibitions under the federal *Species at Risk Act* and prohibitions under the New Brunswick *Species at Risk Act* do not apply to species of Special Concern. Prohibitions of the Ontario *Endangered Species Act* are afforded to the species. This prohibits killing, capturing, or harassing individuals, as well as damage or destruction of habitat.

In Michigan, Pygmy Snaketail is listed as Threatened under Michigan's *Natural Resource and Environmental Protection Act* (MNFI 2017). In New York it is listed Special Concern by the Department of Environmental Conservation (NYSDEC 2017).

## **Non-Legal Status and Ranks**

The conservation status ranks for Pygmy Snaketail are:

- Global Status: G3-Vulnerable (last reviewed 2006) (NatureServe 2017).
- Canada National status: N2- Imperiled (last reviewed 2015) (Canadian Endangered Species Conservation Council 2016).
- New Brunswick status: S2- Imperiled (last reviewed 2015) (Canadian Endangered Species Conservation Council. 2016).
- Ontario Status: S1- Critically Imperiled (last reviewed 2015) (Canadian Endangered Species Conservation Council. 2016).
- United States statuses: Kentucky (S1S2), Maine (S2S3), Massachusetts (SX), Michigan (S1), Minnesota (SNR), New York (S1), North Carolina (S1), Pennsylvania (S1), Tennessee (S3?), Virginia (S1S2), Wisconsin (S4) (NatureServe 2017).

## **Habitat Protection and Ownership**

Pygmy Snaketail is afforded General Habitat Protection in Ontario (ON MNRF 2017), which is protection of habitat defined as “an area on which a species depends directly or indirectly to carry out its life processes” (Ontario 2012). The Namakan River subpopulation is on provincial crown land.

In New Brunswick waterways are provincial crown land. Ownership of land adjacent to rivers hosting subpopulations varies between sites:

- St. Croix River: Mostly provincial crown land.
- Magaguadavic River: Mostly privately owned land.

- Salmon River: The shoreline is almost entirely privately owned land at the site of the single record and in the 10km of appropriate habitat upstream of it. Further upstream, shoreline ownership is approximately half provincial crown and half private. Land more than 1km from the river is approximately half provincial crown land in the stretch 10km upstream of the record, and nearly all provincial crown land further upstream..
- Southwest Miramichi River: Mostly privately owned land.
- Cains River: Most shoreline is privately owned within three kilometres of the single site where the species has been recorded; beyond that shoreline is mostly provincial crown land. Most land more than 1km from the river is provincial crown land along the entire river.
- Saint John River: Mostly privately owned land.

Under the New Brunswick *Clean Water Act*, there are various prohibitions to disturbing shoreline habitat without a permit, including prohibition of the deposit of fill or any other material within 30 metres of a watercourse, the removal of vegetation from the bank of a watercourse, and the removal of trees within 30 metres of a watercourse. Lots continue to be cleared on some rivers, like the Magaguadavic River, presumably with the appropriate permits.

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Brunswick.

## INFORMATION SOURCES

Abbott, J.C. 2006–2017. OdonataCentral: An online resource for the distribution and  
identification of Odonata. Available at <http://www.odonatacentral.org>. (Accessed:  
October 26, 2017).

ACCDC. 2018. Atlantic Canada Conservation Data Centre database. Sackville, NB.  
Digital database: accessed September 2018.

Anon. 1988. Long-term management plan for the diadromous fisheries of the St. Croix  
River. Department of Fisheries and Oceans. Canadian Manuscript Report of  
Fisheries and Aquatic Sciences No. 1969. Vi + 73 pp.

Atlantic Dragonfly Inventory Program, 2015 edition (ADIP). 2015. Database maintained  
by Paul M. Brunelle, New Brunswick Museum.

Baillie, J., and B. Groombridge. 1996. IUCN: red list of threatened animals. The World  
Conservation Union, Gland, Switzerland: 105–107, 171 (Odonata).

Brennan, R.J. 2014. Ontario Liberals take a hard line against First Nations community's  
hydro project. The Toronto Star. Available online at  
<[https://www.thestar.com/news/canada/2014/07/17/ontario\\_liberals\\_take\\_a\\_hard\\_line  
e\\_against\\_first\\_nations\\_communitys\\_hydro\\_project.html](https://www.thestar.com/news/canada/2014/07/17/ontario_liberals_take_a_hard_line_against_first_nations_communitys_hydro_project.html)>. Accessed 3 November  
2017.

British Dragonfly Society. 2018. Common Clubtail. Available online at  
<https://www.british-dragonflies.org.uk/species/common-club-tail>. Accessed 12  
August 2018.

Bromley, S.W. 1924. A new Ophiogomphus (Aeschnidae: Odonata) from  
Massachusetts. Entomological News 35(10): 343–344.

Brunelle, P.M. pers. comm. 2017. *Email correspondence to J. Klymko*. November 2017.  
Director, Atlantic Dragonfly Inventory Program, Halifax, Nova Scotia.

Canadian Council of Ministers of the Environment (CCME). 2017. Canadian water  
quality guidelines for the protection of aquatic life: CCME Water Quality Index,  
User's Manual–2017 Update. In: Canadian environmental quality guidelines, 1999,  
Canadian Council of Ministers of the Environment, Winnipeg, MB.

Canadian Endangered Species Conservation Council. 2016. Wild Species 2015: The  
General Status of Species in Canada. National General Status Working Group:  
128 pp.

- Calvert, P.P. 1924. The supposed male of *Ophiogomphus howei* Bromley (Odon.: Aeschnidae). *Entomological News* 35: 345–347.
- Carle, F.L. 1986. The classification, phylogeny and biogeography of the Gomphidae (Anisoptera): I: classification. *Odonatologica* 15:275–326.
- Carle, F.L. 1992. *Ophiogomphus (Ophionurus) australis* spec. nov. from the gulf coast of Louisiana, with larval and adult keys to American *Ophiogomphus* (Anisoptera: Gomphidae). *Odonatologica* 21(2): 141–152.
- Catling, P.M. 2002. Pygmy snaketail *Ophiogomphus howei*, new to Canada. *Argia* 14(3):11–12.
- Catling, P. M., R. A. Cannings, and P.M. Brunelle. 2005. An Annotated Checklist of the Odonata of Canada. *Bulletin of American Odonatology* 9(1):1–20.
- Catling, P.M. 2007. Variation of hind-wing colour and length in *Sympetrum internum* (Odonata: Libellulidae) from the Canadian prairie provinces. *The Canadian Entomologist* 139:872–880.
- Catt, J. 1949. Small Mouthed Black Bass in the Waters of New Brunswick and Nova Scotia. *The Canadian Fish Culturalist* 4:15–18.
- Collins, S.D. and McIntyre, N.E. 2017, Extreme loss of diversity of riverine dragonflies in the northeastern U.S. is predicted in the face of climate change. *Bulletin of American Odonatology* 12(2):7–19.
- Corbet, P.S. 1999. *Dragonflies: Behavior and Ecology of Odonata*. Comstock Publishing Associates, Ithaca, NY. 864 pp.
- COSEWIC. 2008. COSEWIC assessment and status report on the Pygmy Snaketail *Ophiogomphus howei* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 34 pp.
- Cox, P. 1896. Catalogue of the marine and freshwater fishes of New Brunswick and Nova Scotia. *Bulletin of the Natural History Society of New Brunswick* 13:62–75.
- Daigle, J.J. pers. comm. 2017. *Email correspondence to J. Klymko*. October 2017. Correspondence to J. Klymko. Independent Entomologist, Tallahassee, Florida.
- Donnelly, T.W. pers. comm. 2007. *Correspondence to P. Brunelle*. Professor Emeritus, Binghamton University, Binghamton, New York.
- Dorn, N.J. and Wojdak, J.M. 2004. The role of omnivorous crayfish in littoral communities. *Oecologia* 140:150-159.
- Doucet, D.A. and Edsall, J. 2008. A rare Odonata Survey of the Miramichi watershed. Report to the New Brunswick Wildlife Trust and the New Brunswick Environmental Trust.
- DuBois, R.B. and Pratt, D. 2017. Species and life stages of Odonata nymphs sampled with large drift nets in two Wisconsin rivers. *The Great Lakes Entomologist*. 50(1–2):11–16



- DuBois, R.B. pers. comm. 2017. *Email correspondence to J. Klymko*. November 2017. Research Scientist, Wisconsin Department of Natural Resources, Superior, Wisconsin.
- Dunkle, S.W. 2000. *Dragonflies through binoculars: a field guide to dragonflies of North America*. Oxford University Press. 266 pp.
- Environment and Climate Change Canada. 2018. Canadian Environmental Sustainability Indicators: Water quality in Canadian rivers. Available at < [www.canada.ca/en/environment-climate-change/services/environmentalindicators/water-quality-canadian-rivers.html](http://www.canada.ca/en/environment-climate-change/services/environmentalindicators/water-quality-canadian-rivers.html).> . Accessed 10 September 2018
- Gemini Power Corp. 2010. High Falls Development Partnership (Lac LaCroix First Nation). Available online at < <http://geminipowercorp.ca/highfallsdevelopmentpartnership8.php>> Accessed 3 November 2017.
- Gibbs, K.E., B.J. Bradeen, and D. Boland. 2004. Spatial and temporal segregation among six species of coexisting *Ophiogomphus* (Odonata: Gomphidae) in the Aroostook River, Maine. *Northeastern Naturalist* 11(3): 295–312.
- Gilhen, J. pers. comm. 2017. *Email correspondence to J. Klymko*. November 2017. Nova Scotia Museum, Halifax, Nova Scotia.
- Hebert, P.D. pers. comm. 2018. Correspondence to Cory Sheffield, Terrestrial Arthropod Specialist Subcommittee member. Director, Centre for Biodiversity Genomics, Guelph, Ontario.
- Hickling, R., D.B. Roy, J.K. Hill, and C.D. Thomas. 2005. A northward shift of range margins in British Odonata. *Global Change Biology* 11:502–506.
- Hof, C., M. Brändle, and R. Brandl. 2006. Lentic odonates have larger and more northern ranges than lotic species. *Journal of Biogeography* 33:63–70.
- Jones, C.D. pers. comm. 2017. *Email correspondence to J. Klymko*. October 2017. Provincial Arthropod Zoologist, Ontario Natural Heritage Information Centre, Peterborough, Ontario.
- Kallemeyn, L.W., K.L. Holmberg, J.A. Perry and B.Y. Odde. 2003. *Aquatic Synthesis for Voyageurs National Park*. US Geological Survey, Information and Technology Report 2003–0001, 95 pp.
- Kennedy, C.H., and H.B. White III. 1979. Description of the nymph of *Ophiogomphus howei* (Odonata: Gomphidae). *Proceedings of the Entomological Society of Washington* 81:64–69.
- Kidd, S.D., R.A. Curry, and K.R. Munkittrick (eds.) 2011. *The Saint John River: A State of the Environment Report*. Canadian Rivers Institute, Fredericton, NB. Viii + 175 pp.

- Killorn, D. 2014. Magaguadavic River Water Management Plan. Eastern Charlotte Waterways Inc., Blacks Harbour, NB. 19 pp.
- Klymko, J. 2010. Odonate Surveys on the Tusket, Medway, and Lahave Rivers. Report to Nova Scotia Species at Risk Conservation Fund. 12 pp.
- Klymko, J., and Robinson, S.L. 2011. Pygmy Snaketail Surveys on the Restigouche and St. Mary's Rivers. A report for the Canadian Wildlife Federation Endangered Species Fund. 7 pp.
- Klymko, J., and Robinson, S.L. 2013. Skillet Clubtail Surveys on the Shubenacadie River. A report for the Canadian Wildlife Federation Endangered Species Fund. 6 pp.
- Klymko, J., and Robinson, S.L. 2017. Pygmy Snaketail (*Ophiogomphus howei*) Surveys in New Brunswick. A report to the New Brunswick Wildlife Trust Fund. 16 pp.
- Lodge, D.M., M.W. Kershner, J.E. Aloi, and A.P. Covich. 1994. Effects of an Omnivorous Crayfish (*Orconectes rusticus*) on a Freshwater Littoral Food Web. *Ecology* 75:1265-1281.
- Maine Dragonfly and Damselfly Survey, 2015 Edition. 2015. Database maintained by Paul M. Brunelle, New Brunswick Museum.
- Maki, R. pers. comm. 2017. *Email correspondence to J. Klymko*. November 2017. Aquatic Ecologist, Voyageurs National Park, Grand Rapids, Minnesota.
- Master, L., D. Faber-Langendoen, R. Bittman, G.A. Hammerson, B. Heidel, J. Nichols, L. Ramsay, and A. Tomaino. 2009. NatureServe conservation status assessments: factors for assessing extinction risk. NatureServe, Arlington, VA.
- McAlpine, D.F., T.J. Fletcher, M.A. Osepchook, J.C Savoie. 1999. A range extension for *Orconectes virilis* (Decapoda, Cambaridae) and a third crayfish species for New Brunswick, Canada. *Crustaceana* 72:356–358
- McAlpine, D.F., A.H.E. McAlpine, A. Madden. 2007. Occurrence of the potentially invasive crayfish, *Orconectes virilis* (Decapoda, Cambaridae) in eastern New Brunswick, Canada. *Crustaceana* 80(4):509–511
- McAlpine, D.F. pers. comm. 2017. *Telephone correspondence to J. Klymko*. November 2017. Research Curator and Head, Zoology Section, New Brunswick Museum, Saint John, New Brunswick.
- Michigan Natural Features Inventory (MNFI) 2017. *Ophiogomphus howei*, Pygmy Snaketail. Rare Species Explorer. Available online at <<https://mnfi.anr.msu.edu/explorer/species.cfm?id=12087>>. Accessed 6 November 2017.
- Miramichi River Environmental Assessment Committee (MREAC). 2007. Miramichi Watershed State of the Environment Report–2007. MREAC, Miramichi, NB. viii + 134 pp.

- Miyake, M. and T. Miyashita. 2011. Identification of alien predators that should not be removed for controlling invasive crayfish threatening endangered odonates. *Aquatic Conserv: Mar. Freshw. Ecosyst.*, 21:292–298.
- NatureServe. 2018. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available at <<http://explorer.natureserve.org>>. Accessed: 13 September 2018.
- Needham, J.G., M.J., Westfall and M.L. May. 2014. *Dragonflies of North America: The Odonata (Anisoptera) Fauna of Canada, the Continental United States, Northern Mexico and the Greater Antilles*, Third Edition. Scientific Publishers, Gainesville, Florida. 657 pp.
- New York State Department of Environmental Conservation (NYSDEC). 2017. List of Endangered, Threatened and Special Concern Fish & Wildlife Species of New York State. Available online at <<http://www.dec.ny.gov/animals/7494.html/>>. Accessed 6 November 2017.
- Oblak, J.A. 2011. Transboundary Water Quality and Human Health Issues in an International Watershed Context: The St. Croix Watershed. International Joint Commission Health Professionals Task Force. v+99 pp.
- Oldham, M.J., pers. comm. 2017. *Email correspondence to J. Klymko*. October 2017. Botanist/Herpetologist, Ontario Natural Heritage Information Centre, Peterborough, Ontario.
- Ontario. 2017. Categorizing and Protecting Habitat under the Endangered Species Act. ii + 8pp.
- Ontario Ministry of Natural Resources (ON MNRF). 2017. Ophiogomphe de Howe. Available online at <<https://www.ontario.ca/fr/page/ophiogomphe-de-howe>>. Accessed October 22, 2017.
- Ontario Odonata Atlas Database. 2017. Natural Heritage Information Centre, Ontario Ministry of Natural Resources and Forestry. Queried on Oct 19, 2017 by C.D. Jones.
- Paulson, D. 2011. *Dragonflies and Damselflies of the East*. Princeton Field Guides. Princeton. New Jersey. 576 pp.
- Paulson, D.R., and S.W. Dunkle. 1996. Common names of North American dragonflies and damselflies, adopted by the Dragonfly Society of the Americas. *Argia* 8(2): supplement.
- Phillips, I.D., R.D., Vinebrooke, and M.A. Turnerc. 2009. Experimental reintroduction of the crayfish species *Orconectes virilis* into formerly acidified Lake 302S (Experimental Lakes Area, Canada). *Canadian Journal of Fisheries and Aquatic Sciences* 66(11):1892–1902.
- Poropat, E., Boxall, J. 2016. A search for *Ophiogomphus howei*–Pygmy Snaketail in northwestern Ontario. A report for the Species At Risk Stewardship Fund 2016. 21 pp.

- Salafsky, N., D. Salzer, A.J. Stattersfield, C. Hilton-Taylor, R. Neugarten, S.H.M. Butchart, B. Collen, N. Cox, L.L. Master, S. O'Connor, and D. Wilkie. 2008. A standard lexicon for biodiversity conservation: unified classifications of threats and actions. *Conservation Biology* 22:897–911.
- Savard, M. 2011. Atlas préliminaire des libellules du Québec (Odonata). Entomofaune du Québec, Saguenay, Québec. 53 pp.
- Scott, W.B., and E.J. Crossman. 1998. The freshwater fishes of Canada. Galt House Publications Limited, Oakville, Ontario. xx + 966 pp.
- Sélys Longchamps, E. de. 1854. Synopsis des Gomphines. *Bulletin de l'Académie Royale des Sciences de Belgique* 21:23–112.
- Steffens, W.P. and W.A. Smith 1999. Status Survey for Special Concern and Endangered Dragonflies of Minnesota: Population Status, Inventory and Monitoring Recommendations. A report submitted to the Minnesota Department of Natural Resources Natural Heritage and Nongame Research Program. 56 pp.
- Tennessee, K.J. pers. comm. 2017. *Email correspondence to J. Klymko*. October 2017. Independent Research Professional, Oshkosh, Wisconsin.
- Tennessee, K.J. 1993. New distribution records for *Ophiogomphus howei* (Odonata: Gomphidae). *The Great Lakes Entomologist* 26(3):246–249.
- Tingley, S., pers. comm. 2017. *Email correspondence to J. Klymko*. October 2017. Amateur naturalist, Cocagne, New Brunswick.
- United States Fish and Wildlife Service (USFWS). 2017. Species Profile for Midget snaketail (*Ophiogomphus howei*). Available online at <[https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=I0DV\\_](https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=I0DV_)> Accessed October 22, 2017.
- Van den Broeck, J., and C. Jones. 2009. 2009 investigation of the Namakan River System (Fort Frances District, Ontario) for the presence of Pygmy Snaketail (*Ophiogomphus howei*). Ontario Ministry of Natural Resources. 8 pp.
- Walker, E.M. 1953. The Odonata of Canada and Alaska. Vol. I. Part I: General. Part II: The Zygoptera-damselflies. Univ. Toronto Press, Toronto. xi + 292 pp.
- White, E.L., J.D. Corser, and M.D. Schlesinger. 2010. The New York dragonfly and damselfly survey 2005–2009: Distribution and status of the odonates of New York. New York Natural Heritage Program, Albany, New York. ix + 424 pp.
- Wisconsin Department of Natural Resources. 2013. Natural Resources Board Agenda Item 3.B.1. 81 pp.

## **BIOGRAPHICAL SUMMARY OF REPORT WRITER**

John Klymko is the zoologist at the Atlantic Canada Conservation Data Centre in Sackville, New Brunswick. He has conducted Odonata surveys, primarily based on exuviae, throughout New Brunswick and Nova Scotia since 2010. He has conducted studies on Syrphidae, Vespidae, Apoidea, Coleoptera, Lepidoptera, birds, reptiles, and plants throughout the Maritimes, and has documented close to a hundred new provincial insect records. John is a member of COSEWIC's Arthropods Specialist Subcommittee and an editor of the Journal of the Acadian Entomological Society. He received his B.Sc. in Biology and M.Sc. in Insect Systematics, both from the University of Guelph.

## **COLLECTIONS EXAMINED**

The following Canadian collections and those of nearby states were examined. All were examined prior to the 2008 assessment of Pygmy Snaketail except the Atlantic Canada Conservation Data Centre collection. Those containing specimens of the Pygmy Snaketail are indicated.

A.D. Picket Entomological Museum, Nova Scotia Agricultural College, Truro, Nova Scotia.

Atlantic Canada Conservation Data Centre collection, Sackville, New Brunswick; specimens collected by John Klymko are here, pending deposit at the New Brunswick Museum.

Atlantic Dragonfly Inventory Program Data (ADIP); specimens deposited in the New Brunswick Museum, the Nova Scotia Museum, or remaining with the volunteers pending deposit.

Brunelle Synoptic Collection, Halifax, Nova Scotia; pending deposit.

Canadian National Collection of Insects, Ottawa, Ontario (CNCI); only Paul Catling specimens of the Pygmy Snaketail (deposited after Brunelle inventory).

Maine Department of Inland Fisheries and Wildlife; Maine Damselfly and Dragonfly Survey Data (2015); specimens are currently with Brunelle; including specimens taken under contracted survey for the Department. These specimens will be deposited with the Maine State Museum, Augusta, Maine.

New Brunswick Museum, Saint John, New Brunswick. Specimens collected by Denis Doucet are deposited here.

Nova Scotia Museum of Natural History, Halifax, Nova Scotia.

Nova Scotia Department of Natural Resources, Baddeck, Nova Scotia.

Nova Scotia Department of Natural Resources Insectary, Shubenacadie, Nova Scotia.

Royal Ontario Museum, Toronto, Ontario.

University of Maine, Orono, Maine; the Pygmy Snaketail specimens of Daniel Boland and Billie Bradeen are deposited here, except for those taken by Boland under contract to MDIFW, which are deposited with the Maine Damselfly and Dragonfly Survey material.

University of Massachusetts, Amherst, Massachusetts.

University of New Hampshire, Durham, New Hampshire.

## Appendix 1. IUCN Threats Calculation on the Pygmy Snaketail.

<b>Assessment Date:</b> 4/04/2018			
<b>Assessors:</b> Jenny Heron (Co-chair and facilitator), Paul Grant (Co-chair and author), David McCorquodale, John Klymko (SSC members), Syd Cannings (SSC and COSEWIC member), Shelley Pardy (COSEWIC member for NL), Nathalie Desrosiers (COSEWIC member for QC), Michael Svoboda (CWS-QC), and Angèle Cyr (COSEWIC Secretariat and comment recorder)			
		<b>Level 1 Threat Impact Counts</b>	
<b>Threat Impact</b>		<b>high range</b>	<b>low range</b>
A	Very High	0	0
B	High	0	0
C	Medium	0	0
D	Low	2	2
<b>Calculated Overall Threat Impact:</b>		<b>Low</b>	<b>Low</b>

Threat		Impact (calculated)	Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development	Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	
1.1	Housing & urban areas	Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	<b>See Threats Section</b>
1.2	Commercial & industrial areas					
1.3	Tourism & recreation areas					
2	Agriculture & aquaculture					
2.1	Annual & perennial non-timber crops					
2.2	Wood & pulp plantations					
2.3	Livestock farming & ranching					
2.4	Marine & freshwater aquaculture					
3	Energy production & mining					
3.1	Oil & gas drilling					
3.2	Mining & quarrying					
3.3	Renewable energy					
4	Transportation & service corridors					
4.1	Roads & railroads					The impact of traffic road in terms of roadkill is probably negligible and potential mortality rates are unknown. Majority of roads are also not right next to the river and most areas are quite wild, limiting any impact.–Not a threat.
4.2	Utility & service lines					
4.3	Shipping lanes					
4.4	Flight paths					
5	Biological resource use	Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.1	Hunting & collecting terrestrial animals						Most of the collecting is of exuviae, the adults are very difficult to detect and therefore are not caught often.– Not a threat.
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	<b>See Threats Section.</b>
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance						
6.1	Recreational activities						
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						
7	Natural system modifications	D	Low	Small (1-10%)	Serious - Slight (1-70%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
7.1	Fire & fire suppression						
7.2	Dams & water management/use	D	Low	Small (1-10%)	Serious - Slight (1-70%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	<b>See Threats Section</b>
7.3	Other ecosystem modifications						
8	Invasive & other problematic species & genes		Unknown	Large (31-70%)	Unknown	High (Continuing)	
8.1	Invasive non-native/alien species		Unknown	Large (31-70%)	Unknown	High (Continuing)	<b>See Threats Section</b>
8.2	Problematic native species						Didymo blooms have the potential to affect benthic invertebrate communities where they occur. Where Didymo blooms occur are in areas where nutrient poor waters, the Pygmy Snaketail sites may not be susceptible to blooms.–Not a threat
8.3	Introduced genetic material						
9	Pollution		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	
9.1	Household sewage & urban waste water						
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	<b>See Threats Section</b>
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy						



Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather						
11.1	Habitat shifting & alteration						
11.2	Droughts						
11.3	Temperature extremes						
11.4	Storms & flooding						
Classification of Threats adopted from IUCN-CMP, Salafsky <i>et al.</i> (2008).							