

COSEWIC
Assessment and Status Report

on the

Skillet Clubtail
Gomphurus ventricosus

in Canada



SPECIAL CONCERN
2022

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 Assessment Summary

Assessment Summary – May 2022

Common name

Skillet Clubtail

Scientific name

Gomphurus ventricosus

Status

Special Concern

Reason for designation

This dragonfly of eastern North America is rarely observed and only in small numbers at known sites. Larvae live in small to large rivers. It is thought that adults spend much of their time away from the river, foraging, and only return to breed — thus are seldom seen. Increased survey effort and reporting have resulted in the documentation of 10 new subpopulations since the first assessment in 2010, distributed across a much broader area, and there are now 13 known subpopulations. The species is exposed to urban and rural development, the cumulative effects of aquatic pollution to larvae, roadkill, boat wakes, and invasive aquatic species. Failure to mitigate these threats could result in the species becoming Threatened.

Occurrence

Ontario, Quebec, New Brunswick, Nova Scotia

Status history

Designated Endangered in November 2010. Status re-examined and designated Special Concern in May 2022.



COSEWIC
Executive Summary

Skillet Clubtail
Gomphurus ventricosus

Wildlife Species Description and Significance

Skillet Clubtail is one of the most striking dragonfly species in Canada. Adults are characterized by a flat, pan-like expansion at the end of their otherwise slim abdomen. The body length is 45-48 mm long, dark brown and black, with conspicuous yellow markings on the dorsal abdomen, greenish-yellow markings on the thorax, dark green eyes, and clear wings.

Distribution

The global range of Skillet Clubtail is confined to North America east of the Mississippi and Red rivers, north to Minnesota and New Brunswick, and south to Tennessee. In Canada it occurs in 13 widely separated subpopulations in southern Ontario (Saugeen River), southern Quebec (Batiscan, Bécancour, Nicolet, Nicolet-Sud-Ouest, Sainte-Anne, Godefroy, Saint-François, Chaudière, and Chicot rivers), New Brunswick (Saint John, Salmon, and Canaan rivers), with additional historical subpopulations in Quebec, Nova Scotia, and in Ontario.

Habitat

Skillet Clubtail larvae live in small to large rivers with a silt, cobble, and bedrock substrate and pools and patches of soft sediments. They inhabit a wide range of waters; ranging in clarity from clear to stained and relatively turbid. Adult habitat is poorly understood, and adults are rarely observed. Adults apparently spend most of their lives in forests and open habitats within up to approximately three kilometres of the river.

Biology

Skillet Clubtail has three life stages and develops through complete metamorphosis. Females deposit their eggs in the water, and the larvae hatch and create shallow burrows in the soft substrates, where they can take at least two years to develop before adult emergence. In the centre of the continent, the species emerges in late May and flies to mid-August, but over most of its Canadian range, the species has a synchronous adult emergence in the latter two weeks of June. Following emergence, the dragonflies fly from the river for an extended period of maturation. Adults appear to spend little time near the larval waters, and likely spend most of their life in the surrounding forest.

Population Sizes and Trends

The Canadian population size and trends of Skillet Clubtail are unknown. Since the first COSEWIC status report, eight previously unknown subpopulations have been documented in southern Ontario and Quebec, as well as museum specimens from two additional Quebec subpopulations. Substantial search effort in New Brunswick has produced few records of the species, suggesting that it is rare in that province. The record in Ontario from along the Ottawa River remains historical.

Threats and Limiting Factors

There are four low-level threats to Skillet Clubtail individuals and habitats. These threats include habitat loss to both the terrestrial adult foraging life stage, and aquatic larval stages, caused by housing and urban development; adult roadkill is ongoing at most subpopulations; wave-wash from passing boats may kill emerging dragonflies on the larger rivers; and water pollution from agricultural run-off. Threats of unknown impact include aquatic invasive species that change the habitat and/or consume dragonfly larvae, water quality changes caused by residential development, and dams and water management. Rising sea levels are a potential future threat to the Saint John River subpopulation.

Protection, Status and Ranks

Skillet Clubtail was designated as Endangered in 2010 and is listed under Schedule 1 of the federal *Species at Risk Act*. Skillet Clubtail is classified as Endangered under New Brunswick's *Species at Risk Act* and Data Deficient under Ontario's *Endangered Species Act*. In Quebec, this species is on the *Liste des espèces floristiques et fauniques susceptibles d'être désignées menacées ou vulnérables* (List of plant and wildlife species which are likely to be designated as threatened or vulnerable).

The federal Recovery Strategy identifies critical habitat for Skillet Clubtail on four sections of the Saint John River and two sections of the Batiscan River. River and stream habitats in Canada receive some protection under the federal *Fisheries Act* where fish habitat is present, although this protection does not specifically apply to Skillet Clubtail. Provincial water protection acts offer protection to water quality and flow in lakes and rivers. None of the larval habitats of Canadian subpopulations are within parks or other protected areas and most of the terrestrial habitat surrounding the rivers is privately owned.

Skillet Clubtail is ranked as G3 (Vulnerable) globally, N2 (Imperiled) in Canada and N3 nationally in the United States. It is ranked as S1 (Critically Imperiled) in Quebec, Nova Scotia, and Ontario, and S1S2 (Critically Imperiled to Imperiled) in New Brunswick. The International Union for Conservation of Nature (IUCN) Red List of Threatened Species ranks Skillet Clubtail as Least Concern.

TECHNICAL SUMMARY

Gomphurus ventricosus

Skillet Clubtail

Gomphe ventru

Range of occurrence in Canada: Ontario, Quebec, New Brunswick, Nova Scotia

Demographic Information

Generation time	> 2 years (larvae live in aquatic habitats for approximately two years; and after emerging, adults live approximately two months)
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, whichever is longer up to a maximum of 100 years]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any period [10 years, or 3 generations, whichever is longer up to a maximum of 100 years], including both the past and the future.	Unknown
Are the causes of the decline a.) clearly reversible and b.) understood, and c.) ceased?	a. No b. Partially c. Unknown
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (EEO)	105,000 km ²
Index of area of occupancy (IAO)(2x2 grid value).	240 km ² (this IAO represents the terrestrial minimum; the IAO is likely larger because of the continuous aquatic waterways that larvae occupy)
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. Unknown b. Possibly (9 of the 13 subpopulations are separated by a distance greater than dragonflies are known to disperse)

Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	Minimum of 13, based on different threats at the 13 different waterways where extant subpopulations occur
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of "locations"*?	No; additional subpopulations identified since the previous status report likely reflects an increase in search effort, rather than an increase in number of subpopulations.
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of "locations"*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	N Mature Individuals
Total	Unknown

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations whichever is longer up to a maximum of 100 years, or 10% within 100 years]?	Unknown
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* See Definitions and Abbreviations on [COSEWIC website](#) and [IUCN](#) for more information on this term.

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

Was a threats calculator completed for this species? Yes. Calculated threat impact: Medium.

- 1.1 Housing and Urban Areas (Low impact)
- 4.1 Roads and railroads (Low Impact)
- 6.1 Recreational activities (Low Impact)
- 9.3 Agricultural and Forestry Effluents (Low Impact)
- 7.2 Dams and water management/use (Unknown Impact)
- 8.1 Invasive non-native/alien species/diseases (Unknown Impact)
- 9.1 Domestic and urban wastewater (Unknown Impact)
- 9.2 Industrial and Military Effluents (Unknown Impact)

What additional limiting factors are relevant?

- Species at northern edge of range in Canada
- Canadian subpopulations are isolated by over 100 km from the nearest known subpopulations in the United States

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	S1 to SH in states adjacent to the Canadian range
Is immigration known or possible?	Unknown; unlikely
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Likely
Are conditions deteriorating in Canada?+	Yes
Are conditions for the source (i.e., outside) population deteriorating?+	Unknown in last 10 years
Is the Canadian population considered to be a sink?+	No
Is rescue from outside populations likely?	Unknown

Data Sensitive Species

Is this a data sensitive species?	No
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Status History

Designated Endangered in November 2010. Status re-examined and designated Special Concern in May 2022.

Current Status and Reasons for Designation:

Current Status: Special Concern	Alpha-numeric codes: Not applicable
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⁺ See [Table 3](#) (Guidelines for modifying status assessment based on rescue effect).

Reasons for designation:

This dragonfly of eastern North America is rarely observed and only in small numbers at known sites. Larvae live in small to large rivers. It is thought that adults spend much of their time away from the river, foraging, and only return to breed — thus are seldom seen. Increased survey effort and reporting have resulted in the documentation of 10 new subpopulations since the first assessment in 2010, distributed across a much broader area, and there are now 13 known subpopulations. The species is exposed to urban and rural development, the cumulative effects of aquatic pollution to larvae, roadkill, boat wakes, and invasive aquatic species. Failure to mitigate these threats could result in the species becoming Threatened.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Population trends unknown.

Criterion B (Small Distribution Range and Decline or Fluctuation). Comes close to meeting EN B2ab(iii); the IAO (at least 240 km²) is below threshold and there is an observed continuing decline in (iii) quality of habitat at some subpopulations. The number of locations (>13) exceeds thresholds, although some subpopulations do not have apparent threats. Subpopulations are not considered severely fragmented.

Criterion C (Small and Declining Number of Mature Individuals). Not applicable. Number of mature individuals unknown, but probably exceeds thresholds and there is insufficient data to show a continuing decline.

Criterion D (Very Small or Restricted Population): Not applicable. Number of mature individuals, IAO, and number of locations exceeds thresholds.

Criterion E (Quantitative Analysis): Not applicable. Insufficient data available.

PREFACE

Skillet Clubtail was designated as Endangered in 2010 by COSEWIC and subsequently listed under Schedule 1 of the federal *Species at Risk Act*. At the time of this assessment, the species was known to be extant at three subpopulations in New Brunswick. The designation was based on the apparent extirpation of subpopulations prior to 2010 from the Ottawa River (Ontario/Quebec), Yamaska River (Quebec), and Shubenacadie River (Nova Scotia).

Since 2010, increased survey effort and improved reporting have resulted in the documentation of 10 new subpopulations (one in Ontario and nine in Quebec). These new subpopulations have greatly expanded the extent of occurrence (EOO) in Canada from 2473 km² (as reported in COSEWIC 2010) to 105,000 km² (as of 2021) and the index of area of occupancy (IAO) from 44 km² to a minimum of 240 km². Records on the United States side of the Rainy River and adjacent to northwestern Ontario were reported in the 2010 status report but were not confirmed in subsequent surveys and are not treated as a Canadian subpopulation in this updated status report. The four subpopulations apparently extirpated prior to 2010 (i.e., from the Ottawa River [Ontario/Quebec], Yamaska River [Quebec], Shubenacadie River [Nova Scotia], and Mount Uniacke [Nova Scotia]) have not been confirmed. Where data are available for extant subpopulations, low-level threats to Skillet Clubtail continue.



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 (2022)

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

Skillet Clubtail *Gomphurus ventricosus*

in Canada

2022

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Table 4. Summary of potential threats for Skillet Clubtail (*Gomphurus ventricosus*) at extant subpopulations (Table 1; Figures 2–4). An “x” indicates that a threat applies to the subpopulation. The severity of the threat at most subpopulations is variable or unknown. 28

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

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: *Gomphurus* Needham 1901
Species: *ventricosus* (Walsh 1863)

Skillet Clubtail (*Gomphurus ventricosus*) is a dragonfly in the clubtail family (Gomphidae). The species was first described in Walsh (1863) as *Gomphus ventricosus*. The genus *Gomphurus* was described by Needham in 1901. Molecular phylogenetic analysis supports splitting *Gomphus* into multiple genera including *Gomphurus* (Ware *et al.* 2017). Most *Gomphus*, including Skillet Clubtail, is now generally accepted in the genus *Gomphurus* (Paulson and Dunkle 2021)¹ and *Gomphus* as presently known is restricted to Eurasia. Skillet Clubtail is distinct and there are no proposed subspecies.

Synonyms: *Gomphus ventricosus* Walsh

English Name: Skillet Clubtail. The English name Skillet Clubtail was assigned in Paulson and Dunkle (1996) and is in the most recent Canadian list (Catling *et al.* 2005). The name “Skillet Clubtail” refers to the slender abdomen of the adult dragonfly having a broad, circular flare at the end and resembling a skillet.

French Name: Gomphe ventru (Pilon and Lagacé 1998).

Type locality: Rock Island County, Illinois.

¹ Since the last COSEWIC (2010) status report, the genus name describing Skillet Clubtail has changed from *Gomphus* to *Gomphurus* (Paulson and Dunkle 2021).

Morphological Description

Skillet Clubtail has three distinct life stages; egg, larva (nymph) and adult.

Adults

Skillet Clubtail adults are 45-48 mm long and have a strikingly widened club at the end of the abdomen (Walker 1958). Males have green to turquoise eyes, an unmarked face, and a body that is dark brown to black with a yellow stripe along the top of the abdomen and yellowish green thorax (Jones *et al.* 2008; Paulson 2011). The sides of the club have large yellow spots. Females resemble the males but have a thicker abdomen and reduced club.

Larvae (nymphs)

Skillet Clubtail larvae (also called nymphs) are elongate, compressed, and difficult to identify from other *Gomphurus* and species of the subgenus *Hylogomphus*. Species can only be distinguished by close examination of the mouth parts and abdominal spines (Savard and Charest 2014; Tennessen 2019). Identification of exuviae (cast larval skins) also requires close examination of the mouthparts and hooks on the sides of the thorax.

Eggs

Skillet Clubtail eggs are undescribed.

Dragonfly species that appear similar to and are within the Canadian range of Skillet Clubtail include Cobra Clubtail (*G. vastus*) and Midland Clubtail (*G. fraternus*). Both species have a similar adult body structure but have an abdomen with a narrower club and smaller spots. The larvae of Skillet Clubtail are different from Cobra Clubtail by the absence of a substantial end hook on the labial palp, and from Midland Clubtail by the straight median lobe of the prementum.

Population Spatial Structure and Variability

The spatial structure and variability of Skillet Clubtail subpopulations have not been studied in Canada or the United States. The Barcode of Life Data System (BOLD) is an online genetics data storage and analysis platform developed at the Centre for Biodiversity Genomics in Canada (see Ratnasingham and Hebert 2007). DNA barcodes are available for 39 Skillet Clubtail specimens in BOLD, all of which are from New Brunswick. The samples constitute one Barcode Index Number (BIN). The specimens collected in New Brunswick do not reveal subpopulation differences, and it is not possible to use these data to establish spatial structure or variability between other subpopulations.

Designatable Units

Skillet Clubtail has one designatable unit within Canada. No subspecies are recognized. The species occurs in both the Atlantic and Great Lakes Plains National Ecological areas (COSEWIC 2011); however, there is no information on genetic structure or data on discreteness or evolutionary significance between subpopulations from these two areas.

Special Significance

Skillet Clubtail is a rare species and therefore of interest to conservation biologists and amateur naturalists. No publicly available Aboriginal Traditional Knowledge (ATK) is identified for Skillet Clubtail (COSEWIC ATK Subcommittee pers. comm. 2021). However, this species is part of Canadian ecosystems that are important to Indigenous people, who recognize the interconnectedness of all species within the ecosystem.

DISTRIBUTION

Global Range

The global range of Skillet Clubtail extends from New Brunswick, through southern Quebec and southern Ontario, west to Minnesota and south to Tennessee and North Carolina (Figure 1). The global range covers about 2,561,000 km², of which 105,000 km² or 4% is in Canada.



Figure 1. Male Skillet Clubtail (*Gomphurus ventricosus*) at Fredericton New Brunswick, July 16, 2015. Photo by Danny O'Shea.

Canadian Range

The Canadian range of Skillet Clubtail extends from the Saugeen River in southwestern Ontario east to southern Quebec and New Brunswick, with historical records in Nova Scotia (Figure 2). The species occurs in 13 extant² and four historical³ subpopulations⁴ (see Table 1⁵).

Table 1. Skillet Clubtail (*Gomphurus ventricosus*) subpopulations in Canada (see Figures 2–3). The subpopulations are numbered 1-13. The letters (a, b, c) represent sites within dispersal distance where the species was observed within a subpopulation.

Sub-population Number	Subpopulation Name	Site Name	Most Recent Record	Notes	Reference/Collection	Status
1	Saugeen River, ON	Paisley	2012	1 adult	Evans pers. comm. 2020	Extant
2a	Batiscan River, QC	Saint-Adelphe	2021	Adults and exuviae, observed annually from 2011 to 2020; a maximum of 118 collected in a single year.	Savard pers. comm. 2021	Extant
2b	Batiscan River, QC	Saint-Stanislas	2020	Saint-Stanislas. 1 teneral found June 13, 2020, 15 km downstream from Saint-Adelphe.	Savard pers. comm. 2021	
2c	Batiscan River, QC	Sainte-Geneviève-de-Batiscan	2021	4 exuviae collected June 27, 2020, 22 km downstream from Saint-Stanislas	Savard pers. comm. 2021	
3	Godefroy River, QC	Bécancour	2019	1 adult male June 6, 2016, and 1 adult male June 12, 2019, in woodland near the confluence of Godefroy and Saint-Laurent rivers.	Savard pers. comm. 2021	Extant

² An extant subpopulation refers to some evidence of presence of single or multiple specimens ideally with evidence of on-site breeding (teneral adults, mating pairs, territorial males, ovipositing females, larvae, or exuviae) at a given site with potential breeding habitat. Evidence is derived from reliable published observation or collection data; unpublished, though documented (i.e., government or agency reports, web sites) observation or collection data; or museum specimen information. The record has been documented within the last 20 years or there is no reason to suspect the species has been extirpated from the site (e.g., the habitat is still intact, no threats) (definition edited from NatureServe 2022).

³ A subpopulation that is known from only historical records but still some hope of rediscovery. There is evidence that the dragonfly may no longer be present in the jurisdiction, but not enough to state this with certainty. Examples of such evidence include (1) that a species has not been documented in approximately 20-40 years despite some searching and/or some evidence of significant habitat loss or degradation; (2) that a species has been searched for unsuccessfully, but not thoroughly enough to presume that it is no longer present in the jurisdiction (definition edited from NatureServe 2022).

⁴ Subpopulations are defined as geographically or otherwise distinct groups in the population between which there is little demographic or genetic exchange (typically one successful migrant individual or gamete per year or less) (IUCN 2001). Some Canadian subpopulations consist of multiple observations along the same riverway. Although in some cases records are separated by over 10 km, these are treated as a single subpopulation on the assumption that there is regular genetic exchange along the river by larval drift and dispersing adults.

⁵ Throughout the text in this document, subpopulation numbers are denoted by the # symbol (i.e., #1-17).

Sub-population Number	Subpopulation Name	Site Name	Most Recent Record	Notes	Reference/ Collection	Status
4a	Saint-François River, QC	Sherbrooke	2005	2 adult females at a wooded hill near the confluence of Magog and Saint-François rivers.	Savard pers. comm. 2021	Extant
4b	Saint-François River, QC	Melbourne	2020	1 exuvia collected near the mouth of the Saumon river, 34 km downstream from Sherbrooke.	Savard pers. comm. 2021	
4c	Saint-François River, QC	Lennoxville	2021	1 exuvia	Savard pers. comm. 2021	
5a	Chaudière River, QC	Saint-George de Beauce	2015	2 adult males in a maple grove > 500 m from the Chaudière River.	Savard pers. comm. 2021	Extant
5b	Chaudière River, QC	Beauceville	2021	2 exuviae	Savard pers. comm. 2021	
5c	Chaudière River, QC	Rivière-du-Loup, Sainte-George	2021	2 adults. In Rivière-du-Loup at junction with Chaudière R. and treated as part of subpopulation 5.	Savard pers. comm. 2021	Extant
6	Chicot River, QC	Saint-Cuthbert	1984	1 adult female, 1 adult male collected at Saint-Cuthbert, presumably in the Chicot River; two specimens at Insectarium de Montréal; identification verified by Savard (2019).	St-Germain 2020; Savard pers. comm. 2021	Extant
7	Bécancour River, QC	Bécancour	2021	6 exuviae, 1 adult female	Savard pers. comm. 2021	Extant
8a	Nicolet River, QC	Victoriaville	2021	5 exuviae	Savard pers. comm. 2021	Extant
8b	Nicolet River, QC	Nicolet	2021	1 adult male	Savard pers. comm. 2021	
9	Nicolet-Sud-Ouest River, QC	Danville	2021	2 exuviae	Savard pers. comm. 2021	Extant
10	Sainte-Anne River, QC	Sainte-Anne-de-la-Pérade	2021	1 exuvia	Savard pers. comm. 2021	Extant
11a	Saint John R, NB	Fredericton, Princess Margaret Bridge	2021	Many exuviae and adults	COSEWIC 2010	Extant
11b	Saint John R, NB	Upper Maugerville	2021	Many exuviae and adults	COSEWIC 2010	Extant
11c	Saint John R, NB	Grand Lake Meadows	2021	Many exuviae and adults	COSEWIC 2010	Extant
11d	Saint John R, NB	Jemseg	2015	Contiguous with Saint John River location. Exuviae	COSEWIC 2010; O'Malley <i>et al.</i> 2021	
12	Salmon River, NB	Salmon	2021	2 adults	COSEWIC 2010	Extant

Sub-population Number	Subpopulation Name	Site Name	Most Recent Record	Notes	Reference/Collection	Status
13	Canaan River, NB	Canaan	2021	1 adult male	COSEWIC 2010	Extant
14	Ottawa River, ON	Unknown	1924	1 adult	COSEWIC 2010	Historical
15	Yamaska River, QC	Farnham	1940	3 adults collected in a wooded area 1.6 km from the Yamaska River	Savard pers. comm. 2021	Historical
16	Mount Uniacke, NS	Hants County	1948	1 adult	COSEWIC 2010	Historical
17	Shubenacadie River, NS	Enfield	1992	1 exuvia	COSEWIC 2010	Historical

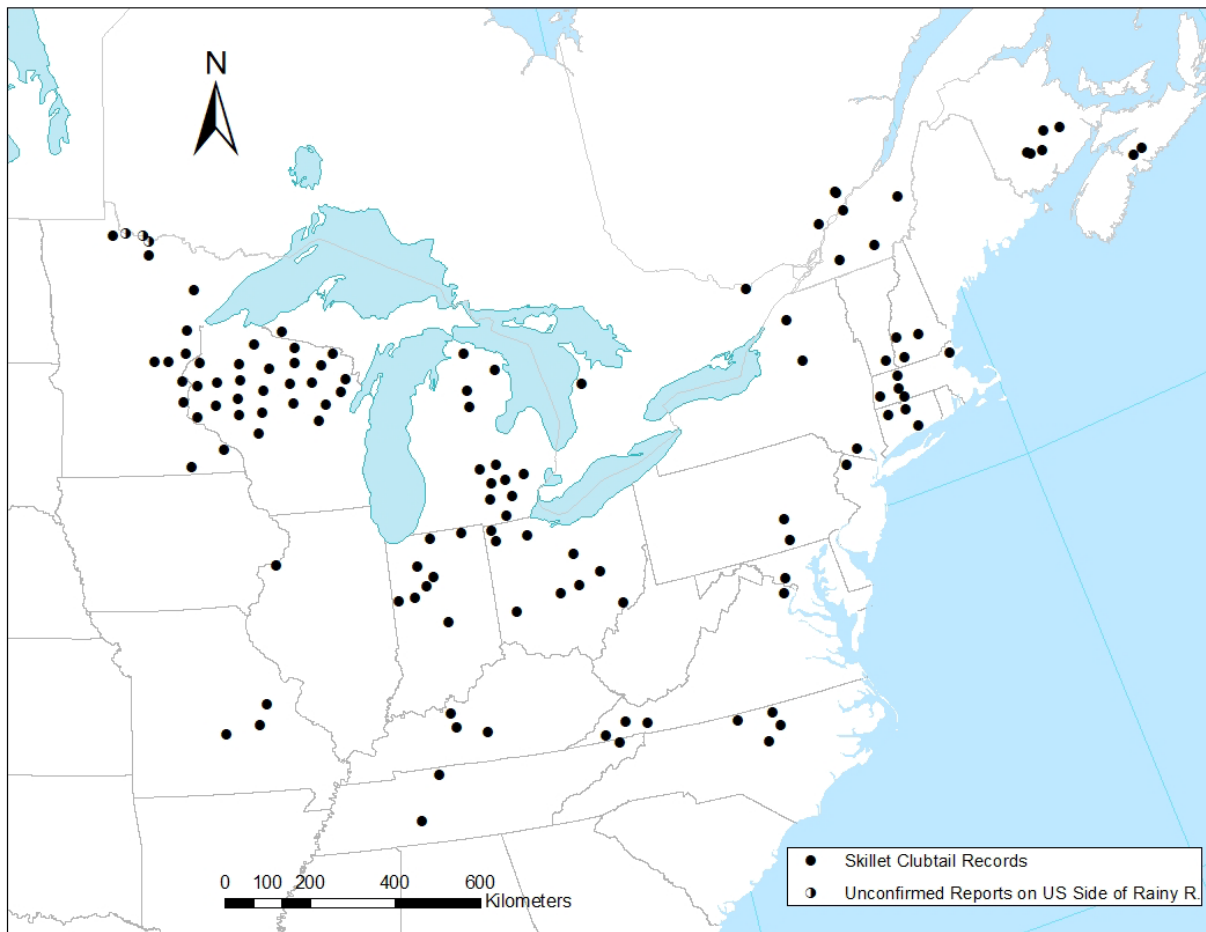


Figure 2. Global range of Skillet Clubtail (*Gomphurus ventricosus*). The black dots indicate all known records of the species in Canada and county records in the United States (data from COSEWIC 2010; Odonata Central 2020). Map prepared by A. Harris.

Ontario range

In Ontario, Skillet Clubtail is known from one extant (#1) and one historical (#14) subpopulation (Table 1 and 2; Figure 3). Skillet Clubtail exuviae were reported on the Minnesota side of the Rainy River adjacent to northwestern Ontario in 1998 (Steffens and Smith 1999) but the species has not been recorded on the Canadian side of the river despite targeted surveys in 2021 (see Search Effort). Some of the exuviae collected in Minnesota were morphologically ambiguous and may be the closely related Midland Clubtail (Steffens and Smith 1999). Rainy River is not treated as a Canadian subpopulation in this status report.

Table 2. Search effort for Skillet Clubtail (*Gomphurus ventricosus*) in Canada.

Province	Sub-population	Region	Year	Total hours	Observations	Surveyors	Reference
ON	-	Rainy River	1998	Unknown	6 exuviae	W. Steffens, W. Smith	Steffens and Smith 1999
ON	-	Rainy River	2010, 2011	19	0	A. Harris, R. Foster	COSEWIC 2012
ON	-	Rainy River	c. 1995-2020	Unknown	0	D. Elder, I. Milne, M. Oldham	Elder pers. comm. 2020; Milne pers. comm. 2020; Oldham pers. comm. 2020; Oldham and Elder 2000
ON	-	Rainy River	2021	18.5	0	A. Harris, B. Ratcliff	Conducted during preparation of this status report
ON	-	Namakan River	2009	8 dates	0	J. Van den Broeck, C.D. Jones	Van den Broeck and Jones 2009
ON	1	Saugeen River	2012	Incidental	1 adult	C. Evans, A. Mills, I. Cook, V. Martin	Evans pers. comm 2020
ON	1	Saugeen River	2019	7.5	0	N. Miller, K. Burrell, M. Burrell, C.D. Jones	Jones pers. comm. 2021
ON	14	Ottawa River	Nine surveys; from c. 2005–2010	700+	0	Various	COSEWIC 2010
QC	15	Yamaska River	c.2010-2018	Unknown	0	A. Mochon	Savard pers. comm. 2021
QC	2a	Batiscan River	2012	Unknown	0	N. Desrosiers, C. Demers	ECCC 2020a
QC	2a	Batiscan River	2013	Unknown	1 teneral	N. Desrosiers, C. Demers	ECCC 2020a
QC	2b	Batiscan River	2020	Unknown	1 teneral	Unknown	Savard pers. comm 2020

Province	Sub-population	Region	Year	Total hours	Observations	Surveyors	Reference
QC	2c	Batiscan River	2021	Unknown	4 exuviae	A. Côté, P. Charest, M. Savard	Savard pers. comm 2020
QC	2a	Batiscan River	2011-2021	Unknown	1 adult, 4 teneral, up to 118 exuviae annually	P. Charest, M. Savard	Savard pers. comm. 2021
QC	3	Godefroy River	2016	Unknown	1 adult	A. Maire	Savard pers. comm. 2021
QC	3	Godefroy River	2017, 2019	Unknown	1 adult	A. Maire	Savard pers. comm. 2021
QC	4a	Saint-François River	2005	Unknown	2 adults	V. Hellebuyck	Insectarium de Montréal Saint-Germain pers. comm. 2020
QC	4b	Saint-François River	2020	Unknown	1 exuvia	A. Mochon	Savard pers. comm. 2020
QC	4c	Saint-François River	2021	Unknown	1 exuvia	A. Mochon	Savard pers. comm. 2020
QC	5a	Chaudière River	2015	Unknown	2 adults	R. Turgeon	Savard pers. comm. 2020
QC	5b	Chaudière River	2021	Unknown	5 exuviae, 1 adult female	P. Charest, A. Côté	Savard pers. comm. 2022
QC	5c	Chaudière River	2021	Unknown	2 adults	F. Brassard, R. Bernard	Savard pers. comm. 2022
QC	6	Chicot River	1984	Unknown	2 adults	V. Hellebuyck	Insectarium de Montréal Saint-Germain pers. comm. 2020
QC	7	Bécancour River	2021	Unknown	5 exuviae, 1 adult female	P. Charest, A. Côté	Savard pers. comm. 2022
QC	8a	Nicolet River	2021	Unknown	5 exuviae	P. Charest, A. Côté	Savard pers. comm. 2022
QC	8b	Nicolet River	2021	Unknown	1 adult male	I. Pothier	Savard pers. comm. 2022
QC	9	Nicolet-Sud-Ouest River	2021	Unknown		I. Pothier	Savard pers. comm. 2022
QC	10	Sainte-Anne River	2021	Unknown	1 exuvia	A. Côté	Savard pers. comm. 2022
NB	11	Saint John River and tributaries (Tobique, Canaan, Meduxnekeag, Jemseg, St-François)	2008, 2014-2016	Unknown	1 exuvia	D. Doucet, P. Brunelle, J. Edsall	ECCC 2020a; O'Malley <i>et al.</i> 2021
NB	11	Saint John River	2014, 2015	153 at 12 sites	169 exuviae	Z. O'Malley, W. Monk	O'Malley and Monk 2016
NB	11	Saint John River	c 2002 to 2010	142	Many	D. Sabine	COSEWIC 2010

Province	Sub-population	Region	Year	Total hours	Observations	Surveyors	Reference
NB	11	Saint John River, Madawaska Co.	2004	11	0	P. Brunelle	COSEWIC 2010
NB	11	Saint John River	2021	Unknown	0	J. Klymko	Klymko pers. comm. 2022
NB	-	Canoose Stream, Saint Croix River	1993-1996	352	0	P. Brunelle	COSEWIC 2010
NB	-	Eel River	2004	85	0	P. Brunelle	Bredin and Brunelle 2004 as cited in COSEWIC 2010
NB	-	Miramichi River and tributaries	2007, 2008	53	0	D. Doucet, P. Brunelle, J. Edsall	COSEWIC 2010
NB	-	Miramichi River and tributaries	2007	Unknown	0	D. Doucet and J. Edsall	Doucet and Edsall 2008 as cited in ECCC 2021
NB	-	Restigouche River	2008	Unknown	0	D. Doucet	ECCC 2021
NB	-	Restigouche River	2011	Unknown	0	J. Klymko and S. Robinson	Klymko and Robinson 2011
NB	-	Magaguadavic River	2008	Unknown	0	D. Doucet	ECCC 2021
NB	12	Salmon River	2021	Unknown	1 or 2 adults	J. Klymko	Klymko pers. comm. 2022
NB	13	Canaan River	2007	Incidental	1 adult	D. Doucet	Doucet and Edsall 2008 as cited in ECCC 2021
NB	13	Canaan River	2016	Unknown	0	J. Klymko and S. Robinson	Klymko pers. comm. 2022
NB	13	Canaan River	2021	Unknown	1 exuvia	J. Klymko and K. St. Laurent	Klymko pers. comm. 2022
NB	13	Canaan River plus 6 other rivers	2016	Unknown	0	J. Klymko and S. Robinson	Klymko and Robinson 2017
NS	17	Shubenacadie River	c 1998 - 2010	40	1 exuvia	P. Brunelle	COSEWIC 2010
NS	17	Shubenacadie River	2012	Unknown hours at 32 sites	0	J. Klymko and S. Robinson	Klymko and Robinson 2013
NS	-	Tusket, Medway, Lahave, Saint Mary's rivers	2010-2011	Unknown	0	J. Klymko and S. Robinson	Klymko and Robinson 2010
NS	-	Annapolis River	2021	Unknown	0	J. Klymko	Klymko pers. comm. 2022

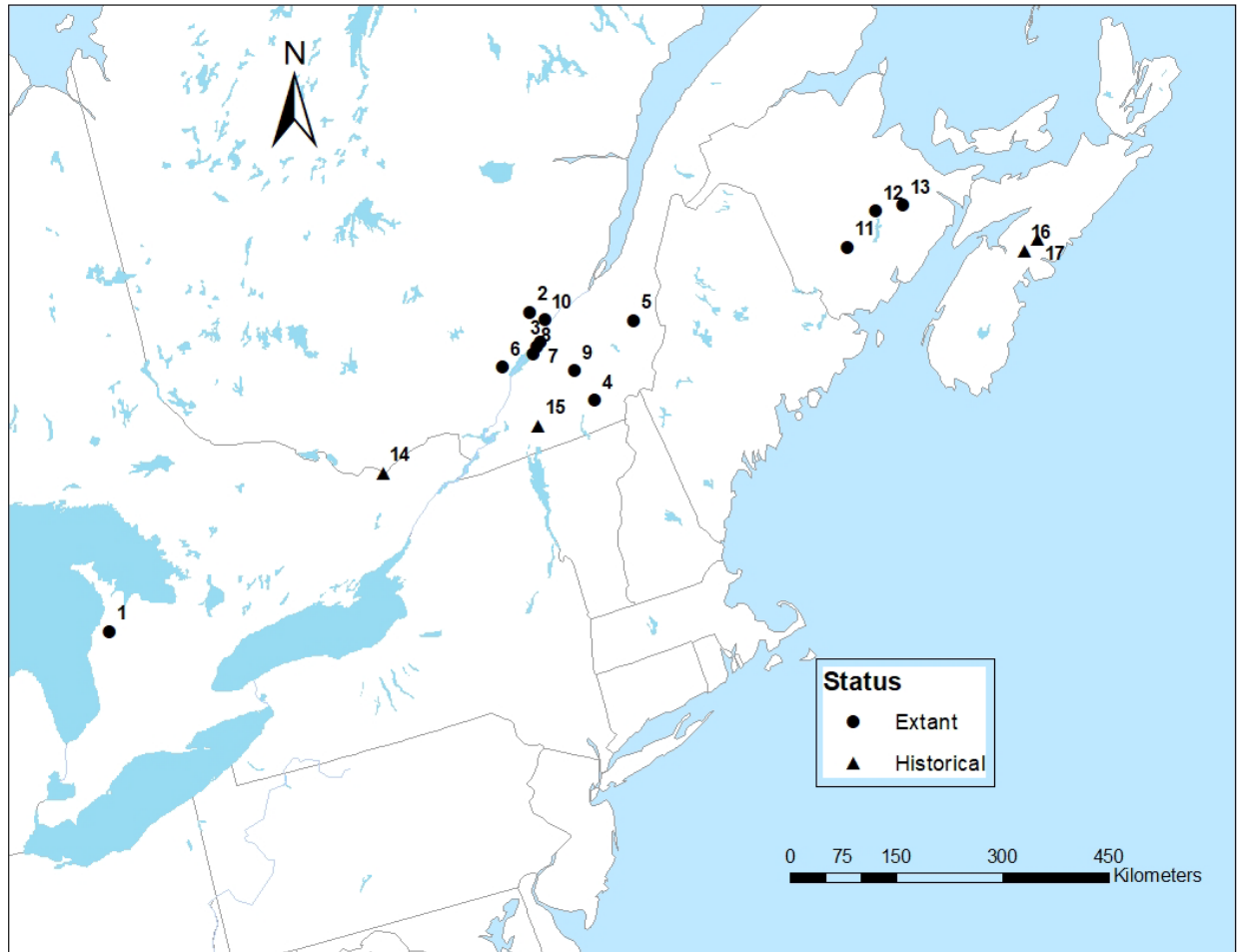


Figure 3. Canadian subpopulations of Skillet Clubtail (*Gomphurus ventricosus*) with records from 1924–2021 (Table 1). Map prepared by A. Harris.

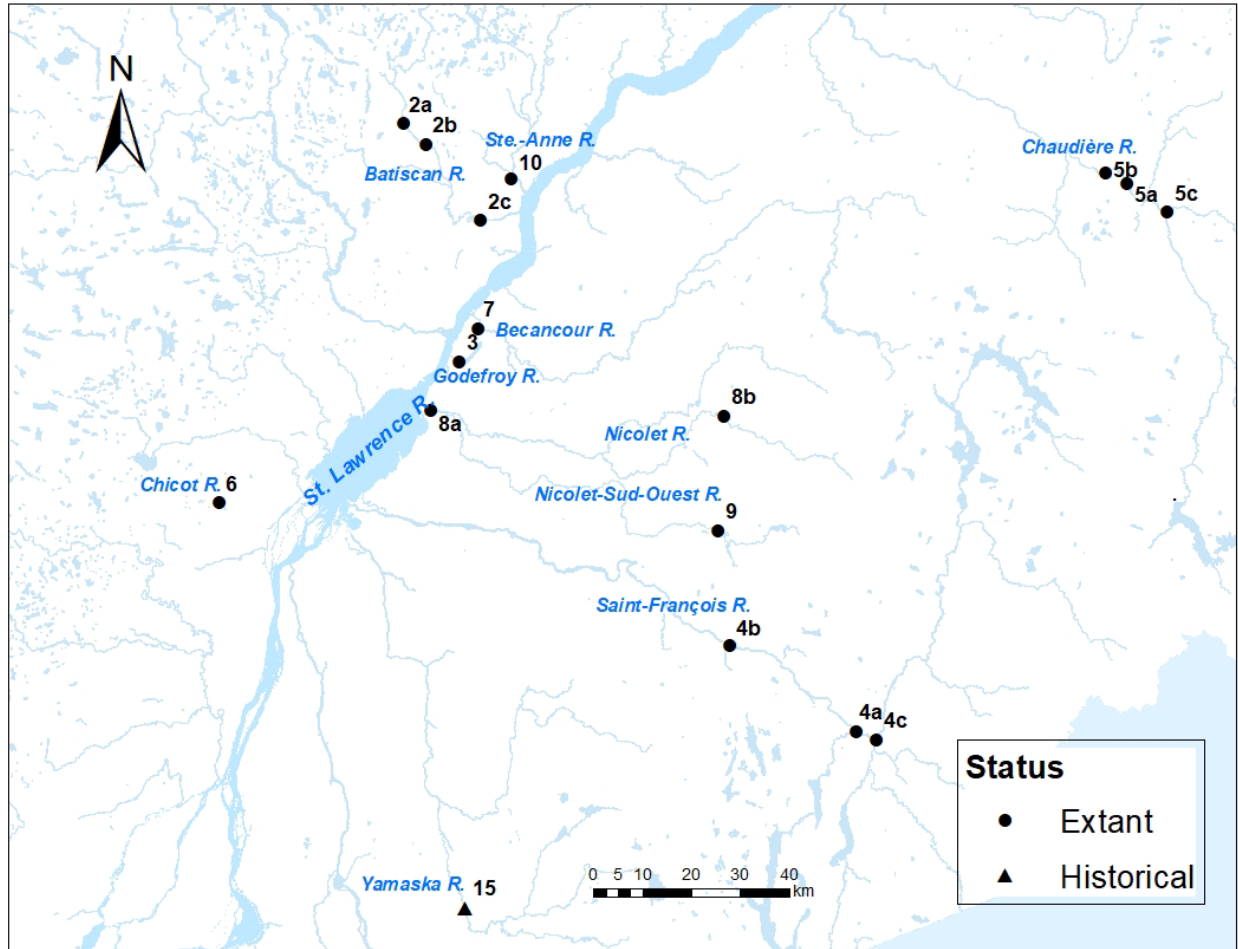


Figure 4. Distribution of Skillet Clubtail (*Gomphurus ventricosus*) in Quebec. The numbers represent subpopulations and the letters (a, b, c) represent places where the species was observed within a subpopulation. Map prepared by A. Harris.

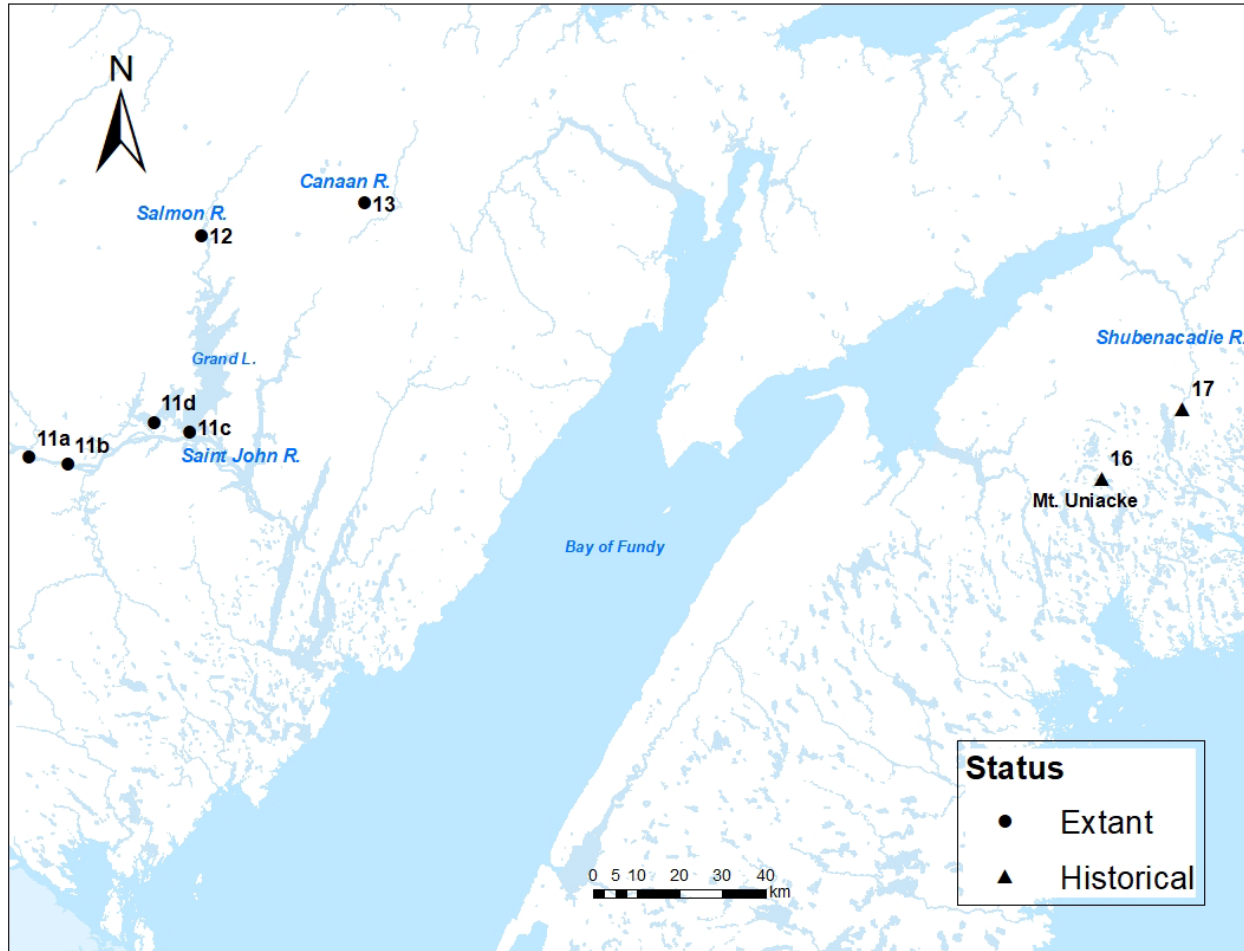


Figure 5. Distribution of Skillet Clubtail (*Gomphurus ventricosus*) in New Brunswick and Nova Scotia. The numbers represent subpopulations and the letters (a, b, c, d) represent places where the species was observed within a subpopulation. Map prepared by A. Harris.

A single adult Skillet Clubtail was documented as an incidental observation at the Saugeen River (#1) in southwestern Ontario in 2012 (Evans pers. comm. 2020). A historical record from “Ottawa” in July 1924 is probably from the Ottawa River (#14), but the species has not been recorded at this locality despite extensive search effort. Historical records from Forest, Ontario and Ignace, Ontario were misidentified and are not included in this report (Jones 2007).

Quebec range

Skillet Clubtail was first recorded from Quebec in 1940, when three males were collected approximately 1 km from the Yamaska River at Farnham (#15) (Robert 1963). Skillet Clubtails were first documented on the Batiscan River (#2) in 2011, on the Chaudière River (#5) in 2015, and the Godefroy River (#3) in 2016 (ECCC 2021). Older Quebec records not documented in COSEWIC (2010) include two 2005 adult specimens from the Sherbrooke area, presumably from the Saint-François River (#4) and an adult specimen

from the Chicot River (#6) at Saint-Cuthbert collected in 1984 (Table 1 and 2). Surveys in 2021 found four previously undocumented subpopulations between Montréal and Quebec City (Savard pers. comm. 2022). Skillet Clubtail has not been reported at the Chicot River since 1984 but no subsequent survey effort has been documented and it is treated as an extant subpopulation.

New Brunswick range

Skillet Clubtail occurs along approximately 50 km of the Saint John River (#11) between the Mactaquac Dam and the confluence of the Jemseg River (COSEWIC 2010). Exuviae collected on the Jemseg River in 2007 and 2015 were within 10 km of the Saint John and are considered part of the Saint John River subpopulation (COSEWIC 2010). Adults were collected on the Canaan River (#13) in 2007 and one exuvia in 2021 (Klymko pers. comm. 2022). Adults were collected at the Salmon River (#12) in 2001 (COSEWIC 2010) and one or two were observed in 2021 (Klymko pers. comm. 2022).

Nova Scotia range

There are two historical records from this province: an adult at Mount Uniacke (#16) Hants County (1948) and an exuvia from the Shubenacadie River (#13) (1992). Both specimens have been lost (COSEWIC 2010). The Mount Uniacke (#16) record is not near any known potential larval habitat (COSEWIC 2010). Surveys at the Shubenacadie River (#17) in 2013 did not record the species (Klymko and Robinson 2013).

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EOO) of Skillet Clubtail in Canada is approximately 105,000 km² as measured by convex polygon encompassing all known extant Canadian subpopulations⁶. This calculation excludes historical subpopulations (#14, 15, 16 and 17) (Table 1).

The index of area of occupancy (IAO) is 240 km² based on a 2 km X 2 km grid, encompassing extant subpopulations. This includes an estimated 40 grid squares (160 km²) on the Saint John River (Klymko pers. comm. 2021). Dragonflies are aquatic for most of their life cycle and select specific biotopes in those aquatic environments; if they are present in a stream, they could be present throughout the same waterway within areas with similar environmental variables. The IAO should encompass both the aquatic and terrestrial life stages and be based on known and projected occurrences to provide an upper plausible bound. The calculated IAO (i.e., 240 km²) is a minimum value and based on adult observations and exuviae collection sites only. The upper limit of the IAO is unknown.

Since the previous COSEWIC (2010) status report, the increase in both the EOO (2473 km² to 105,000 km²) and IAO (44 km² to 240 km²) is a result of additional search effort and confirmation of historical subpopulations in Ontario and Quebec; not a range expansion of Skillet Clubtail.

⁶ Calculated by the report writer using ArcMap.

Search Effort

Skillet Clubtail was first reported in Canada at the Ottawa River (#14) in 1924 with the most recent records in 2020 from the Saint John River (#11) Bécancour River (#7), Nicolet River (#8a and 8b), Nicolet-Sud-Ouest River (#9) and Sainte-Anne River (#10) (Table 1). Targeted surveys and reporting of incidental observations have increased substantially since 2010, particularly in Quebec, New Brunswick, and Nova Scotia. Since 1924, there have been a minimum of 28 sites searched and three to four hundred specimens recorded from across 17 subpopulations.

Dragonfly search methods include searching for and collecting exuviae and net-identify-release of teneral (recently emerged) adults along river shorelines. Adults disperse from the river and are difficult to find except during the brief period when they return to the river to mate and lay eggs. Larvae are rarely found (COSEWIC 2010). Skillet Clubtail has been reported from incidental observations by naturalists (including the most recent subpopulation on the Saugeen River (#1) and as bycatch from surveys targeting other dragonfly species (e.g., Turgeon 2016).

Non-targeted survey data are included in dragonfly atlases in Ontario (Ontario Odonata Atlas Database 2020) and Quebec (Pilon and Lagacé 1998; Savard 2011), and the Atlantic Dragonfly Inventory Program (Brunelle 2010). There are 23 Canadian records of Skillet Clubtail from the Saint John River (#11) area in New Brunswick between 2007 and 2021 on iNaturalist (2021). In Quebec, there are four iNaturalist records from 2016- 2021. There are no Canadian records of Skillet Clubtail in Odonata Central (2020).

The recent documentation of the species at the Saugeen (#1), Batiscan (#2), Chaudière (#5), and Godefroy (#3) rivers suggest that the species may be more widespread than is currently known.

The following is a summary of search effort for Skillet Clubtail in Canada since 2010, including effort prior to 2010 but not documented in the previous COSEWIC (2010) status report (Table 1).

Ontario

Targeted surveys for Skillet Clubtail were completed on the Ontario side of the Rainy River in 2021 (18.5 hours) in support of this status report. Surveys targeting Riverine Clubtail (*Stylurus amnicola*) on the Rainy River collected all dragonfly exuviae encountered in 2010 and 2011; these surveys totalled 19 survey hours (COSEWIC 2012). On the Namakan River (another large river in the region), surveys targeting Pygmy Snaketail (*Ophiogomphus howei*) exuviae and larvae were conducted on eight dates in 2009 (Van den Broeck and Jones 2009). All exuviae collected were identified to species (where possible). Informal dragonfly surveys for adults and exuviae on the Rainy River and other nearby rivers have been conducted since the late 1990s (Elder pers. comm. 2020; Milne pers. comm. 2020; Oldham pers. comm. 2020; Oldham and Elder 2000).

A survey for Skillet Clubtail exuviae on the Saugeen River was completed on June 19, 2019 (7.5 survey hours) (Jones pers. comm. 2021).

As a surrogate measure of null survey effort, the Ontario Odonata Atlas maintains records of dragonflies and damselflies throughout the province. The atlas has a total of 99,208 records of which 26,922 records are since 2010 (Ontario Odonata Atlas Database 2020). The atlas includes 2 records of Skillet Clubtail (Ottawa and Saugeen rivers).

Quebec

Targeted surveys for exuviae near the historical Farnham (#15) site from about 2010 and 2018 did not record Skillet Clubtail (ECCC 2021).

A Skillet Clubtail was recorded on the Batiscan River (#2) in 2011 during inventories for the Quebec odonate atlas (Savard pers. comm. 2021). Subsequent exuviae surveys in 2012-2013 found one teneral in the process of emerging on the bank of the river. Additional surveys for exuviae and adults were conducted on the Batiscan River in 2012-2020 (Savard pers. comm. 2021; ECCC 2021). An adult Skillet Clubtail was documented on the Godefroy River (#3) in 2016 but subsequent exuviae surveys in 2017 were unsuccessful (ECCC 2021). An adult male was found in June 2019 (Savard pers. comm. 2021). Surveys in 2021 found new subpopulations at the Bécancour, Nicolet, Nicolet-Sud-Ouest, and Sainte-Anne rivers as well as new sites at the Chaudière and Saint-François subpopulations (Desrochiers pers. comm. 2022; Savard pers. comm. 2022).

Null survey effort in Quebec is not documented.

New Brunswick

Emergence surveys on the Saint John River (#11) in 2014 and 2015 found 169 exuviae (O'Malley and Monk 2016).

Surveys at the Canaan River (#13) in 2016 did not record Skillet Clubtail (Klymko and Robinson 2017) but in 2021 a Skillet Clubtail exuvia was found (Klymko pers. comm. 2022). Surveys on the Salmon River (#12) in 2021 produced one or two adult records (Klymko 2022). There have also been unsuccessful surveys on the Restigouche River and its tributaries in 2008 (ECCC 2021), the Restigouche River in 2011 (Klymko and Robinson 2011), the New, Lepreau, Magaguadavic, Didgeguash, Petitcodiac, and Oromocto rivers in 2016 (Klymko and Robinson 2017), the Saint John River between St. Francis and Edmundston in 2018, the Tobique River in 2019, and sites on the Saint John River between Grand Falls and Mactaquac headpond in 2021 (Klymko pers. comm. 2021).

Nova Scotia

An exuviae survey targeting Skillet Clubtail was conducted on the Shubenacadie River (#17) in 2012 including the historical site from 1992. No Skillet Clubtails were recorded among 1,275 exuviae collected at 32 sites (Klymko and Robinson 2017). Non-targeted surveys for dragonfly exuviae were conducted on portions of Tusket, Medway, Lahave, and Saint Mary's rivers in 2010-2011 (Klymko 2010; Klymko and Robinson 2011). No new occurrences were found. An adult and exuviae survey on the Annapolis River in 2021 did not find the species (Klymko pers. comm. 2022).

There is no Aboriginal traditional knowledge on search effort or observations for Skillet Clubtail in Canada.

HABITAT

Habitat Requirements

The habitat requirements of Skillet Clubtail are poorly understood. Larval habitat typically consists of slow-running rivers with a mix of silt, cobble, and bedrock substrate (Louton 1983). Most of the rivers that Skillet Clubtail inhabit flow through a combination of forested and agricultural land. In Canada, rivers range in size from the Canaan River (#13) with a mean annual flow of 13 m³/sec (Cassie 2005) to the Ottawa River (#14) with a mean annual flow of 1,948 m³/sec (Thorp *et al.* 2005). Waters range from clear to stained to relatively turbid (White *et al.* 2010). The larvae apparently burrow into fine silt or clay substrate. Upon emergence, they drift downstream to emerge on the banks of pools or climb onto tree trunks (Paulson 2011; O'Malley and Monk 2016). Larvae sometimes inhabit lakes with sand substrate (Dunkle 2000) but have not been found in this habitat in Canada.

Skillet Clubtails apparently spend most of their adult life in forests and open habitats. Adults are rarely observed but most records are within 3 km of the river. Most adults are observed when they return to the river to mate (COSEWIC 2010). The relative importance of forest and other vegetation types is unknown. Oviposition has not been documented for Skillet Clubtail, but based on information from similar species, it probably occurs onto the surface of the water at rapids (Corbett 1999).

Habitat Trends

Historical habitat trends that have degraded Skillet Clubtail habitat in most of its Canadian range include the loss of forest cover, installation of dams, and long-term chronic water pollution. Water pollution trends have been slowed or reversed in some rivers over the past 10 years; however, data are incomplete and reported differently in the different provinces (see Threats).

In southern Ontario, approximately 19% of the Saugeen River (#1) watershed is forested with 30% forest cover in riparian areas (Saugeen Conservation 2019). Forest cover remained stable or increased slightly between 2002 and 2016. Total phosphorus concentrations decreased between 2002 and 2016 (Saugeen Conservation 2019), but overall water quality (Canadian Council of Ministers of the Environment 2017) deteriorated between 2003 and 2018 (ECCC 2020).

In southern Quebec, water quality is generally fair to poor, but stable in the Saint Lawrence River tributaries between Montréal and Quebec City (ECCC 2020). Water quality in tributaries of the Batiscan River (#2) improved between 2003 and 2015 (SAMBBA 2015). Most of the Quebec subpopulation watersheds have predominantly agricultural lands near the Saint Lawrence River and variable amounts of forest cover inland.

Water quality tends to be good to excellent (determined by comparing specific water quality data to water quality guidelines [ECCC 2020]) in Atlantic Canada except in more human populated areas (ECCC 2020). Most of the Saint John River watershed (87%) is forest and wetland but removal of riparian vegetation may have contributed to poor water quality at some sites (New Brunswick Department of Environment 2007a). Water quality has deteriorated at three monitoring stations on the Saint John River between 2004 and 2018 (ECCC 2020). Lands surrounding the Saint John River (#11) subpopulation consists of a large, growing urban and agricultural area where natural vegetation required by adults has declined (COSEWIC 2010).

The Canaan River (#13) watershed remains mostly forest and wetland (93%) but land clearing, removal of riparian vegetation, and erosion of streambanks by livestock has caused locally impaired water quality (New Brunswick Department of Environment 2007b).

BIOLOGY

The biology of Skillet Clubtail is poorly known. Previously unpublished data from New Brunswick surveys were provided by Paul Brunelle in COSEWIC (2010). Where data are lacking, details are based on other *Gomphurus* and related species.

Life Cycle and Reproduction

Skillet Clubtail have three morphological life stages: egg, larva [nymph] and adult. The egg and larval life stages are aquatic, and the adult life stage is terrestrial.

Skillet Clubtail adult flight period extends from late May until August, but on the Saint John River (#11), emergence is synchronous with all individuals emerging over about a week in late June (COSEWIC 2010). After emerging, adults disperse to surrounding forests and fields and spend little time at the river (COSEWIC 2010; Paulson 2011). Adults feed on flying insects. Mating may occur away from the larval habitat (COSEWIC 2010), but males sometimes make short patrols over the river from a perch on the bank, suggesting territorial defence (Dunkle 2000). Females apparently dip the end of the abdomen into the water to

release eggs (COSEWIC 2010) but oviposition behaviour is poorly documented. When eggs hatch, *Gomphurus* larvae burrow into fine sediments in slow to moderately flowing sections of streams (Paulson 2011; Tennessen 2019) where they feed on aquatic invertebrates.

Larvae of other *Gomphurus* species take at least two years to develop to adulthood (Tennessen 2019). When mature and ready to emerge from aquatic (e.g., gill breathing) to terrestrial (e.g., air breathing), larvae drift downstream to pools where the current slows. There they climb onto the riverbank or tree trunks where they emerge within 11 m of the edge of the water (COSEWIC 2010; O'Malley and Monk 2016). The adult life span is unknown but probably about two months based on the flight dates. The life span is unknown but estimated at under 2.5 years.

Physiology and Adaptability

Little is known on the physiology and adaptability of Skillet Clubtail. Unlike some clubtails, larvae are apparently tolerant of turbid waters (White *et al.* 2010).

Dispersal and Migration

There is little information on the dispersal ability or long-range movements of Skillet Clubtail. Adults have been observed at Fredericton, 3 km from the Saint John River (#11) (COSEWIC 2010), suggesting they disperse at least this far from larval habitat. Other dragonflies are known to disperse up to tens of kilometres from larval habitat (Corbett 1999). The separation distance⁷ between subpopulations is set at 10 km, based on information from other similar species (NatureServe 2022). Skillet Clubtail is non-migratory.

It is unknown if the Skillet Clubtail population in Canada is severely fragmented⁸. At least nine of the thirteen extant subpopulations (Table 4) are separated by a distance greater than dragonflies are known to disperse (i.e., their separation distance); however, the viability of these subpopulations is unknown and/or stable (based on its presence at surveys over multiple years) and severity of threats at these subpopulations is unknown.

⁷ Separation distance: Odonate dispersal capability has been poorly documented with long-range movements inferred from observations in transit and analogy with other insects (Conrad *et al.*, 1999; Corbet, 1999). Adults are known to wander, some over great distances. Corbet (1999) estimated the average distance travelled for a commuting flight (between reproductive and roosting or foraging sites) to be less than 200 m but sometimes greater than one km. Distance travelled is generally greatest for river-breeding odonates, but can vary considerably between taxa (Corbet, 1999). Both D. Paulson and S. Valley (personal communication, 1998) suggest a population should be defined by the river drainage in which it is found, but drainages or catchments vary by orders of magnitude in size and isolation, so it is not obvious how to effect this recommendation. The combination of breeding dispersal in the range of a few km with the potential for periodic long distance dispersal providing landscapes are not fragmented has led to the somewhat arbitrary assignment of separation distances at 10 km (unsuitable and suitable habitats) (NatureServe 2022).

⁸ Severely fragmented: A taxon can be considered to be severely fragmented if most (>50%) of its total area of occupancy is in habitat patches that are (1) smaller than would be required to support a viable population, and (2) separated from other habitat patches by a large distance. Fragmentation must be assessed at a scale that is appropriate to biological isolation in the taxon under consideration (IUCN 2010). For complete guidance it is strongly suggested that IUCN (2010) is read.

Interspecific Interactions

Skillet Clubtail larvae are likely eaten by turtles, fish, amphibians, crayfish, birds, and other dragonfly larvae. At the Saint John River (#11), teneral are eaten by birds and caught in spider webs in trees during emergence when unable to fly and larvae are swarmed by ants as they crawl from the water (O'Malley and Monk 2016). Predation by birds on teneral may be proportionally lower than more abundant dragonflies (Sabine pers. comm. 2021). Adults are also likely prey of amphibians (Corbett 1999) and probably the Dragonhunter (*Hagenius brevistylus*), a large dragonfly which feeds predominantly on other Odonata and is common throughout the Canadian range of Skillet Clubtail (COSEWIC 2010).

Twenty-two other Odonate species are recorded with Skillet Clubtail on the Saint John River (#11) at Fredericton (COSEWIC 2010). Of these, Black-shouldered Spinyleg (*Dromogomphus spinosus*), Cobra Clubtail (*Gomphurus vastus*), Boreal Snaketail (*Ophiogomphus colubrinus*), Rusty Snaketail (*O. rupinsulensis*), Zebra Clubtail (*Stylurus scudderi*), and Prince Baskettail (*Epitheca princeps*) mostly closely share habitat requirements and probably compete for food with Skillet Clubtail at least in the larval stage.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

To date, Skillet Clubtail surveys have focused on recording the species' presence at a site and data collection methods have not gathered information to estimate population size or detect population changes in Canada. Given the difficulty in finding larvae and adults, counting exuviae is probably the most efficient method of estimating population size and trends but is limited to a very restricted period in early summer.

Abundance

Data are insufficient to estimate the abundance of Skillet Clubtail in Canada. Hundreds of adults and exuviae have been collected on the Saint John River (#11). A total of 169 Skillet Clubtail exuviae were among 3638 exuviae collected on the lower Saint John River and Grand Lake between 2014 and 2016 (O'Malley 2018). At Batiscan River (#2), 192 Skillet Clubtail exuviae were collected between 2011-2020 with 52 in 2016, 73 in 2017, and 118 in 2020 (Desrosiers pers. comm. 2018; Savard pers. comm. 2021; Charest in prep.). There are no studies that enable dragonfly populations to be derived from exuviae observations.

Fluctuations and Trends

Data are insufficient to estimate population fluctuations and trends of Skillet Clubtail in Canada. Over the past ten years, subpopulations recorded in Ontario and Quebec reflect increased search effort and reporting rather than range expansion.

Rescue Effect

Rescue from the United States is unlikely. Skillet Clubtail is absent from Maine (Maine Damselfly and Dragonfly Survey 2021) making rescue of New Brunswick subpopulations (#11, 12, 13) improbable. Subpopulations in southern Ontario and Quebec are more than 100 km from the nearest known occurrences in New York, New Hampshire, and Vermont where the species is ranked as Critically Imperiled (S1) (NatureServe 2022) and unlikely to serve as a source population.

THREATS AND LIMITING FACTORS

The Skillet Clubtail threat assessment (Table 3) is based on the IUCN-CMP (International Union for Conservation of Nature–Conservation Measures Partnership) unified threats classification system. The IUCN-CMP Threats Classification system is consistent with methods used by COSEWIC, federal agencies, provinces and territories, and it adopts an international standard. For a detailed description, see the Open Standards website (Conservation Measures Partnership 2016a). For information on how the values are assigned, see Salafsky *et al.* (2008), Master *et al.* (2012), and Table 3 footnotes for details.

Table 3. Results for the Skillet Clubtail (*Gomphurus ventricosus*) threats assessment in Canada. The classification is based on the IUCN-CMP (International Union for the Conservation of Nature–Conservation Measures Partnership) unified threats classification system. For a detailed description of the threat classification system, see the CMP web site (CMP 2019). Threats may be observed, inferred, or projected to occur in the near term and are characterized here in terms of scope, severity, and timing. Threat “impact” is calculated from scope and severity. For information on how the values are assigned, see Master *et al.* (2009) and footnotes to this table. The assigned overall threat impact for Skillet Clubtail is *Low*.

Species Name	Skillet Clubtail (<i>Gomphurus ventricosus</i>)		
Date:	March 4 2021; revised May, 2022		
Assessors:	Kristiina Ovaska (Facilitator), Jennifer Heron (Arthropods Specialist Subcommittee [SSC] Co-chair), David McCorquodale (Arthropods SSC Co-chair), Rosana Soares (COSEWIC Secretariat), Allan Harris (report writer, SSC member), John Klymko (SSC), Jeff Ogden (SSC member), John S. Richardson (SSC member), Brian Starzomski (SSC member), Leah Ramsay (SSC member), Robert Buckowski (SSC member), Dawn Marks (SSC member), Jayme Lewthwaite (SSC member), Colin Jones (Ontario COSEWIC member, SSC member), Mary Sabine (New Brunswick COSEWIC member), Ken Tuninga (CWS), Kathy St-Laurent (ECCC), Nathalie Desrosiers (Ministère des Forêts de la Faune et des Parcs du Québec), Michel Savard (Initiative pour un atlas des libellules du Québec, Entomofaune du Québec (EQ) Inc.), Julie Mcknight (ECCC), Marianne Gagnon (CWS-QC). Threats calculator updated following discussion at the May 2022 COSEWIC Wildlife Species Assessment Meeting.		
Overall Threat Impact	Level 1 Threat Impact Counts		
	Threat Impact	high range	low range
	A Very High	0	0
	B High	0	0
	C Medium	0	0
	D Low	4	4
Calculated Overall Threat Impact:	Medium		Medium

Assigned Overall Threat Impact:	Medium Impact.
Impact Adjustment Reasons:	No adjustment.
Overall, Threat Comments	The threats appear to be Low across each subpopulation.

Threat			Impact (calculated) ¹	Scope (Next 10 Years) ²	Severity (10 Years or 3 Generations) ³	Timing ⁴	Comments
1	Residential & commercial development	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	
1.1	Housing & urban areas	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	See Threats and Limiting Factors
1.2	Commercial & industrial areas						Not scored.
1.3	Tourism & recreation areas						Not scored.
2	Agriculture & aquaculture						
2.1	Annual & perennial non-timber crops						Not scored.
2.2	Wood & pulp plantations						Not scored.
2.3	Livestock farming & ranching						Not scored.
2.4	Marine & freshwater aquaculture						Not scored.
3	Energy production & mining						
3.1	Oil & gas drilling						Not scored.
3.2	Mining & quarrying						Not scored.
3.3	Renewable energy						Not scored.
4	Transportation & service corridors	D	Low	Pervasive – Large (31-100%)	Slight (1-10%)	High (Continuing)	
4.1	Roads & railroads	D	Low	Pervasive - Large (31-100%)	Slight (1-10%)	High (Continuing)	See Threats and Limiting Factors
4.2	Utility & service lines						Not scored.
4.3	Shipping lanes						Not scored.
4.4	Flight paths						Not scored.
5	Biological resource use		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						Not scored.
5.2	Gathering terrestrial plants						Not applicable.

Threat			Impact (calculated) ¹	Scope (Next 10 Years) ²	Severity (10 Years or 3 Generations) ³	Timing ⁴	Comments
5.3	Logging & wood harvesting		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Logging occurs in most or all watersheds. Forest harvesting along watercourses with Skillet Clubtail has the potential to affect habitat through loss or alteration of terrestrial adult foraging, mating and resting habitat caused by clearing vegetation. How dependent adults are on tree cover along rivers is unknown. Sedimentation from surface runoff resulting in decline in aquatic habitat quality is also possible. Logging to varying scope and severity occurs within the watersheds of most or all subpopulations but the severity of this threat is probably negligible. All provinces have codes of practice to protect water quality.
5.4	Fishing & harvesting aquatic resources						Not scored.
6	Human intrusions & disturbance	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	See Threats and Limiting Factors.
6.2	War, civil unrest & military exercises						Not scored.
6.3	Work & other activities						Not scored.
7	Natural system modifications		Unknown	Restricted (11-30%)	Unknown	High (continuing)	
7.1	Fire & fire suppression						Not scored.
7.2	Dams & water management/use		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	See Threats and Limiting Factors.
7.3	Other ecosystem modifications						Not scored.
8	Invasive & other problematic species & genes		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
8.1	Invasive non-native/alien species/diseases		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	See Threats and Limiting Factors.
8.2	Problematic native species/diseases						Not scored.
8.3	Introduced genetic material						Not scored.
8.4	Problematic species/diseases of unknown origin						Not scored.
8.5	Viral/prion-induced diseases						Not scored.
8.6	Diseases of unknown cause						Not scored.
9	Pollution	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
9.1	Domestic & urban wastewater		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	See Threats and Limiting Factors.
9.2	Industrial & military effluents		Unknown	Large (31-70%)	Unknown	High (Continuing)	See Threats and Limiting Factors.

Threat			Impact (calculated) ¹	Scope (Next 10 Years) ²	Severity (10 Years or 3 Generations) ³	Timing ⁴	Comments
9.3	Agricultural & forestry effluents	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	See Threats and Limiting Factors
9.4	Garbage & solid waste						Not scored.
9.5	Air-borne pollutants						Not scored.
9.6	Excess energy						Not scored.
10	Geological events						
10.1	Volcanoes						Not scored.
10.2	Earthquakes/tsunamis						Not scored.
10.3	Avalanches/landslides						Not scored.
11	Climate change & severe weather		Not Calculated (outside assessment timeframe)	Small (1-10%)	Extreme (71-100%)	Low (Possibly in the long term, >10 years/3 gen)	
11.1	Habitat shifting & alteration		Not Calculated (outside assessment timeframe)	Small (1-10%)	Extreme (71-100%)	Low (Possibly in the long term, >10 years/3 gen)	<p>Rising sea levels associated with climate change could push saltwater further up the Saint John River (#11) and reduce habitat availability. Similar effects are possible at the Sainte-Geneviève-de-Batiscan (#2c). Musquash Island at the outlet of Washademoak Lake (#11) is presently the upstream extent of saline influence at low seasonal water flows (Gillis 1974). This is roughly 5 km downstream of the farthest downstream occurrence of Skillet Clubtail. Modelling the extent of sea level rise is complex but one analysis projected an increase of 12±3 cm at Saint John relative to 2000 levels by 2025 (Daigle 2009). Continuing sea level rises could conceivably influence habitat as far upstream as the Mactaquac Dam (20 km upstream from Fredericton), encompassing all of the Saint John River subpopulation (Sabine pers. comm. 2021).</p> <p>Warming temperatures associated with climate change could improve conditions for this species at the northern edge of its range by expanding thermal habitat and/or extending the growing season.</p>
11.2	Droughts						Not scored.
11.3	Temperature extremes						Not scored.
11.4	Storms & flooding						There have been some extreme flood events in recent years, but impacts to subpopulations are unknown and these areas are not monitored. Flooding events can lead to further pollution (scored under 9.1).
11.5	Other impacts						Not scored.

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

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

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

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

Table 4. Summary of potential threats for Skillet Clubtail (*Gomphurus ventricosus*) at extant subpopulations (Table 1; Figures 2–4). An “x” indicates that a threat applies to the subpopulation. The severity of the threat at most subpopulations is variable or unknown.

Subpopulation Number and Name	Nearest Subpopulation Number	Distance to Nearest Subpopulation (km)	IUCN-CMP Threat Category (see Table 3 and Threats and Limiting Factors)									
			Housing and Urban Areas	Roads	Logging	Boats	Dams	Invasive Species	Domestic Wastewater	Industrial & military effluents	Agriculture and Forestry Effluents	Habitat shifting & alteration (e.g., Sea Level Rise)
			1.1	4.1	5.3	6.1	7.2	8.1	9.1	9.2	9.3	11.1
1. Saugeen River, Ontario	6	669	x	x	x	?	x	x	x		x	
2. Batiscan River, Quebec	10	10.6		x	x	x	x	x	x		x	
3. Godefroy River, Quebec	7	7.6	x	x	x			x	x		x	
4. Saint-François River, Quebec	9	23.7	x	x	x	x	x	x	x	x	x	
5. Chaudière River, Quebec	8	92.8	x	x	x	?	x	x	x		x	
6. Chicot River, Quebec	8	47.1	x	x	x	?		x	x		x	
7. Bécancour River, Quebec	3	7.6	x	x		?		x	x		x	
8. Nicolet River, Quebec	3	12.1	x	x		?		x	x		x	
9. Nicolet-Sud-Ouest River, Quebec	8	23.6	x	x		?		x	x	x	x	
10. Sainte-Anne River, Quebec	2	10.6	x	x		?	x	x	x			
11. Saint John River, New Brunswick	12	45.8	x	x	x	x	x	x	x	x	x	x
12. Salmon River, New Brunswick	13	38.7		x	x	?			x		x	
13. Canaan River, New Brunswick	12	38.7		x	x	?			x		x	
Total number of subpopulations impacted from the threat			10	13	9	3	6	13	11	3	12	1
Threat Impact			Low	Low	Negligible	Low	Unknown	Unknown	Unknown	Unknown	Low	Unknown

Threats are defined as the proximate activities or processes that have caused, are causing, or may cause in the future the destruction, degradation, and/or impairment of the Skillet Clubtail in Canada. Limiting factors are not considered during this assessment process. For purposes of threat assessment, only present and future threats are considered. Historical threats, indirect or cumulative effects of the threats, or any other relevant information that would help understand the nature of the threats are described in the text below. Threats with a scored impact (e.g., the four Low impact threats) are discussed first, followed by those of Unknown impact.

Threats for Skillet Clubtail were assessed for the entire Canadian Range. The calculated overall threat impact is Low based on input from various regional experts and specialists (see Table 4).

Threat 1. Residential and Commercial Development (Low impact)

1.1 Housing and Urban Areas (Low impact)

Residential development along riparian areas has the potential to damage both terrestrial adult habitat and aquatic larval habitat. These impacts include clearing of vegetation (e.g., loss of adult foraging habitat, water quality degradation, and increased human access to the watercourse). Housing and urban area development refers to the clearing and conversion of land, and impacts the adult (terrestrial) foraging, resting, and mating (territory) habitat. The Saint John River (#11) is subject to development pressure, but most occurred historically with much of the undeveloped land zoned for flood protection and wetland conservation (Sabine pers. comm. 2021). Development pressure is probably relatively low along the Batiscan (#2), Salmon (#12), and Canaan (#13) rivers, but could be more significant along the Saugeen (#1), Chicot (#6), Saint-François (#4), Godefroy (#3) and Chaudière (#5) rivers, depending on the exact location of the egg-laying and larval emergence sites.

The scope of housing and urban areas was scored as Small because housing and urban area development are only a threat for parts of some subpopulations. The severity was Moderate because adult Skillet Clubtails can probably use low density housing and urban areas for foraging. The timing is High (Continuing) because the threat is ongoing.

Threat 4. Transportation and Service Corridors (Low impact)

4.1 Roads and railroads (Low Impact)

Vehicle traffic on riverside roads can cause mortality (roadkill) of adults (Rao and Girish 2007). The risk is greatest at roads where vehicles travel at more than 50 km/hr, which is the speed at which dragonflies are unable to avoid approaching vehicles (COSEWIC 2010). The amount of traffic and the nature of the road are significant. Well constructed roads through woodlands and secondary highways, which allow high speed but have narrow rights of way, seem particularly dangerous for dragonflies (COSEWIC 2010). Larger highways with wide rights of way are much less so (COSEWIC 2010).

Roads near Skillet Clubtail habitat (i.e., parallel to the river at less than 100 m from the shore and/or bridge crossings) are present at all subpopulations (GoogleEarth imagery). Road density is highest along sections of the Saint-François (#4), Batiscan (#2), Godefroy (#3), Chicot (#6), Chaudière (#5), and Saint John (#11) rivers and lowest at Salmon (#12) and Canaan (#13) rivers. The urban area of Fredericton presents a road-kill danger to dispersing adult Skillet Clubtails, although urban areas have a low speed limit (50 km/hour), and the TransCanada Highway (2001) moved most traffic away from the Saint John River. The Princess Margaret Bridge is elevated and may be high enough to minimize mortality (Sabine pers. comm. 2021). Trends in vehicle traffic are unknown.

The impact of road mortality at the population level is unknown but probably slight to negligible. Skillet Clubtail and other gomphids are probably less susceptible to roadkill than other odonates (e.g., darners, emeralds, and baskettails), which are more inclined to feed over roads (Sabine pers. comm. 2021). Roadkill of Skillet Clubtails has not been documented in New Brunswick (Sabine pers. comm. 2021).

Toxic chemical spills are a potential threat, particularly where road and rail corridors are adjacent to the river.

The scope of roads and railroads was scored as Pervasive because roads are present near all subpopulations. The severity was Slight because Skillet Clubtail foraging habits put them at relatively low risk of mortality and the timing is High (Continuing) because the threat is ongoing.

Threat 6. Human Intrusions and Disturbance (Low Impact)

6.1 Recreational activities (Low impact)

Wakes from boats can result in mortality during emergence by washing teneral and larvae into the river (COSEWIC 2010; O'Malley and Monk 2016). The impact of this threat probably varies between subpopulations. Most larval emergence on the Saint John River (#11) was on tree trunks between 0 and 11 m from shore (O'Malley and Monk 2016; O'Malley *et al.* 2020; Sabine pers. comm. 2021) where the impact of boat wakes would presumably be low. In Quebec emergence was observed on the riverbank less than 1 m from the shore where wakes may have a greater effect (Desrosiers pers. comm. 2020). The severity may be greatest when there is heavy boat traffic during a mass emergence.

Boat traffic is greatest at the Saint John River (#11), Batiscan River (#2), and Saint-François River subpopulations and likely a low or negligible threat at other subpopulations. Motorboat wake is a demonstrated threat on the Saint John River at least when larvae are moving from the water to the emergence site (O'Malley and Monk 2016). Because this dragonfly emerges within a short time period, wakes caused by boat traffic could have a substantial impact to a subpopulation. The scope was scored Restricted, severity scored Slight, and the threat is ongoing (High timing).

Threat 9. Pollution (Low Impact)

9.1 Domestic and urban wastewater (Unknown Impact)

Skillet Clubtail may be intolerant of eutrophication caused by increased nutrient input from domestic and urban wastewater and other sources. Eutrophication can degrade habitat by decreasing dissolved oxygen. Increased salinity from de-icing salts in urban runoff is also a threat (Castillo *et al.* 2018). Elevated salinity can impair osmoregulation in freshwater dragonfly larvae and cause death at high salt concentrations (Corbet 1999).

The headwaters of the Batiscan River (#2) watershed are largely forested with few or no sources of wastewater or effluent (SAMBBA 2015). Tributaries downstream of Saint-Adelphe, however, have poor water quality due to drainage from the eutrophic waters from Lake Pierre-Paul and runoff from residential and agricultural lands (SAMBBA 2015). Water quality in these tributaries improved between 2003 and 2015 (SAMBBA 2015).

The Godefroy (#3), Saint-François (#4), Chicot (#6), and Chaudière (#5) rivers flow through largely agricultural landscapes and are probably subject to similar water quality changes as the Batiscan River (#2). The Chicot River (#6) has higher levels of suspended solids, total phosphorus, and nitrites and nitrates than the other rivers (Gouvernement du Québec 2020).

Although water quality has generally improved on the Saint John River (#11) since the 1960s (CRI 2011), discharge from food processing plants, pulp and paper mills, non-municipal and municipal sources, and urban runoff continue to cause locally elevated turbidity and total phosphorus concentrations, and depleted dissolved oxygen (New Brunswick Department of Environment and Local Government 2019). Flooded septic systems caused sewage and other runoff to spill into the Saint John River during a record flood in 2018 (Sabine pers. comm. 2021).

9.2 Industrial and Military Effluents (Unknown Impact)

As described under 9.1, industrial runoff has probably contributed to eutrophication and decreased dissolved oxygen at the Saint John River (#11) subpopulation. There are also two paper mills on the Saint François River (#4) near Sherbrooke and a former asbestos mine less than 1 km from the Nicolet-Sud-Ouest River subpopulation (#9). No large sources of industrial effluent are found near the other subpopulations.

9.3 Agricultural and Forestry Effluents (Low Impact)

All rivers supporting Skillet Clubtail subpopulations have agricultural lands within their watersheds. As is the case with urban runoff (see 9.1), nitrates/nitrites and phosphorus in fertilizers in agricultural runoff have probably contributed to stream eutrophication and decreased dissolved oxygen.

Pesticide use on agricultural lands in these watersheds is not documented but probably includes glyphosate and neonicotinoids. Exposure to glyphosate (and the surfactant used with the herbicide) reduced survival and altered behaviour and physiological processes in odonate larvae (Janssens and Stoks 2017) and reduced invertebrate species richness in aquatic communities (Relyea 2006).

The neonicotinoid insecticide imidacloprid was registered for use in the United States and Canada in 1994 and 1995, respectively (Cox 2001). Approvals for other neonicotinoid insecticides followed. Neonicotinoid pesticides usually are applied in a systemic manner and travel throughout plant tissues, can persist and accumulate in soils and are water soluble and prone to leaching into waterways (Goulson 2013). They are used routinely on golf courses and agricultural lands (Sur and Stork 2003; Jepsen *et al.* 2013), in forestry, and aquaculture as well as in veterinary products (Simon-Delso *et al.* 2015). Currently most application is via a seed coating, but application on foliage also occurs. Neonicotinoid insecticides are widely used on Corn (*Zea mays*) and Soybean (*Glycine max*) crops in Ontario and Quebec (Labrie *et al.* 2020; Ontario Ministry of Agriculture, Food and Rural Affairs 2014). Declines in dragonfly populations have been attributed to agricultural use of neonicotinoids through direct toxic effects or declining prey availability (Nakanishi *et al.* 2018; Van Dijk *et al.* 2013). Sub-lethal impacts of neonicotinoids on invertebrates include altered foraging behaviour, reduced reproduction, and greater susceptibility to pathogens (Goulson 2013, van der Sluijs *et al.* 2013). Health Canada (2021a; 2021b) published new guidelines/restrictions for thiamethoxam and clothianidin (both neonicotinoids) risk to aquatic invertebrates. A study by Schmidt *et al.* (2022) compared experimental (mesocosm) and observational (field) studies and concluded the synergistic effects were consistent, indicating that neonicotinoid mixtures pose greater than expected risks to stream health.

Chemical herbicides are used for forestry in Ontario and New Brunswick. However, these herbicides were banned on provincial forestlands in Quebec in 2001 (Thiffault and Roy 2010). Both provinces restrict application of pesticides near water bodies (Thiffault and Roy 2010; Ogden pers. comm. 2021). Glyphosate is the most frequently used herbicide for forestry in Canada (Rolando *et al.* 2017), the impacts of which are described above. Forest insect pests are typically controlled with *Bacillus thuringiensis* var. *kurstaki* (Btk) (Canadian Forest Service 2020), which has relatively low toxicity to dragonfly larvae (Corbett 1999). Tebufenozide, which acts by inducing premature moulting, is used in New Brunswick to control Spruce Budworm (*Choristoneura fumiferana*) (Ogden pers. comm. 2021). Impacts on dragonflies are unknown.

Threat 7. Natural System Modifications (Unknown Impact)

7.2 Dams and water management/use (Unknown Impact)

Dams affect freshwater ecosystems by altering the natural hydrology of river systems, including changes to flow regimes, water temperatures, sediment transport, and nutrient loads (Nilsson and Berggren 2000; Bednarek *et al.* 2001; Saunders *et al.* 2002). Upstream of dams, the creation of reservoirs can lead to permanent terrestrial and riparian habitat loss (Nilsson and Berggren 2000), and lasting changes to species diversity (Nilsson *et al.*

1997). Reservoirs created from damming activities can also cause changes to water temperatures, resulting in habitat that enables warm water fishes and encouraging further colonization by introduced species (Canadian Rivers Institute 2011). A detailed assessment of the effects of dams and water level regulation on Skillet Clubtail has not been conducted but the species has persisted in the Saint John River below the Mactaquac Dam for many decades (Sabine pers. comm. 2021).

The Saint John River (#11) is actively regulated for power generation and flood control by an upstream dam at Mactaquac (Canadian Rivers Institute 2011) and this has the greatest potential impacts on Skillet Clubtail habitat. Most of the other rivers supporting Skillet Clubtail subpopulations have smaller dams in the watershed intended for wildlife and recreational purposes. These include 21 dams in the Saugeen River (#1) watershed (Saugeen Conservation 2019), 103 dams in the Batiscan River (#2) watershed (SAMBBA 2015), and over 200 dams in the Saint John River Basin (#11) (Canadian Rivers Institute 2011).

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

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

Invasive non-native species have the potential to have direct and indirect effects on Skillet Clubtail, but no effects have been demonstrated in Canada. Introduced fish and crayfish are potential predators on Skillet Clubtail (Corbett 1999).

Introduced species in New Brunswick River systems containing Skillet Clubtail that may be a threat for the species include Muskellunge (*Esox masquinongy*), Chain Pickerel (*Esox niger*), Smallmouth Bass (*Micropterus dolomieu*), Spinycheek Crayfish (*Orconectes limosus*), and Virile Crayfish (*Orconectes virilis*) (McAlpine *et al.* 2007). Smallmouth Bass and Chain Pickerel have been in the lower Saint John River for over 100 years and Muskellunge for over 40 years (Sabine pers. comm. 2021). Largemouth Bass (*Micropterus salmoides*) were recently detected in the Saint John River above Mactaquac Dam (Sabine pers. comm. 2021). The aquatic introduced species in the rivers supporting other Skillet Clubtail subpopulations are unknown. The impacts of these non-native species are unknown but the southern portions of the United States range of Skillet Clubtail largely overlaps with the natural range of many of these fish and crayfish species, suggesting that they can coexist. The long period of coexistence between Skillet Clubtail and introduced fish in the Saint John River suggests that the severity is slight to negligible but the impacts of newer invasives are unknown.

The diatom *Didymo* (*Didymosphenia geminata*) was found in 2006 in the Restigouche and upper Saint John (#11) river systems and several rivers in eastern Quebec (New Brunswick Natural Resources and Energy Development 2009). *Didymo* may be native to eastern Canada, but blooms have occurred recently because of warming climate (Lavery *et al.* 2014). *Didymo* can form dense mats resulting in decreases in mayflies, caddisflies, and stoneflies and increases in chironomids (Gillis and Chalifour 2010). At high densities, *Didymo* mats can restrict invertebrate movement (Gillis and Chalifour 2010).

Invasive aquatic plants such Eurasian Watermilfoil (*Myriophyllum spicatum*) are present in the Saint John River (#11) and possibly other rivers supporting Skillet Clubtails. After invading a waterbody, this plant can grow to a high density, followed by a die-off that can deplete dissolved oxygen (Ontario Ministry of Environment Conservation and Parks 2021), potentially causing mortality or inhibiting growth of larvae.

Limiting Factors

Skillet Clubtail is at the northern limit of its range in Canada and may be vulnerable to increased mortality, lower recruitment, or slower development caused by colder climate than in the United States range. Most Canadian subpopulations are isolated by over 100 km from the nearest United States subpopulations and are inherently vulnerable to extirpation.

Number of Locations

Skillet Clubtail is known from 13 subpopulations in Canada. Each subpopulation represents at least one location⁹ and the threat category, scope, and severity of the threats are different at each of the 13 extant subpopulations. The main threats present at most locations include urban and agricultural wastewater, roadkill of adult dragonflies, and invasive species (Table 4).

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Skillet Clubtail was listed as Endangered on Schedule 1 of the *Species at Risk Act* (SARA) in June 2017. SARA includes prohibitions against the killing, harming, harassing, capturing, taking, possessing, collecting, buying, selling, or trading of individuals. In the case of invertebrates, these protections apply only on federal Crown lands. The Recovery Strategy (ECCC 2021) partially identifies critical habitat (see Habitat Protection and

⁹ 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. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations. Where a taxon is affected by more than one threatening event, location should be defined by considering the most serious plausible threat. Where the most serious plausible threat does not affect all the taxon's distribution, other threats can be used to define and count locations in those areas not affected by the most serious plausible threat.

Ownership) and includes a schedule of studies required to complete the identification of critical habitat.

In New Brunswick, Skillet Clubtail was classified as Endangered under the *Species at Risk Act* in May 2013 (New Brunswick Natural Resources 2020a). In Ontario, it is listed as “Data Deficient” under the *Endangered Species Act* (Ontario Ministry of Environment Conservation and Parks 2020). In Quebec, this species is listed on the *Liste des espèces floristiques et fauniques susceptibles d’être désignées menacées ou vulnérables* (List of plant and wildlife species which are likely to be designated as threatened or vulnerable) under the “*Loi sur les espèces menacées ou vulnérables*” (RLRQ, c. E-12.01) (LEMV) (Act respecting threatened or vulnerable species) (CQLR, c. E-12.01) (Québec 2021).

Non-Legal Status and Ranks

Skillet Clubtail is ranked as G3 (Vulnerable) globally by NatureServe (2022) and N3 (Vulnerable) nationally in the United States (NatureServe 2022). In Canada it is ranked as N2 (Imperiled) by Wild Species 2015 (Canadian Endangered Species Conservation Council 2016). The IUCN Red List of Threatened Species ranks Skillet Clubtail as Least Concern (IUCN 2020).

Skillet Clubtail is ranked as S1 (Critically Imperiled) in Quebec, Nova Scotia, and Ontario, and as S1S2 (Critically Imperiled to Imperiled) in New Brunswick (NatureServe 2022). It has the following ranks in the United States: Connecticut (S2), Indiana (S1S2), Iowa (SNR; not ranked), Kentucky (S1S2), Maryland (SH; historical), Massachusetts (S2), Michigan (SNR), Minnesota (SNR), Missouri (SU; unknown), New Hampshire (S1), New Jersey (SU; unknown), New York (S1), North Carolina (S1S2), Ohio (S2), Pennsylvania (SH), Tennessee (S3), Vermont (S1), Virginia (S1), and Wisconsin (S4; apparently secure).

Skillet Clubtail is not listed on the United States Endangered Species List.

Habitat Protection and Ownership

The federal Recovery Strategy identifies critical habitat for Skillet Clubtail, spatially defined as four sections of the Saint John River (#11) and two sections of the Batiscan River (ECCC 2020). However, there are no federal lands in these areas and no habitat protection is afforded under SARA.

River and stream habitats in Canada receive some protection under the federal *Fisheries Act* where fish habitat is present. Ontario’s *Lakes and Rivers Improvement Act*, Quebec’s *Watercourses Act*, and New Brunswick’s *Clean Water Act* and *Clean Environment Act* offer protection to water quality and volume.

None of the larval habitats of Canadian subpopulations are within parks or other protected areas. Terrestrial habitat surrounding the rivers is mainly privately owned at the Saugeen (#1), Ottawa (#14), Yamaska (#15), Godefroy (#3), Saint-François (#4), Chaudière (#5), Chicot (#6), Saint John (#11) and Shubenacadie (#17) rivers (Energie et

Resources Naturelles Québec 2020; New Brunswick Department of Natural Resources 2020; Nova Scotia Department of Natural Resources 2020; Ontario Ministry of Natural Resources 2020). Parts of the lands surrounding the lower Saint John River are in the Grand Lake Protected Natural Area. The upper reaches of the Batiscan (#2), Salmon (#12), and Canaan (#13) river watersheds are mainly provincial land along with parts of the lower Saint John River (Energie et Ressources Naturelles Québec 2020, New Brunswick Department of Natural Resources 2020b).

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Paul M. Brunelle wrote the first COSEWIC status report.

Front cover photograph of a male Skillet Clubtail (*Gomphurus ventricosus*) at Fredericton, New Brunswick, July 16, 2015. Photograph by Danny O'Shea (with permission).

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Allan Harris is a biologist with over 30 years' experience in northern Ontario. He has a B.Sc. in Wildlife Biology from the University of Guelph and an M.Sc. in Biology from Lakehead University. After spending seven years as a biologist with Ontario Ministry of Natural Resources, he co-founded Northern Bioscience, an ecological consulting company based in Thunder Bay, Ontario. Together with Rob Foster, AI has written or cowritten over twenty COSEWIC status reports including 15 insects, 5 vascular plants, a spider, a land snail, and a bird. He was a member of the Committee on the Status of Species at Risk in Ontario (2009 - 2014) and presently serves on the Arthropod Species Subcommittee of the Committee on the Status of Endangered Wildlife in Canada.

COLLECTIONS EXAMINED

The following collections were examined in preparation for the first (COSEWIC 2010) and updated status report:

- Atlantic Dragonfly Inventory Program (ADIP) Dartmouth, Nova Scotia. Paul Brunelle personal database.
- Canadian National Collection of Insects, Arachnids and Nematodes (CNC), Agriculture and Agri-Food Canada, K.W. Neatby Building, Ottawa, Ontario
- Carleton University, Ottawa, Ontario
- David G. Furth, MRC 165, P.O. Box 37012, Washington, DC, 20013-7012.
- Lyman Entomological Museum, Macdonald Campus, McGill University, Ste-Anne-de-Bellevue, Québec (Stéphanie Boucher, Curator)
- Insectarium de Montréal, Montréal, Québec
- New Brunswick Museum (NBM), Saint John, New Brunswick
- Royal Ontario Museum (ROM), Department of Natural History, Toronto, Ontario
- Smithsonian Institution, National Museum of Natural History (NMNH), Washington, DC