COSEWIC
Assessment and Status Report

on the

Riverine Clubtail
Stylurus amnicola

in Canada

SPECIAL CONCERN
2023

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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A male Riverine Clubtail (*Stylurus amnicola*) from Big East River Provincial Park, July 15, 2020; photo by Peter Mills.

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COSEWIC
Assessment Summary

Assessment Summary – May 2023

Common name
Riverine Clubtail

Scientific name
Stylurus amnicola

Status
Special Concern

Reason for designation
This rare dragonfly is known in Canada from at least 17 subpopulations found on 22 rivers across Manitoba, Ontario, and Quebec. In the last decade, there have been records from several new rivers although the species is cryptic and occurs in low abundance, thus these records do not suggest a range expansion. The species appears to favour rivers with mostly sandy substrates with clear to slightly turbid water. It is vulnerable to the cumulative threats, primarily those that have the potential to impact water quality and riparian habitat, including pollution, loss of forest cover from agricultural, forestry, industrial and residential, development, and transportation.

Occurrence
Manitoba, Ontario, Quebec

Status history
In May 2023, the Boreal, Prairie, and Great Lakes Plains populations were considered as a single unit across the Canadian range and was designated Special Concern.

COSEWIC
Executive Summary

Riverine Clubtail
Stylurus amnicola

Wildlife Species Description and Significance

Riverine Clubtail (*Stylurus amnicola*) is a medium-sized (47–49 mm long), slender, blackish dragonfly, with yellow spots on the abdomen. In males, the abdomen terminates in a prominent club. The front of the thorax has a distinctive T-shaped thoracic collar that distinguishes this species from other clubtails in the genus *Stylurus*. Many odonate species are considered indicators of good water quality. Riverine Clubtail is rare and not well known by the public.

Distribution

Globally, Riverine Clubtail ranges in North America from Manitoba eastward to Quebec in the north, and southward through Minnesota and Vermont to Louisiana and central Georgia. In Canada, Riverine Clubtail ranges from southeastern Manitoba through southwestern Ontario, to southeastern Quebec. In Canada, there are 17 extant subpopulations located on 22 rivers.

In the first COSEWIC status report, Riverine Clubtail was assessed as three separate designatable units (DUs): the Boreal population (Ottawa River and St. Lawrence River valleys of Quebec), the Great Lakes Plains population (central north shore of Lake Erie in Ontario), and the Prairie population (southcentral Manitoba). Since this initial assessment, the species has been recorded at several new sites on rivers in Ontario and Quebec, as well as at additional sites in the United States. These new data occur within areas that show the three DUs are geographically connected and no longer support a three DU structure. Riverine Clubtail is now being assessed as one DU.

Habitat

Riverine Clubtail occurs in riverine habitats ranging in size from the large St. Lawrence River to medium-sized creeks, generally where the riparian canopy does not completely cover the width of the channel. The species is typically found in rivers with predominantly sandy substrates and clear to slightly turbid water; these waters are required for larval development and adult breeding habits (e.g., mate selection and egg laying). After emerging from the water, adults disperse and feed in the forest canopy before returning to find a mate and lay eggs at the water's surface.

Biology

Riverine Clubtail has three distinct morphological forms: egg, larva (nymph), and adult. Female adults lay eggs over fast-flowing, open sections of the river; eggs then drift downstream to hatch in pools and slower-flowing waters. Larvae remain in the water and bury under soft sediments, with only the tip of the abdomen extended into the water column for respiration. Larvae rapidly extend their mouthparts to capture small benthic invertebrates and as larvae get larger, prey items include small fish and tadpoles. Larvae spend 2–4 years in aquatic habitats and when ready to become adults, they crawl onto sandy banks or nearby vegetation, shed their skin through a process called ecdysis and emerge as adults. In Canada, adult emergence begins in late June or early July, and adults fly until early September. Males establish small territories and swiftly patrol small sections of river, often around fast, open water, waiting for females to fly into their territories.

Population Sizes and Trends

Population sizes or trends for Riverine Clubtail in Canada are unknown.

Threats and Limiting Factors

The primary threats to Riverine Clubtail are those that impact water quality and riparian habitat. Several subpopulations in Ontario and Manitoba occur in a landscape dominated by agricultural land use. Although dams continue to alter water levels on the rivers where Riverine Clubtail occurs, the species persists at these sites. Climate change may also be a threat to this species, since more extreme weather events increase the chance of mortality, particularly for emerging larvae and adults. The habitats for subpopulations located in central/northern Ontario and the more northern areas of Quebec are heavily forested, and as a result are likely to maintain good water quality and shoreline habitats. Riverine Clubtail habitat is likely limited by the species' preference for sandy-bottomed rivers with riparian vegetation.

Protection, Status and Ranks

The Great Lakes Plains population (DU) is listed as Endangered under the federal *Species at Risk Act* (SARA) and provincially under Ontario's *Endangered Species Act*. Critical habitat for this population of Riverine Clubtail (as per the federal recovery strategy) includes instream environments and 200 m of surrounding shoreline habitat. Riverine Clubtail is not protected under the *Loi sur les espèces menacées ou vulnérables du Québec (*Act respecting threatened or vulnerable species) or under Manitoba's *Endangered Species and Ecosystems Act*.

The global rank is G4 (Secure), the national rank is N2 (Vulnerable) and the provincial ranks are S1 (Critically Imperiled) in Quebec, S2 (Imperiled) in Ontario, and S3 (Vulnerable) in Manitoba. In the United States, Riverine Clubtail receives protection in several states, where it is considered Endangered (Massachusetts) or Threatened (Connecticut and Indiana); it is tracked in several other states with subnational ranks of SH (Extirpated) to S3S4 (Apparently secure).

TECHNICAL SUMMARY

Stylurus amnicola

Riverine Clubtail

Gomphe riverain

Range of occurrence in Canada: Manitoba, Ontario, Quebec

Demographic Information

Generation time (average age of parents in the population)	2–4 years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations, 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. No. c. No.
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	EOO (clipped to the Canadian border): 753,150 km^2 (records from 2003–2022; older records excluded)
Index of area of occupancy (IAO)(2x2 grid value)	IAO: 224 km^2 (records from 2003–2022; older records excluded)
Is the population “severely fragmented” i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. Unknown

Number of “locations”* (use plausible range to reflect uncertainty if appropriate)	17–22 (17 is considered the minimum, based on the number of known subpopulations; 22 is based on the number of waterways in which the species occurs). The most serious plausible threat is water pollution (Table 5). Locations have been identified as separate based on the watercourse regardless of proximity; water quality threats could vary between sites.
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of “locations”*?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, in habitat quality at some sites
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of “locations”*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	N Mature Individuals
Unknown	Unknown
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]?	Not applicable, insufficient data.

* See Definitions and Abbreviations on COSEWIC website for more information on this term.

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

Was a threats calculator completed for this species? Yes, September 12, 2022. Overall assigned threat impact Medium. Threats that apply include

1.1 Residential & commercial development (Low impact)

9.1 Domestic & urban wastewater (Unknown impact)

9.2 Industrial & military effluents (Unknown impact)

9.3 Agricultural & forestry effluents (Medium-Low impact)

4.4 Roads & railroads (Low impact)

5.3 Logging & wood harvesting (Low impact)

7.2 Dams & water management/use (Unknown impact).

7.3 Other ecosystem modifications (Unknown impact)

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

11.1 Habitat shifting & alteration (Unknown impact)

11.2 Droughts (Unknown impact)

11.4 Storms & flooding (Unknown impact)

What additional limiting factors are relevant?

- Dispersal ability
- Sandy-bottomed riverine habitats for larval development

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Depending on the jurisdiction, possibly Extirpated to Vulnerable (Table 2).
Is immigration known or possible?	Unknown; yes, likely possible
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada?[+]	Yes, at some sites based on decline in water quality
Are conditions for the source (i.e., outside) population deteriorating?[+]	Unknown
Is the Canadian population considered to be a sink?[+]	No
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC Status History: In May 2023, the Boreal, Prairie, and Great Lakes Plains populations were considered as a single unit across the Canadian range and was designated Special Concern.

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

Status and Reasons for Designation:

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

Reasons for designation:

This rare dragonfly is known in Canada from at least 17 subpopulations found on 22 rivers across Manitoba, Ontario, and Quebec. In the last decade, there have been records from several new rivers although the species is cryptic and occurs in low abundance, thus these records do not suggest a range expansion. The species appears to favour rivers with mostly sandy substrates with clear to slightly turbid water. It is vulnerable to the cumulative threats, primarily those that have the potential to impact water quality and riparian habitat, including pollution, loss of forest cover from agricultural, forestry, industrial and residential, development, and transportation.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Insufficient data to reliably infer, project, or suspect population trends.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. IAO likely > 224 km^2 is below the threshold for Endangered but population is not severely fragmented, occurs at >10 locations, and does not experience extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Insufficient data to determine number of mature individuals and/or continuing decline.
Criterion D (Very Small or Restricted Population): Not applicable. Number of mature individuals and vulnerability to rapid and substantial population decline are unknown.
Criterion E (Quantitative Analysis): Not applicable. Insufficient data, analysis not conducted.

Special Concern Criteria

a. Meets b. The species may become Threatened if threats are not efficiently mitigated or managed.
b. Not applicable. Insufficient data
c. Not applicable. Insufficient data
d. Not applicable. Insufficient data

PREFACE

Riverine Clubtail (*Stylurus amnicola*) was assessed as three designatable units (DUs) in the first COSEWIC (2012) status report. The Great Lakes Plains population in Ontario was assessed as Endangered and listed under Schedule 1 of the federal *Species at Risk Act* (SARA) on February 2, 2018. The other two DUs (Boreal and Prairie populations) were assessed as Data Deficient and were not listed under SARA.

Since the first COSEWIC (2012) status report, Riverine Clubtail has been recorded at additional sites in Ontario, Quebec and throughout the United States. These new sites have revealed a range that appears more connected, and a three DU structure is no longer supported. In Ontario, the range has expanded, with additional sites identified throughout central and northern Ontario, on the Aux Sables River (2014), Spanish River (2015), Big East River (2020) and Vermilion River (2022). An additional Carolinian subpopulation was identified in Middlesex County near the Thames River (2022). There are additional sites within Quebec, on the Rivière Rouge (2018), Rivière Jacques-Cartier (2019) and Rivière de l'Aigle (2022) in the southern part of the province, as well as two new sites farther northeast on the Rivière Ashuapmushuan (2014) and Rivière Mistassini (2018) in the Saguenay region. In addition to the new Riverine Clubtail sites, there is no genetic, morphological, or other evidence to support the three DUs proposed in the first COSEWIC (2012) report. Riverine Clubtail is now being assessed as one DU.

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
(2023)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

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

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

COSEWIC Status Report

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Riverine Clubtail

Stylurus amnicola

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2023

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Kingdom: Animalia – animals
Phylum: Arthropoda – arthropods
Class: Insecta – insects
Subclass: Pterygota – winged insects
Order: Odonata – damselflies and dragonflies
Suborder: Anisoptera – dragonflies
Family: Gomphidae – clubtails
Genus: *Stylurus* – hanging clubtails
Species: *Stylurus amnicola* (Walsh 1862)

Synonyms: *Gomphus amnicola* Walsh 1862, *Gomphus abditus* Baker 1914

English common name: Riverine Clubtail
French common name: Gomphe riverain
Indigenous name(s): none known.

Needham (1897) originally described *Stylurus* as a subgenus of *Gomphus*. Although *Stylurus* was subsequently raised to generic level (e.g., Williamson 1932; Needham 1947), Walker (1958) retained it as a subgenus of *Gomphus*. *Stylurus* was elevated to generic rank by Carle (1986) and has been accepted as a full genus in all official lists published since (Catling *et al.* 2005; Paulson and Dunkle 2021).

There are no subspecies of Riverine Clubtail.

Members of the genus *Stylurus* are known as “hanging clubtails” because of their habit of hanging vertically from vegetation.

Morphological Description

Riverine Clubtail has three distinct morphological forms: adult, larva (nymph; numerous moults) and egg. Adult dragonflies (Figures 1–4) are slender with a 47–49 mm body length and 29–33 mm hind wing length (Walker 1958; Needham *et al.* 2014). Females are slightly larger than males, and males have a prominent club at the end of the abdomen. Abdominal segments 8 and 9 have prominent lateral yellow spots in both sexes (Figures 1–3), and the dragonfly’s face is yellowish green with dark lines on the sutures. The eyes are yellowish-brown and grey in newly emerged adults (Figure 4) and turn blue-green as adults mature.

Riverine Clubtail adults can be distinguished from other members of the genus *Stylurus* by the pattern on the front of the thorax (T-shaped collar), the yellow femora on the hind legs, and the small size (Mead 2003; Paulson 2011; Jones *et al.* 2013).

Stylurus larvae are distinguished from other gomphids by the lack of tibial burrowing hooks. Mature Riverine Clubtail larvae are pale brown and are differentiated from other *Stylurus* by their smaller size (2.8–2.9 cm length), evenly tapering abdominal segments towards the tip of the abdomen, hairy legs, and a relatively straight end tooth to the palpal blade (Walker 1958; Tennessen 2019). The egg stage is undescribed.

Figure 1. Riverine Clubtail (*Stylurus amnicola*) male showing the distinctive T-shaped collar on the front of the thorax. Vermilion River, Ontario (Subpopulation #7: Vermilion River), July 26, 2022. Photograph by Desta Frey.

Figure 2. Female Riverine Clubtail (*Stylurus amnicola*) showing pale femurs and yellow spots on the sides of the abdomen. Red River at Winnipeg Manitoba (Subpopulation #1: Manitoba), July 2011. Photograph by Al Harris.

Figure 3. Male Riverine Clubtail (*Stylurus amnicola*). Big Otter Creek, Ontario (Subpopulation #2), July 2008. Photograph by Al Harris.

Figure 4. Teneral Riverine Clubtail (*Stylurus amnicola*). Rivière Petite-Nation, Quebec (Subpopulation #16: Rivière Petite-Nation), July 2011. Photograph by Al Harris.

Population Spatial Structure and Variability

The spatial structure and variability of Riverine 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 not available for specimens of Riverine Clubtail.

Riverine Clubtail is locally common in parts of its range, but sparsely distributed and rare in others (Paulson 2017; Paulson and Dunkle 2021). There is no other data to establish spatial structure or variability between subpopulations.

Designatable Units

COSEWIC recognizes a unit below the level of a recognized taxonomic species as a designatable unit (DU) if it has attributes that make it both "discrete" and "evolutionarily significant." Discrete means that there is currently very little transmission of heritable (cultural or genetic) information from other such units, and evolutionarily significant means that the unit harbours heritable adaptive traits or an evolutionary history not found elsewhere in Canada.

In the first COSEWIC (2012) status report, Riverine Clubtail was assessed as three DUs: the Boreal population (Ottawa River and St. Lawrence River valleys of Quebec [QC]), the Great Lakes Plains population (central north shore of Lake Erie in Ontario [ON]), and the Prairie population (southcentral Manitoba [MB]). There are no subspecies of Riverine Clubtail, and this initial assessment was based on geographic range disjunction (see COSEWIC 2012).

A putative DU may be considered discrete if there is little or no transmission of heritable information between it and other DUs. For example, there is no evidence from genetic markers or heritable morphology, behaviour, life history or phenology, or any other evidence indicating limited transmission of this heritable information across the species. For Riverine Clubtail, there is no evidence of heritable traits or markers that clearly distinguish the three DUs. The current DU structure is not considered discrete using this criterion.

Alternatively, a DU may be considered discrete if there is natural (i.e., not the product of human disturbance) geographic disjunction between DUs such that transmission of information (e.g., individuals) between these "range portions" has been severely limited for an extended time and is not likely to occur in the foreseeable future. "Extended time" is intended to mean that sufficient time has passed that either natural selection or genetic drift are likely to have produced discrete units, given the specific biology of the taxon.

When Riverine Clubtail was first assessed in 2012 (COSEWIC 2012), there were extensive geographic range gaps between observations/subpopulations. Over the past ten years (since 2012), the dragonfly has been recorded at additional sites in ON, QC and throughout the United States, and these new sites have revealed a range that appears to

be more connected. In addition, it is likely that there is genetic exchange between subpopulations. In Ontario, the range has expanded, with additional sites identified throughout central and northern ON, on the Aux Sables River (2014), Spanish River (2015), Big East River (2020), and Vermilion River (2022), and an additional Carolinian subpopulation identified in Middlesex County near the Thames River (2022). There are additional sites within QC on the Rivière Rouge (2018) and Rivière de l'Aigle (2022) in the southern part of the province as well as two new sites further northeast on the Rivière Ashuapmushuan (2014) and Rivière Mistassini (2018) in the Saguenay region.

The subpopulation in MB remains isolated from other Canadian subpopulations and is located approximately 230 km north of observations of this species made in Minnesota. Subpopulations within QC are similarly separated from corresponding observations in Vermont. Given the recent records of this species obtained on rivers in ON, even at sites where previous inventories were completed and did not detect Riverine Clubtail (Bowles and Sõber 2005), it is likely there are additional sites in MB, ON, and QC, as well as nearby in the United States.

Given these new subpopulations, the three DUs described in the first COSEWIC (2012) status report are no longer considered discrete.

If a putative DU is found to be discrete, its significance can be assessed. A DU is considered significant if there is direct evidence or strong inference that the putative DU has been on an independent evolutionary trajectory for an evolutionarily significant period (usually intraspecific phylogenetic divergence indicating origins in separate Pleistocene refugia), or if there is direct evidence or strong inference that can be used to infer that the putative DU possesses adaptive heritable traits that cannot be practically reconstituted if lost. For example, persistence of the discrete, putative DU in an ecological setting where a selective regime is likely to have given rise to DU-wide local adaptations that could not be reconstituted. Because Riverine Clubtail did not meet the criterion for discreteness, significance is not applicable, and the species is being assessed as one DU.

Special Significance

Riverine Clubtail is a rare species and of interest to conservation biologists and amateur naturalists. Adult and larval Odonata are widely used as indicators of water quality and habitat condition in a range of freshwater ecosystems (D'Amico *et al.* 2004; Butler and deMaynadier 2008; Kutcher and Bried 2014). No publicly available Aboriginal Traditional Knowledge (ATK) has been identified for Riverine Clubtail. 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 Riverine Clubtail extends from MB, ON, and QC in the north southward through Minnesota to northern Louisiana and central Georgia (Figure 5). The western extent is from Nebraska south to Louisiana, and the eastern extent from the Connecticut River watershed to the Carolinas and Georgia. The global maximum extent of occurrence is approximately 3.8 million km^2 and has not changed since the first COSEWIC (2012) status report. Approximately 19.8% of the global range occurs in Canada.

Recent surveys have documented the species presence in North Dakota and Tennessee (Abbott 2022). The species is extirpated from Pennsylvania and historical in New York and Maryland (Table 2). Riverine Clubtail has not been recorded from Maine (deMaynadier pers. comm. 2022), New Jersey (Somes pers. comm. 2022) or West Virginia (Olcott 2011).

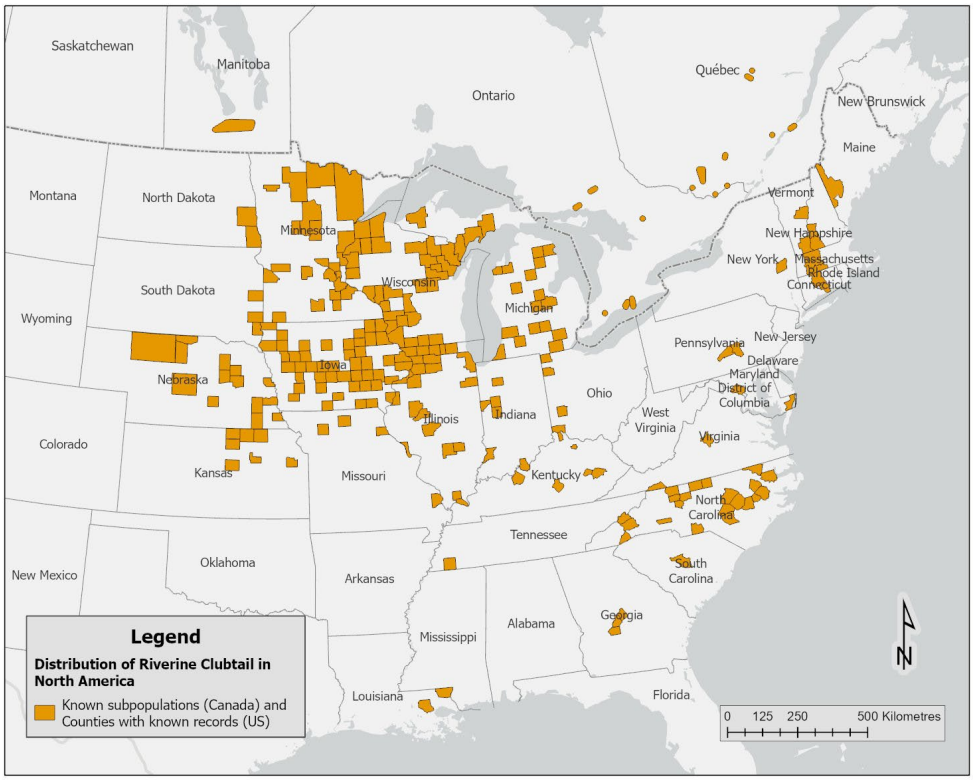

Figure 5. Global range of Riverine Clubtail (*Stylurus amnicola*). The global maximum extent of occurrence is approximately 3.8 million km^2 and has not changed since the first COSEWIC (2012) status report. Approximately 19.8% of the global range occurs in Canada. The occurrence information used to create this map is listed in Collections Examined and Tables 1 and 3, and is from NatureServe (2022).

Canadian Range

The Canadian range of Riverine Clubtail extends from the Assiniboine and Red rivers in MB in the west, to Quebec City on the St. Lawrence River in the east (Figure 6). There are 17 extant[1] subpopulations[2] recorded from 22 waterways in Canada (Figures 6–9; Table 1). The northernmost subpopulation is found in eastern QC near Lac Saint-Jean (#15, #16) and the southernmost is found in Norfolk County on Big Otter Creek and Big Creek (#2, #3). The Canadian range extent is approximately 753,150 km^2.

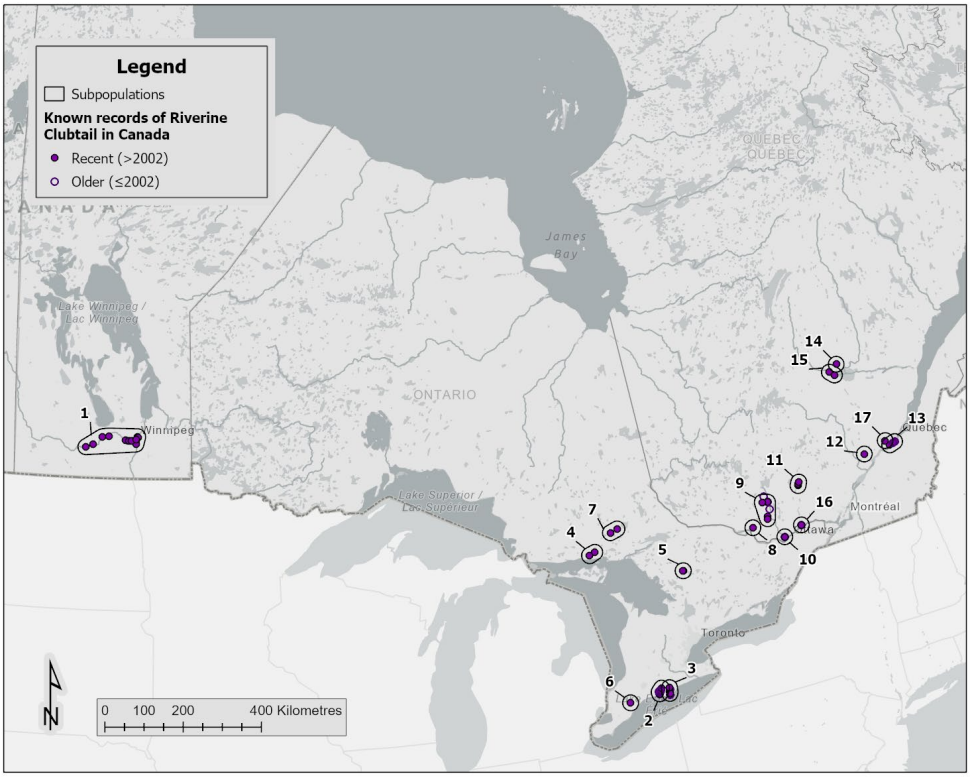

Figure 6. Canadian range of Riverine Clubtail (*Stylurus amnicola*) including all 17 known subpopulations. Map by Alain Filion (COSEWIC Secretariat).

[1] An extant subpopulation refers to some evidence of the presence of single or multiple specimens, ideally with evidence of on-site breeding (e.g., 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, low or no threats) (definition edited from NatureServe 2022).

[2] Subpopulations are defined as geographically or otherwise distinct groups in the population (population refers to all subpopulations) 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. The separation distance is 10 km (i.e., records of individuals greater than 10 km apart are considered separate subpopulations). For some subpopulations, records are separated by over 10 km, yet 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, there is suitable intervening habitat that has not been searched, and there may be unrecorded individuals between known sightings. There are 17 Riverine Clubtail subpopulations in Canada. Throughout this status report, the # symbol followed by 1–17 refers to the subpopulation number.

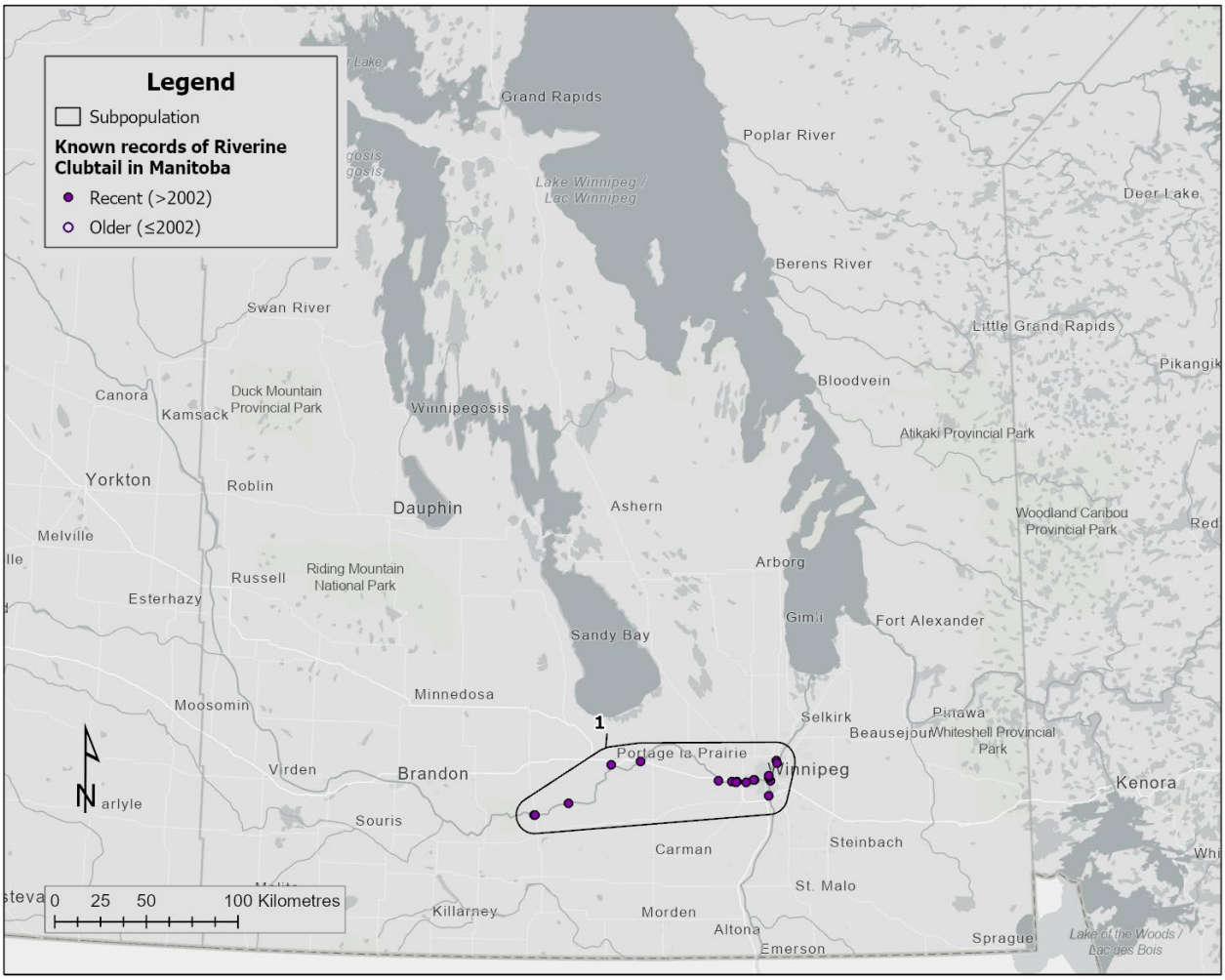

Figure 7. Range of Riverine Clubtail (*Stylurus amnicola*) in Manitoba. Map by Alain Filion (COSEWIC Secretariat).

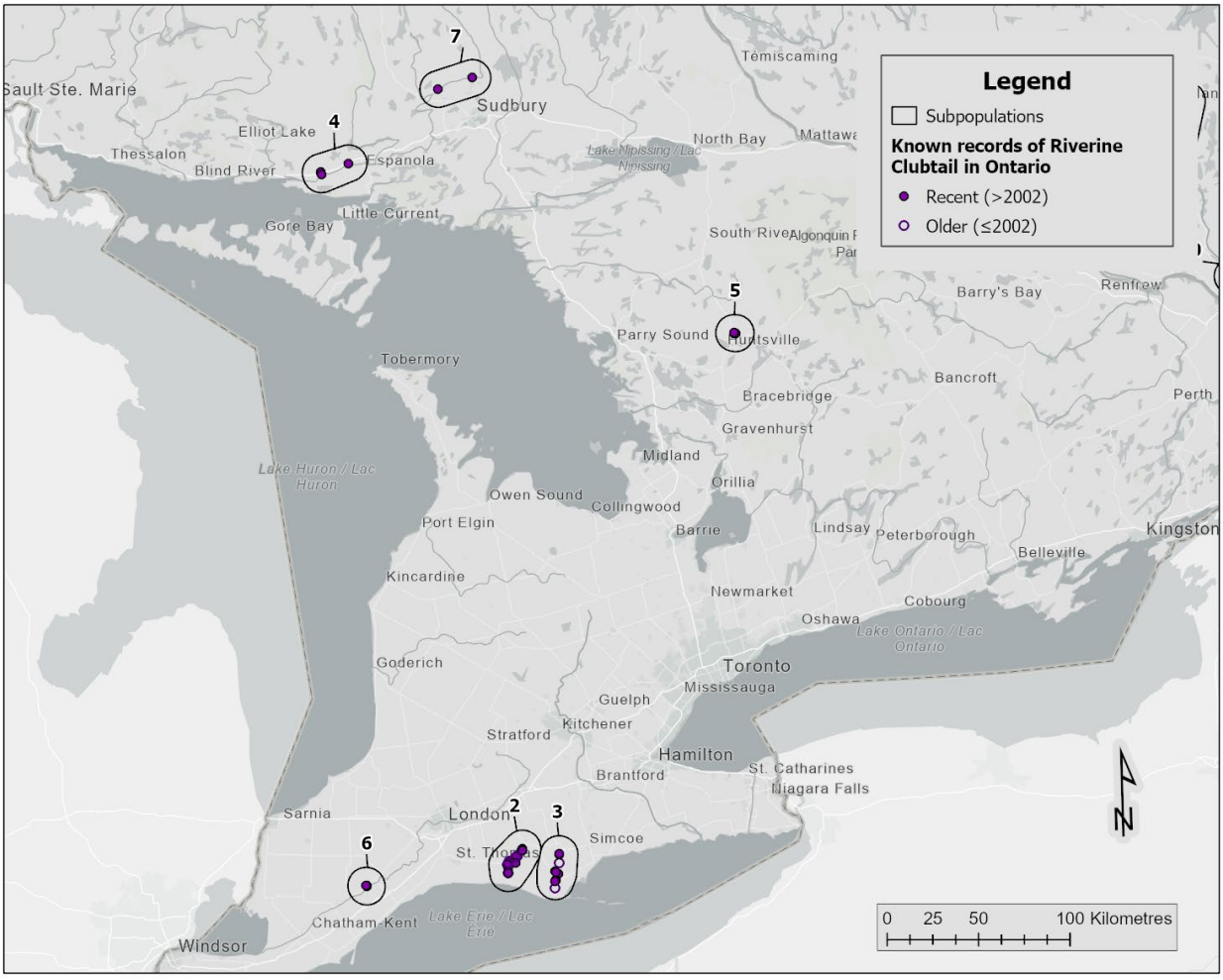

Figure 8. Range of Riverine Clubtail (*Stylurus amnicola*) in southwestern Ontario. Map by Alain Filion (COSEWIC Secretariat).

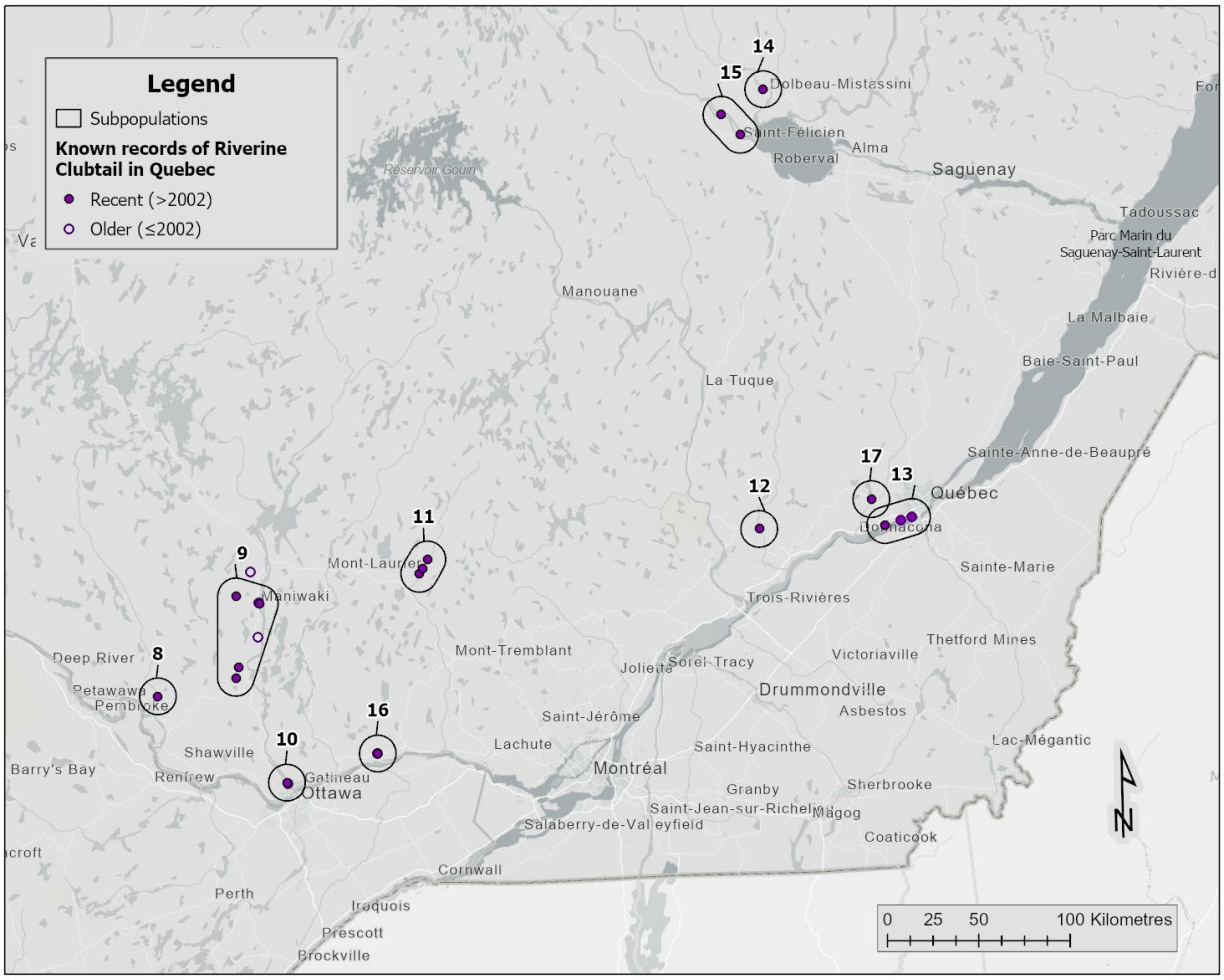

Figure 9. Range of Riverine Clubtail (*Stylurus amnicola*) in southern Quebec. Map by Alain Filion (COSEWIC Secretariat).

Manitoba

In MB, Riverine Clubtail is recorded from three rivers, representing one subpopulation (#1). The species is found on the Assiniboine River west of Winnipeg, and on the Red River and Bunn's Creek within the city limits (Figure 7, Table 1).

Ontario

Riverine Clubtail has been documented on eight rivers in ON, comprising six subpopulations (Figure 8, Table 1). The southernmost records are on Big Otter Creek (#2) and Big Creek (#3) in Norfolk County and Wardsville (#6) in Middlesex County. The species is also recorded at two sites in central Ontario, on the Big East River (#5) and the Aux Sables and Spanish rivers west of Espanola towards Massey (#4). Further north, Riverine Clubtail also occurs on the Vermilion River near Sudbury (#7).

Quebec

Riverine Clubtail occurs on 12 rivers in 10 subpopulations (Figure 9, Table 1). In the south, this includes the Gatineau River (#10), Rivière Coulonge (#8) and Rivière Petite-Nation (#16) near their confluence with the Ottawa River. A cluster of observations are also present further north on the Gatineau River and on associated tributaries, including the Picanoc River, Rivière Désert, and Rivière de l'Aigle (#9). To the east, the species is present on the Rivière Rouge, near L'Ascension (#11). Further east in QC, the species occurs on the St. Lawrence River near Quebec City (#13) and on the Rivière Bastican (#12). The northern extent is along two tributaries to Lac Saint-Jean, including the Rivière Mistassini (#14) and Rivière Ashuapmushuan (#15).

All subpopulations are considered extant, although the Gatineau River subpopulation near Gatineau (#10) may be extirpated (Desrosiers pers. comm. 2022).

See Appendix 3 for additional maps which show the separation distance between subpopulations.

Table 1. Riverine Clubtail (Stylurus amnicola) subpopulations in Canada, years recorded, and most recent search effort. 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 considered as a single subpopulation on the assumption that there is regular genetic exchange along the river through larval drift and dispersing adults. There are 17 extant Riverine Clubtail subpopulations in Canada.

Subpopulation Number	Subpopulation Name	Rationale	Province	Associated River/ Site	Years recorded	Year of most recent search effort and reference
1	Manitoba	All records are hydrologically connected, and records represent a regular continuum.	Manitoba	Assiniboine River, Red River, Bunn's Creek	2004, 2008–2011, 2016–2017, 2019	2019 (Manitoba Dragonfly Survey 2022)
2	Big Otter Creek	Little Otter Creek is a tributary to Big Otter Creek and observations are separated by as little as 2 km, with suitable habitat found between these sites.	Ontario	Big Otter Creek, Little Otter Creek	1999, 2000, 2002, 2007–2008, 2010–2012, 2020, 2022	2022 (iNaturalist 2022)
3	Big Creek	Observations on Big Creek are not hydrologically connected to Big Otter Creek and are separated by nearly 20 km of agricultural land. Regular genetic exchange is unlikely.		Big Creek	2000, 2008, 2011–2013, 2018–2021	2021 (iNaturalist 2022)

Subpopulation Number	Subpopulation Name	Rationale	Province	Associated River/ Site	Years recorded	Year of most recent search effort and reference
4	Aux Sables	Rivers are hydrologically connected, and observations are present in proximity to one another (<1km).		Aux Sables River, Spanish River	2014–2015	2015 (Ontario Odonata Atlas Database 2022)
5	Big East River	Single site separated > 20 km from other known observations.		Big East River	2020–2021	2021 (Mills 2021)
6	Middlesex County	Single site well removed from any known site. The larval source river is likely the Thames River as it is the nearest suitable watercourse to observations of adults.		Wardsville Woods near Thames River	2022	2022 (iNaturalist)
7	Vermilion River	Two observations separated by >20 km on the same river with suitable habitat in between. Some of this habitat is private property and lack of access prevents surveys. It is assumed this is one subpopulation.		Vermilion River	2022	2022 (See Appendix 2).
8	Rivière Coulonge	Single site separated > 20 km from other known observations.	Quebec	Rivière Coulonge	2011	2011 (Harris and Foster 2011)
9	North Gatineau River and Tributaries	All sites are hydrologically connected and represent a continuum of records. Note the only record from the Rivière Désert from 1920; this observation is at the river mouth junction with the Gatineau River where more recent records exist.		Gatineau River (near Maniwaki), Rivière Désert, Rivière Picanoc, Rivière de l'Aigle	1920, 1996, 2011, 2016, 2022	2022 (iNaturalist 2022)
10	Southern Gatineau River	Possibly extirpated. This site is located >100 km downstream from other sites on the Gatineau River and associated tributaries.		Gatineau River (near Gatineau QC)	1920, 1928, 2011	2011 (Harris and Foster 2011)
11	Rivière Rouge	Single site separated > 20 km from other known observations.		Rivière Rouge	2018	2018 (iNaturalist 2022)

Subpopulation Number	Subpopulation Name	Rationale	Province	Associated River/ Site	Years recorded	Year of most recent search effort and reference
12	Rivière Bastican	Single site separated > 20 km from other known observations.		Rivière Bastican	2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021	2022 (Quebec Dragonfly Atlas 2022)
13	St. Lawrence River	Single site separated > 20 km from other known observations.		St. Lawrence River	1997, 1998, 1999, 2000, 2003, 2004, 2015	2022 (iNaturalist 2022)
14	Rivière Mistassini	Separated by approximately 20 km from the nearest known record on the Rivière Ashuapmushuan		Rivière Mistassini	2018, 2020, 2021	2022 (Quebec Dragonfly Atlas 2022)
15	Rivière Ashuapmushuan	Separated by approximately 20 km from the nearest known record on the Rivière Mistassini.		Rivière Ashuapmushuan	2014, 2015, 2016, 2018, 2021, 2022	2022 (Quebec Dragonfly Atlas 2022)
16	Rivière Petite-Nation	Geographically isolated from the closest subpopulations.		Rivière Petite-Nation	1990, 1995, 2011, 2016	2022 (iNaturalist 2022)
17	Jacques-Cartier River	New subpopulation		Jacques-Cartier River	2019	Alain Côté (2019)

Table 2. Subnational conservation status ranks for Riverine Clubtail (Stylurus amnicola). Unless otherwise noted, the global and national (both Canada and United States) status ranks have not been updated since August 16, 2000 (NatureServe 2022).

Jurisdiction	National/Subnational Conservation Status Rank
Global	G4
Canada	N3
United States	N3N4
Quebec	S1 (updated March 2021, Gauthier pers. comm. 2022)
Ontario	S2
Manitoba	S3
Alabama	SNR
Connecticut	S2
Georgia	S1
Illinois	S2
Indiana	S1S2
Iowa	S3
Kansas	SNR
Kentucky	S2
Louisiana	SNR
Maine	SNR
Maryland	SH

Jurisdiction	National/Subnational Conservation Status Rank
Massachusetts	S2
Michigan	S2S3
Minnesota	SNR
Missouri	SNR
Nebraska	SNR
New Hampshire	S2S3
New York	SH
North Carolina	S3
North Dakota	SNR
Ohio	S2
Pennsylvania	SH
South Carolina	SNR
South Dakota	SNR
Tennessee	S2S3
Virginia	S1
Vermont	S1
West Virginia	SNR
Wisconsin	S3S4

Search Effort

Riverine Clubtail was first recorded in Canada on the Gatineau River (#10) near Hull, QC in 1920 (Walker 1928, 1935, 1958). The species was not documented again in Canada until the 1990s, when it was found at three other sites in QC (Pilon and Lagacé 1998). It was recorded in ON in 1999 (Catling *et al.* 1999) and in MB in 2004 (Hughes and Catling 2005), but is presumed to have been established at these sites prior to being observed. The most recent record is from the Vermilion River (#7) in ON in 2022 (Table 3). This species occasionally goes unreported at known sites for several years before surveys once again confirm that it has persisted (Table 3).

Most Canadian records of Riverine Clubtail are of larvae, exuviae, or teneral adults (Tables 3 and 4). Adults are more difficult to detect; they have a short adult lifespan and tend to forage high in the canopy or patrol mid-river (Paulson 2011; Jones *et al.* 2013). Search effort for Riverine Clubtail is primarily visual for exuviae (shed exoskeletons) and resting teneral adults along riverbanks within several hundred metres of bridges or other waterway access points. Exuviae surveys are considered by some to be the most effective survey technique (Vogt pers. comm. 2011). Larvae have been caught emerging on sandy riverbanks and kept until full adult eclosion to confirm identification (Walker 1928; Menard 1996; Harris and Foster 2011). Sieving for larvae through sand and silt substrates along river margins has also been an effective survey technique (Harris and Foster 2011). Although exuviae and larval surveys are more reliable than adult surveys, these survey types are not possible when water levels are high. Due to survey challenges, there are likely additional Riverine Clubtail sites in Canada and elsewhere within the species' range.

Search effort within each province is summarized below (Table 3 and Table 4).

Manitoba

Riverine Clubtail was first recorded in Manitoba in 2004 on the Assiniboine River (#1) and confirmed in 2019 (Table 3). Search effort by dragonfly enthusiasts and naturalists continues to increase in MB, particularly in proximity to urban areas. Over 800 odonate observations have been recorded on iNaturalist in the city of Winnipeg, most of them within the past five years (iNaturalist 2022). Odonatologists continue to monitor the Assiniboine and Red rivers (Dodgson and de March pers. comm. 2022).

There has been little or no targeted search effort for Riverine Clubtail outside of Winnipeg (Table 4). The Assiniboine and Red rivers extend into Saskatchewan and North Dakota respectively, but no targeted surveys have been conducted there. Riverine Clubtail has been observed in several tributaries to the Red River in both Minnesota and North Dakota, including the Red Lake River in Minnesota at a site approximately 220 km south of Winnipeg (Abbott 2022).

Ontario

Riverine Clubtail was first recorded in Ontario on Big Otter Creek (#2) in 1999 and most recently on the Vermilion River (#7) in 2022 (Table 3). The ON Odonata Atlas has a total of 99,208 records, of which 26,922 date to 2010 (Jones pers. comm. 2022). Naturalists and dragonfly enthusiasts have also logged over 110,000 odonate observations on iNaturalist across the province (iNaturalist 2022).

Recent Riverine Clubtail search effort includes both incidental and targeted odonate surveys (Tables 3 and 4). Although several central and northwestern ON rivers have been surveyed, this search effort is considered minimal in comparison with that in southern ON (Table 4). Potentially suitable habitat for Riverine Clubtail in these areas is remote and search effort has not been as thorough there as farther south in the province.

Targeted Riverine Clubtail surveys were carried out during the preparation of this status report, on 19 km of rivers in northern ON in July 2022 (Appendix 2). Habitats were prioritized based on a review of geological characteristics and recommendations from dragonfly specialists (Mills pers. comm. 2022; Jones pers. comm. 2022). A new site was recorded on the Vermilion River (#7) (Table 3, Table 4). The Boland River north of Elliott Lake was also searched but did not yield any observations of this species (Table 4). Surveys were completed 2 to 3 times on the Mississagi River at Iron Bridge although adults evaded capture and confirmation was not possible (Jones pers. comm. 2023).

The recent observations of Riverine Clubtail at new sites on rivers in ON, including remote northern parts of the province and the more human-populated south, suggest the species could occur on additional rivers.

Quebec

Riverine Clubtail was first recorded in QC in 1920 on the Gatineau River (#10) and most recently on the Rivière Ashuapmushuan and Rivière de l'Aigle, in 2022 (Table 3). Search effort in QC for odonates has increased in recent years. Over 23,000 odonate records have been logged across QC on iNaturalist, particularly in southern QC (iNaturalist 2022). Searches for exuviae and adults as part of the QC Dragonfly Atlas have logged new observations and an expansion of the known range for this species (QC Dragonfly Atlas 2022).

Search effort for Riverine Clubtail before 2011 included 29 sites on 15 rivers (Harris and Foster 2011) (Table 3, Table 4). The search effort included a 60 km stretch of the St. Lawrence River between Île d'Orléans and Deschambault (Perron pers. comm. 2012) and the Ottawa River, where 700 hours of search effort for adults and exuviae was completed (mostly on the ON side) (Jones pers. comm. and Catling pers. comm. in COSEWIC 2010b).

Table 3. Riverine Clubtail (*Stylurus amnicola*) records in Canada.

Date (y/m/d)	Subpopulation Number	Site	# Individuals	Source
MANITOBA				
2004/07/01	1	Assiniboine River, southeast of Lavenham	2 exuviae	Hughes and Catling 2005
2004/07/04	1	Assiniboine River at Hwy 34 near Holland	1 exuvia	Hughes and Catling 2005
2004/07/04	1	Red River at Winnipeg (The Forks)	2 exuviae	Hughes and Catling 2005
2004/07/06	1	Assiniboine River at Headingly (bridge)	1 exuvia	Hughes and Catling 2005
2004/07/06	1	Assiniboine River at Headingly (Lido Plage)	1 adult male	Hughes and Catling 2005
2004/07/06	1	Assiniboine River at Highway 34 near Holland	1 exuvia	Hughes and Catling 2005
2004/07/06	1	Assiniboine River at Portage la Prairie (below the dam)	5 exuviae	Hughes and Catling 2005
2004/07/06	1	Assiniboine River east of Portage la Prairie	2 exuviae	Hughes and Catling 2005
2004/07/07	1	Assiniboine River at Winnipeg (Assiniboine Park)	1 exuvia	Hughes and Catling 2005
2004/07/09	1	Assiniboine River at Headingly (Westmore Natural River Park)	1 adult male, 1 adult female, 1 exuvia	Hughes and Catling 2005
2004/07/24	1	Red River at Winnipeg (Maple Grove Park)	1 adult female	Hughes and Catling 2005
2008/07/09	1	Assiniboine River at Winnipeg (Assiniboine Park)	1 adult male	Manitoba Dragonfly Survey 2022
2008/08/01	1	Assiniboine River at Headingly (Westmore Natural River Park)	1 adult male	Manitoba Dragonfly Survey 2022

Date (y/m/d)	Subpopulation Number	Site	# Individuals	Source
2009/06/30	1	Assiniboine River at Headingly	1 adult male	Manitoba Dragonfly Survey 2022
2009/07/05	1	Bunn's Creek in Winnipeg	1 adult female, 1 adult male	Manitoba Dragonfly Survey 2022
2010/06/28	1	Red River at St. Boniface, downstream of Provencher	1 adult female	Manitoba Dragonfly Survey 2022
2010/07/01	1	Bunn's Creek in Winnipeg	1 adult male	Manitoba Dragonfly Survey 2022
2010/07/02	1	Assiniboine River at Winnipeg (Beauchemin Park)	2 adults	Manitoba Dragonfly Survey 2022
2010/07/05	1	Red River at Winnipeg, near Riverview hospital	1 adult female	Manitoba Dragonfly Survey 2022
2010/07/08	1	Assiniboine River at Winnipeg (Beauchemin Park)	1 adult females, 2 adult males	Manitoba Dragonfly Survey 2022
2011/07/07	1	Red River at North Perimeter Park, Winnipeg	1 exuvia	Harris and Foster 2011
2011/07/07	1	Red River Municipal Park on east bank of Red River opposite The Forks Winnipeg MB	3 teneral adults, 3 exuviae	Harris and Foster 2011
2011/07/10	1	Assiniboine River at Winnipeg.	1 adult male, 1 adult female	Abbott 2022
2011/07/12	1	Assiniboine River at Winnipeg (Beauchemin Park)	1 female	Abbott 2022
2011/07/13	1	Assiniboine River at Winnipeg (Beauchemin Park)	1 adult male	Abbott 2022
2016/06/20	1	Assiniboine River residential yard, Headingly County	1 adult male	Abbott 2022
2017/07/06	1	Assiniboine River residential yard, Headingly County	3 adult male, 1 adult female	Abbott 2022
2017/07/25	1	Assiniboine River residential yard, Headingly County	1 female	Abbott 2022
2019/06/24	1	Assiniboine River residential yard, Headingly County	1 female	Abbott 2022
ONTARIO				
1999/07/11	2	Big Otter Creek at Elgin Road 44, west of Eden	25 adults	Catling and Brownell 1999
1999/08/02	2	Big Otter Creek at Elgin Road #38, west of Straffordville	4+ adults	Catling and Brownell 1999
2000/07/01	2	Big Otter Creek at Elgin Road 45	2 teneral adults	Ontario Odonata Atlas Database 2022
2000/07/06	3	Big Creek at north end of Rowan Mills Conservation Area	2 adults	Ontario Odonata Atlas Database 2022
2000/07/17	2	Big Otter Creek at Regional Road 38, north side, east of Richmond	2 adults	Ontario Odonata Atlas Database 2022

Date (y/m/d)	Subpopulation Number	Site	# Individuals	Source
2000/07/31	2	Big Otter Creek at Eden Line (Regional Road 44), north side	5 adults	Ontario Odonata Atlas Database 2022
2000/07/31	2	Big Otter Creek at Regional Road 38, south side, east of Richmond	6 adults	Ontario Odonata Atlas Database 2022
2000/07/31	2	Big Otter Creek at Richmond Road (Regional Road 43), south of Richmond	2 adults	Ontario Odonata Atlas Database 2022
2000/07/31	2	Big Otter Creek, south of Eden Line, approximately 3 km west of Eden (site#1)	5 adults	Ontario Odonata Atlas Database 2022
2000/07/31	2	Big Otter Creek, south of Eden Line, approximately 3 km west of Eden (site#1)	3 adults	Ontario Odonata Atlas Database 2022
2000/07/31	2	Big Otter Creek, south of Eden Line, approximately 3 km west of Eden (site#1)	3 adults	Ontario Odonata Atlas Database 2022
2000/08/07	3	Big Creek at Cty Road 1 (west of Glenshee)	1 adult	Ontario Odonata Atlas Database 2022
2002/07/18	2	Big Otter Creek at Culloden Road	3 adults	Ontario Odonata Atlas Database 2022
2007/08/01	2	Big Otter Creek at Elgin City Road #38	1 adult	Ontario Odonata Atlas Database 2022
2007/08/01	2	Big Otter Creek at Culloden Road	4 adults	Ontario Odonata Atlas Database 2022
2008/07/13	2	Big Otter Creek at Cullonden Road	1 exuvia	Harris and Foster 2009
2008/07/13	2	Big Otter Creek at Eden Line	1 exuvia	Harris and Foster 2009
2008/07/14	3	Big Creek 0.7 km south of Walsingham	1 exuvia	Harris and Foster 2009
2008/07/14	3	Big Creek at Spring Arbour	2 exuvia	Harris and Foster 2009
2008/07/14	3	Big Creek at Spring Arbour	1 exuvia	Harris and Foster 2009
2008/07/14	3	Big Creek between Regional Road 1 and Highway 59	1 exuvia	Harris and Foster 2009
2008/07/14	3	Big Creek at Spring Arbour	1 adult	iNaturalist 2022
2008/07/15	2	Big Otter Creek south of Eden Line	1 adult	iNaturalist 2022
2008/07/15	2	Big Otter Creek near Culloden Road	1 adult	iNaturalist 2022
2008/07/15	2	Big Otter Creek south of Eden Line	2 adults	Harris and Foster 2009
2008/07/31	2	Big Otter Creek south of Eden Line	3 exuviae	Harris and Foster 2009
2010/07/26	2	Big Otter Creek at Little Otter Creek	4 adult males	Ontario Odonata Atlas Database 2022
2010/07/27	2	Big Otter Creek	1 adult male	Ontario Odonata Atlas Database 2022
2010/07/27	2	Big Otter Creek at Little Otter Creek	2 males	Ontario Odonata Atlas Database 2022

Date (y/m/d)	Subpopulation Number	Site	# Individuals	Source
2010/07/27	2	Big Otter Creek	1 male	Ontario Odonata Atlas Database 2022
2010/08/06	2	Big Otter Creek south of Tilsonburg	2 adults	iNaturalist 2022
2010/08/06	2	Big Otter Creek just south of Tillsonburg	1 female	Ontario Odonata Atlas Database 2022
2011/07/20	3	Big Creek at 6th Concession	1 exuvia	EarthTramper Consulting Inc. 2011
2011/07/20	3	Big Creek at Norfolk Country Road 45	1 exuvia	EarthTramper Consulting Inc. 2011
2011/07/20	2	Big Otter Creek at Regional Road 43 (Richmond)	3 exuviae	EarthTramper Consulting Inc. 2011
2011/07/20	2	Big Otter Creek at Regional Road 46 (Culloden Road)	3 exuviae	EarthTramper Consulting Inc. 2011
2011/07/20	2	Big Otter Creek at Regional Road 45 (Calton Line)	2 exuviae	EarthTramper Consulting Inc. 2011
2011/08/01	3	Big Creek, Paddle 4	1 exuvia	EarthTramper Consulting Inc. 2011
2012/07/17	3	Big Creek at Lyndedoch Road	1 adult	iNaturalist 2022
2012/08/01	3	Big Creek at Lynedoch Road	1 adult female, 1 adult male	Ontario Odonata Atlas Database 2022
2012/08/06	3	Big Creek at Lynedoch Road	1 adult	iNaturalist 2022
2012/08/20	2	Big Otter Creek at Regional Road 46 (Culloden Road)	1 adult	Ontario Odonata Atlas Database 2022
2013/08/01	3	Big Creek at Lynedoch Road	1 adult	iNaturalist 2022
2013/08/01	3	Big Creek at Lynedoch Road	1 adult	iNaturalist 2022
2013/08/03	3	Big Creek at Lynedoch Road	1 adult	iNaturalist 2022
2014/08/09	4	Chutes Provincial Park	10 adults	Ontario Odonata Atlas Database 2022
2015/07/30	4	Chutes Provincial Park	4 exuviae	Ontario Odonata Atlas Database 2022
2015/07/30	4	Spanish River at Massey boat launch	2 exuviae	Ontario Odonata Atlas Database 2022
2015/07/31	4	Spanish River at Burns Crossover Road	1 exuvia	Ontario Odonata Atlas Database 2022
2018/07/04	3	Big Creek at Lynedoch Road	1 adult	iNaturalist 2022
2018/08/04	3	Big Creek at Lynedoch Road	1 adult	iNaturalist 2022
2019/08/20	3	Big Creek at Lynedoch Road	1 adult	iNaturalist 2022
2019/08/20	3	Big Creek at Lynedoch Road	1 adult	iNaturalist 2022
2020/07/14	5	Big East River	1 adult male	Ontario Odonata Atlas Database 2022
2020/07/14	5	Big East River	1 adult male	Ontario Odonata Atlas Database 2022
2020/07/14	5	Big East River	1 adult male	Ontario Odonata Atlas Database 2022

Date (y/m/d)	Subpopulation Number	Site	# Individuals	Source
2020/07/15	5	Big East River	1 adult male	iNaturalist 2022
2020/07/15	5	Big East River	1 adult male	Ontario Odonata Atlas Database 2022
2020/07/15	5	Big East River	1 adult male	Ontario Odonata Atlas Database 2022
2020/08/05	3	Big Creek at Lynedoch Road	1 adult	Abbott 2022
2020/08/10	3	Big Creek at Lynedoch Road	1 adult	iNaturalist 2022
2020/08/10	3	Big Creek at Lynedoch Road	1 adult male, 1 adult female	iNaturalist 2022
2020/08/10	3	Big Creek at Lynedoch Road	4 adults	iNaturalist 2022
2020/08/29	3	Big Creek at Lynedoch Road	1 adult	iNaturalist 2022
2020/08/29	3	Big Creek at Lynedoch Road	1 adult	iNaturalist 2022
2020/08/30	2	Big Otter Creek at Culloden Road	1 adult	iNaturalist 2022
2020/09/01	3	Big Creek at Lynedoch Road	4 adults	Abbott 2022
2020/09/06	3	Big Creek at Lynedoch Road	1 adult	iNaturalist 2022
2020/09/06	3	Big Creek at Lynedoch Road	1 adult	iNaturalist 2022
2021/06/15	5	Big East River	1 larva	Mills 2021
2021/07/23	3	Big Creek at Lynedoch Road	1 adult	iNatualist 2022
2021/07/23	3	Big Creek at Lynedoch Road	1 adult	iNaturalist 2022
2021/08/08	3	Big Creek at Lynedoch Road	1 adult	iNaturalist 2022
2021/08/08	3	Big Creek at Lynedoch Road	1 adult	iNaturalist 2022
2021/08/08	3	Big Creek at Lynedoch Road	1 adult	iNaturalist 2022
2021/08/08	3	Big Creek at Lynedoch Road	1 adult	iNaturalist 2022
2021/08/09	5	Big East River	1 adult	Mills 2021
2022/06/24	6	Wardsville Woods, west of Wardsville	1 adult male	iNaturalist 2022
2022/06/24	6	Wardsville Woods, west of Wardsville	1 adult male	iNaturalist 2022
2022/06/24	6	Wardsville Woods, west of Wardsville	1 adult male	iNaturalist 2022
2022/06/25	6	Wardsville Woods, west of Wardsville	1 adult male	iNaturalist 2022
2022/06/25	6	Wardsville Woods, west of Wardsville	1 adult male	iNaturalist 2022
2022/06/27	6	Wardsville Woods, west of Wardsville	1 adult	iNaturalist 2022

Date (y/m/d)	Subpopulation Number	Site	# Individuals	Source
2022/06/27	6	Wardsville Woods, west of Wardsville	1 adult	iNaturalist 2022
2022/07/02	6	Wardsville Woods, west of Wardsville	1 adult	iNaturalist 2022
2022/07/26	7	Vermilion River east of Highway 96	4 adult males	See Appendix 2.
2022/07/27	7	Vermilion River at Morgan Road	4 exuviae	See Appendix 2.
2022/07/30	2	Big Otter Creek at Culloden Road	1 adult male	iNaturalist 2022
QUEBEC				
1920-06-26	Unknown	Right bank of the Rivière Gatineau	1 exuvia with adult	Royal Ontario Museum 2022
1920-06-29	10	Bay opposite Larose, right bank of the Rivière Gatineau	1 exuvia with adult	Royal Ontario Museum 2022
1920-06-30	10	Rivière Gatineau, below Larose	1 exuvia with adult	Royal Ontario Museum 2022
1920-07-05	9	Rivière Désert	1 adult	Royal Ontario Museum 2022
1928-06-29	10	Rivière Gatineau, bay opposite Larose, (near Collège Saint-Alexandre, Gatineau-Hull)	3 adult males, exuviae including 1 newly emerged female	Walker 1934
1990-07-19	16	Rivière Petite-Nation near Plaisance	1 exuvia	No observer information. Ouellet-Robert Collection, Favret, December 2022
1995-06-30	16	Rivière Petite-Nation, above the falls north of Plaisance	2 adult male, 2 adult female	Ménard 1996
1996-06-01	9	Rivière Désert at Montcerf near Maniwaki	1 exuvia	Ménard 1996; Hutchinson and Ménard 2016
1997-07-10	13	St. Lawrence River at Anse du Moulin Banal, Saint-Augustine-de-Desmaures, near Quebec City	6 exuviae	Perron and Ruel 1998
1997-07-10	13	St. Lawrence River at Anse du Moulin Banal, Saint-Augustine-de-Desmaures, near Quebec City	1 exuvia with adult	Favret et al. 2020
1997-07-16	13	St. Lawrence River at Anse du Moulin Banal, Saint-Augustine-de-Desmaures, near Quebec City	2 exuviae	Favret et al. 2020.
1998-07-01	13	St. Lawrence River at Anse du Moulin Banal, at base of the cliff west of Cap Jean-Gros, near Quebec City	17 exuviae (8 males and 9 females)	Perron and Ruel 2002.
1999-06-23	13	St. Lawrence River near Anse du Moulin Banal, Saint-Augustine-de-Desmaures, near Quebec City	2 exuviae	Favret et al. 2020

Date (y/m/d)	Subpopulation Number	Site	# Individuals	Source
1999-06-30	13	St. Lawrence River near Anse du Moulin Banal, Saint-Augustine-de-Desmaures, near Quebec City	1 exuvia	Favret et al. 2020
1999-07-01	13	St. Lawrence River at Anse du Moulin Banal, at base of the cliff west of Cap Jean-Gros, near Quebec City	3 exuviae (2 males, 1 female)	Perron and Ruel 2002
2000-07-01	13	St. Lawrence River at Anse du Moulin Banal, at base of the cliff west of Cap Jean-Gros, near Quebec City	6 exuviae (3 males, 3 females)	Perron and Ruel 2002.
2000-08-08	13	St. Lawrence River near Anse du Moulin Banal, Saint-Augustine-de-Desmaures, near Quebec City	1 emerging adult	Favret et al. 2020
2003-07-12	13	St. Lawrence River at Plage-Jacques-Cartier in Cap-Rouge, near Quebec City	1 exuvia	Favret et al. 2020
2003-07-14	13	St. Lawrence River at Plage-Jacques-Cartier in Cap-Rouge, near Quebec City	2 exuviae	Favret et al. 2020
2004-07-07	13	St. Lawrence River near Anse du Moulin Banal, Saint-Augustine-de-Desmaures, near Quebec City	1 emerging adult	Favret et al. 2020
2004-07-27	13	St. Lawrence River near Anse du Moulin Banal, Saint-Augustine-de-Desmaures, near Quebec City	1 emerging adult	Favret et al. 2020
2011-07-03	10	Rivière Gatineau (east bank) at Gatineau, 1 km upstream of Collège Saint-Alexandre	1 emerging adult	Harris and Foster 2011
2011-07-04	9	Rivière Gatineau at Maniwaki	1 larva	Harris and Foster 2011
2011-07-04	9	Rivière Coulonge north of Fort Coulonge	2 exuviae	Harris and Foster 2011
2011-07-05	16	Rivière de la Petite-Nation at Plaisance Falls	1 exuvie, 1 larve; 1 emerging adult	Harris and Foster 2011
2011-07-05	9	Riviere Picanoc at Cousineau Bridge	6 exuviae 1 larva	Harris and Foster 2011
2011-07-05	9	Riviere Picanoc east of Lac à Crête	1 exuvia	Harris and Foster 2011
2011-07-05	16	Rivière Petite-Nation at Papineau	1 adult	iNaturalist 2022
2012 to 2020 every year	11	Rivière Bastican at St-Adelphe	Several exuviae	Quebec Dragonfly Atlas 2022

Date (y/m/d)	Subpopulation Number	Site	# Individuals	Source
2014-07 et 2014-08	15	Rivière Ashuapmushuan approximately 20 km upstream of Saint-Félicien	1 adult, 93 exuviae including 1 emerging	Quebec Dragonfly Atlas 2022
2015-07 et 2015-08	15	Rivière Ashuapmushuan approximately 20 km upstream of Saint-Félicien	6 exuviae	Quebec Dragonfly Atlas 2022
2015-07-05	13	St. Lawrence River at Marais-Léon-Provencher, west of Quebec City	1 adult female	iNaturalist 2022
2016-06-19	16	Rivière Petite-Nation at the confluence of the Saint-Sixte and Petite-Nation rivers, 4 km north of Plaisance	8 larvae	Hutchinson and Ménard 2016
2016-07-12	15	Rivière Ashuapmushuan approximately 20 km upstream of Saint-Félicien	121 exuviae including 7 emerging	Quebec Dragonfly Atlas 2022
2016-08-12	9	Rivière Désert at Maniwaki	Larvae	Hutchinson and Ménard 2016
2018-07-13	15	Rivière Mistassini at Dolbeau-Mistassini	1 adult 39 exuviae including 1 emerging	Quebec Dragonfly Atlas 2022
2018-07-19	11	Rivière Rouge at L'Ascension	1 adult	iNaturalist 2022
2018-07-19	11	Rivière Rouge at L'Ascension	1 adult female	iNaturalist 2022
2018-07-19	11	Rivière Rouge at L'Ascension	1 adult female	iNaturalist 2022
2018-07-19	11	Rivière Rouge at L'Ascension	1 adult	iNaturalist 2022
2018-07-26	15	Rivière Ashuapmushuan approximately 20 km upstream of Saint-Félicien	5 exuviae	Quebec Dragonfly Atlas 2022
2019-07-26	17	Jacques-Cartier River in St-Catherine-de-la-Jacques-Cartier	2 exuviae	Alain Côté, 2023
2020-07-01	12	Rivière Bastican at Sainte-Geneviève-de-Batiscan	2 exuviae	Quebec Dragonfly Atlas 2022
2020-07-05	15	Rivière Mistassini at Dolbeau-Mistassini	35 exuviae including 4 emerging	Quebec Dragonfly Atlas 2022
2021-06 et 2021-07	15	Rivière Mistassini at Dolbeau-Mistassini	59 exuviae	Quebec Dragonfly Atlas 2022
2021-07-07	15	Rivière Ashuapmushuan approximately 20 km upstream of Saint-Félicien	8 exuviae including 1 emerging	Quebec Dragonfly Atlas 2022
2021-07-13	15	Rivière Ashuapmushuan at La Doré	2 exuviae	Quebec Dragonfly Atlas 2022
2021-07-20	15	Rivière Ashuapmushuan at Normandin	2 exuviae	Quebec Dragonfly Atlas 2022
2022-07-15	15	Rivière Ashuapmushuan approximately 20 km upstream of Saint-Félicien	300 exuviae including 5 emerging	Quebec Dragonfly Atlas 2022
2022-07-27	15	Rivière Ashuapmushuan at La Doré	1 exuvia	Quebec Dragonfly Atlas 2022
2022-06-30	9	Rivière de l'Aigle Maniwaki	1 adult	Quebec Dragonfly Atlas 2022

Table 4. Targeted search effort for Riverine Clubtail (Stylurus amnicola) in Canada.

River Reach	Survey Date	Surveyors	Search Effort	Riverine Clubtail Observations
MANITOBA				
Assiniboine River				
Brandon, MB – Conservation Drive	July 14, 2010	R. Foster	0.5 person-hours; north bank at Ducks Unlimited Riverbank Discovery Centre searched by foot. Adult odonates recorded and exuviae collected (high water levels impaired ability to find exuviae).	None observed.
Brandon, MB – Kirkcaldy Drive at Paterson Crescent			0.5 person-hours; north bank searched by foot. Adult odonates recorded and exuviae collected (high water levels impaired ability to find exuviae).	None observed.
Brandon, MB – Kirkaldy Drive at Knowlton Drive			0.5 person-hours; north bank searched by foot. Adult odonates recorded and exuviae collected (high water levels impaired ability to find exuviae).	None observed.
Brandon, MB – 1st Street North at Dinsdale Park			0.5 person-hours; north bank searched by foot. Adult odonates recorded and exuviae collected (high water levels impaired ability to find exuviae).	None observed.
Brandon, MB – 4th St. North at weir			0.5 person-hours; south bank searched by foot. Adult odonates recorded and exuviae collected (high water levels impaired ability to find exuviae).	None observed.
Brandon, MB – Veterans Way near 17th St. E			0.5 person-hours; north bank at municipal park searched by foot. Adult odonates recorded and exuviae collected (high water levels impaired ability to find exuviae).	None observed.
1 km NE of Brandon, MB	July 21, 2011		1.2 person-hours. Adult odonates recorded and exuviae collected (high water levels impaired ability to find exuviae).	None observed.
E of Spruce Woods Provincial Park, MB			1.0 person-hours. Adult odonates recorded and exuviae collected (high water levels impaired ability to find exuviae).	None observed.
Brokenhead River				
1.75 person-hours. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	None observed.	A. Harris	1.75 person-hours. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	None observed.
1.25 person-hours. Adult odonates recorded and exuviae collected.	None observed.		1.25 person-hours. Adult odonates recorded and exuviae collected.	None observed.
Cook's Creek				
Winnipeg, MB – HWY 44 ~5 km E of HWY 59	July 7, 2011	A. Harris	0.25 person-hours. Adult odonates recorded and exuviae collected.	None observed.
Cypress River				
Cypress River, MB	July 7, 2011	R. Foster	0.5 person-hours. Adult odonates recorded and exuviae collected.	None observed.
LaSalle River				
Near Pembina Hwy, MB	July 9, 2011	A. Harris	0.25 person-hours. Adult odonates recorded and exuviae collected.	None observed.

River Reach	Survey Date	Surveyors	Search Effort	Riverine Clubtail Observations
Red River				
Winnipeg, MB – North Perimeter Park	July 7, 2011	A. Harris	1.5 person-hours. Adult odonates recorded and exuviae collected (high water levels impaired ability to find exuviae).	Riverine Clubtail exuviae and teneral adults observed.
Winnipeg, MN – at Burns Creek			0.25 person-hours. Adult odonates recorded and exuviae collected (high water levels impaired ability to find exuviae).	None observed.
Winnipeg, MB – Municipal park opposite The Forks			1.0 person-hours. Adult odonates recorded and exuviae collected (high water levels impaired ability to find exuviae).	Several Riverine Clubtail exuviae and teneral adults observed.
St. Norbert Park, MB	July 9, 2011		0.5 person-hours. Adult odonates recorded and exuviae collected (high water levels impaired ability to find exuviae).	None observed.
Seine River				
Winnipeg, MB – near St. Anne St	July 9, 2011	A. Harris	0.25 person-hours. Adult odonates recorded and exuviae collected.	None observed.
Souris River				
Old HWY 10 bridge	July 14, 2010	R. Foster	1.0 person-hours; north bank on upstream side of bridge searched by foot. Adult odonates recorded and exuviae collected (high water levels impaired ability to find exuviae).	None observed.
Souris, ON – 4th Ave E and 1st Ave E			0.5 person-hours; north bank at low head dam 250 m SE of intersection searched by foot. Adult odonates recorded and exuviae collected (high water levels impaired ability to find exuviae).	None observed.
Wawanesa, MB - HWY 344 bridge	July 21, 2011		0.3 person-hours. Adult odonates recorded and exuviae collected (high water levels impaired ability to find exuviae).	None observed.
ONTARIO				
Big Creek				
Big Creek	July 13-15, 2008	A. Harris, R. Foster	Surveyed 7.5 km stretch of creek by canoe. Checked 13 stream crossings.	5 Riverine Clubtail exuviae collected and 1 Riverine Clubtail adult observed.
Norfolk Road 45, ON	August 13, 2010	A. Harris	0.5 person-hours. Adult odonates recorded and exuviae collected.	None observed.
East ¼ Line, ON			0.5 person-hours. Adult odonates recorded and exuviae collected.	None observed.
10th Concession, ON			0.5 person-hours. Adult odonates recorded and exuviae collected.	None observed.
Big Creek	August 1 – August 22, 2011	Solymar, Timpf	Surveyed 15 km stretch of creek by canoe. 156 survey hours for Big, Big Otter, Little Otter, South Otter and Venison creeks. Adult odonates recorded and exuviae collected	1 Riverine Clubtail exuviae collected.
Big Creek – between McDowell Road (Regional #1) and Concession #1 Road	July 13, 20, and August 8, 2011	Solymar, Timpf	9 bridge crossings searched along this reach. Roads and road shoulders inspected for adult odonate mortalities and creek banks searched for exuviae.	2 Riverine Clubtail exuviae collected.
Big East River				
Big East River Provincial Park	July 15, 2020	P. Mills	Adult odonates recorded.	2 adult male Riverine Clubtail observed.
Big East River Provincial Park	August 6, 2020	P. Mills	Adult odonates recorded.	1 adult male Riverine Clubtail observed.

River Reach	Survey Date	Surveyors	Search Effort	Riverine Clubtail Observations
Big East River Provincial Park	August 7, 2020	P. Mills	Adult odonates recorded.	3 adult male and 1 adult female Riverine Clubtail observed.
Big East River Provincial Park	August 12, 2020	P. Mills	Adult odonates recorded.	3 adult male Riverine Clubtail observed.
Big East River Provincial Park	August 17, 2020	P. Mills	Adult odonates recorded.	4 adult male Riverine Clubtail observed.
Big East River Provincial Park	June 15, 2021	P. Mills	2.0 person-hours of dip-netting for mature larvae.	1 larval Riverine Clubtail collected.
Big East River Provincial Park	August 9, 2021	P. Mills	Adult odonates recorded.	1 adult make Riverine Clubtail observed.
Big Otter Creek				
Elgin Road #44, west of Eden	July 11, 1999	P. Catling, V. Brownell	A 250 m section was surveyed for adult odonates along this reach.	25 adults
Eden Line south to Heritage Line	August 10-12, 2004	P. Burke, C. Jones, R. Russell, D. Sutherland	Surveyed 6 km along this reach by canoe. Bridge crossings also searched downstream of this reach. Adult odonates recorded and exuviae collected.	None observed.
Big Otter Creek	July 13-15, 2008	A. Harris, R. Foster	Surveyed 6 km stretch of creek by canoe. Checked 13 stream crossings.	2 Riverine Clubtail exuviae collected and 4 Riverine Clubtail adults observed.
Big Otter Creek	July 13, 20, and August 8, 2011	Solymar, Timpf	Bridge crossings searched. Roads and road shoulders inspected for adult odonate mortalities and creek banks searched for exuviae.	8 Riverine Clubtail exuviae collected.
Big Otter Creek	August 1 – August 22, 2011	Solymar, Timpf	Surveyed 20 km stretch of creek by canoe. 156 survey hours for Big, Big Otter, Little Otter, South Otter and Venison creeks. Adult odonates recorded and exuviae collected.	None observed.
Boland River				
Near Mississagi Provincial Park, ON – unnamed logging road to HWY 639	July 28, 2022	D. Frey N. Miller K. Hoo	10.9 km surveyed by canoe along this reach. 15.75 person-hours. Adult odonates recorded and exuviae collected.	None observed.
Catfish Creek				
Catfish Creek	July 11, 1999	P. Catling, V. Brownell	Brief survey. Adult odonates recorded.	None observed.
Catfish Creek – bridge crossings	July 13-15, 2008	A. Harris, R. Foster	Adult odonates recorded and exuviae collected within 100 m of bridges.	None observed.
Deer Creek				
Deer Creek – bridge crossings	July 13-15, 2008	A. Harris, R. Foster	Searches for adults and exuviae conducted within 100 m of bridges.	None observed.
Deer Creek, ON	August 13, 2010	A. Harris	1.5 person-hours. Adult odonates recorded and exuviae collected.	None observed.
Derrick's Creek				
Derrick's Creek – bridge crossings	July 13-15, 2008	A. Harris, R. Foster	Adult odonates recorded and exuviae collected within 100 m of bridges.	None observed.
Kettle Creek				
Kettle Creek	July 11, 1999	P. Catling, V. Brownell	Brief survey. Adult odonates recorded.	None observed.

River Reach	Survey Date	Surveyors	Search Effort	Riverine Clubtail Observations
Little Otter Creek				
Little Otter Creek – bridge crossings	July 13-15, 2008	A. Harris, R. Foster	Adult odonates recorded and exuviae collected within 100 m of bridges.	None observed.
Little Otter Creek	July 13 – August 22, 2011	Solymar, Timpf	156 survey hours for Big, Big Otter, Little Otter, South Otter and Venison creeks. Adult odonates recorded and exuviae collected.	None observed.
Little Otter Creek – bridge crossings	July 24, 2011	Solymar, Timpf	4 bridge crossings searched. Roads and road shoulders inspected for adult odonate mortalities and creek banks searched for exuviae.	None observed.
Mississagi River				
Iron Bridge Centennial Park	2–3 survey dates (dates not specified)	C. Jones	Adult odonates recorded and mature larvae collected using sieve.	Potential adults observed but not confirmed.
Ottawa River (Ontario)				
Ottawa River – mostly Ontario side	Pre 2010	C. Jones, P. Catling	At least 700 person-hours of survey effort. Adult odonates recorded and exuviae collected.	None observed.
Rainy River				
Emo, ON	June 8, 2010	A. Harris	1.0 person-hours. Adult odonates recorded and exuviae collected.	None observed.
	June 9, 2010		1.0 person-hours. Adult odonates recorded and exuviae collected.	None observed.
	June 22, 2010		1.0 person-hours. Adult odonates recorded and exuviae collected.	None observed.
	June 24, 2010		1.5 person-hours. Adult odonates recorded and exuviae collected.	None observed.
Stratton, ON – boat launch	June 21, 2010	A. Harris, R. Foster	3.0 person-hours. Adult odonates recorded and exuviae collected.	1 teneral adult Riverine Clubtail observed.
Pinewood, ON			2.0 person-hours. Adult odonates recorded and exuviae collected.	None observed.
Rainy River, ON – municipal park			1.0 person-hour. Adult odonates recorded and exuviae collected.	None observed.
Barwick, ON – boat launch			1.0 person-hour. Adult odonates recorded and exuviae collected.	None observed.
Manitou Rapids, ON			3.0 person-hours. Adult odonates recorded and exuviae collected.	None observed.
Rainy River, ON – Rainy River Park	July 25 and 28, 2011	A. Harris	1.5 person-hours. Adult odonates recorded and exuviae collected.	None observed.
South of Stratton, ON – Morley Park	July 25 and 28, 2011		1.25 person-hours. Adult odonates recorded and exuviae collected.	None observed.
Rainy River	June 22-24, 2021	A. Harris B. Ratcliff	18.5 person-hours. 17 sites surveyed, 5.2 km total. Adult odonates recorded and exuviae collected.	None observed. 150 *Stylurus* spp. exuviae not yet identified to species.
Silver Creek				
Silver Creek – bridge crossings	July 13-15, 2008	A. Harris, R. Foster	Adult odonates recorded and exuviae collected within 100 m of bridges.	None observed.
South Otter Creek				
South Otter Creek – bridge crossings	July 13-15, 2008	A. Harris, R. Foster	Adult odonates recorded and exuviae collected within 100 m of bridges.	None observed.

River Reach	Survey Date	Surveyors	Search Effort	Riverine Clubtail Observations
South Otter Creek	July 13 – August 22, 2011	Solymar, Timpf	156 survey hours for Big, Big Otter, Little Otter, South Otter and Venison creeks. Adult odonates recorded and exuviae collected.	None observed.
South Otter Creek – bridge crossings	July 24, 2011	Solymar, Timpf	6 bridge crossings searched. Roads and road shoulders inspected for adult odonate mortalities and creek banks searched for exuviae.	None observed.
Tate Drain				
Tate Drain – bridge crossings	July 13-15, 2008	A. Harris, R. Foster	Adult odonates recorded and exuviae collected within 100 m of bridges.	None observed.
Venison Creek				
Venison Creek – bridge crossings	July 13-15, 2008	A. Harris, R. Foster	Adult odonates recorded and exuviae collected within 100 m of bridges.	None observed.
Venison Creek	July 13 – August 22, 2011	Solymar, Timpf	156 survey hours for Big, Big Otter, Little Otter, South Otter and Venison creeks. Adult odonates recorded and exuviae collected.	None observed.
Venison Creek – bridge crossings	August 10, 2011	Solymar, Timpf	8 bridge crossings searched. Roads and road shoulders inspected for adult odonate mortalities and creek banks searched for exuviae.	None observed.
Vermilion River				
Capreol, ON – Theriault Road to Desmarais Road	July 26, 2022	D. Frey N. Miller K. Hoo	7.6 km surveyed by canoe along this reach. 16 person-hours. Adult odonates recorded and exuviae collected.	4 adult male Riverine Clubtail observed.
Larchwood, ON – Morgan Road bridge east of Nickel Offset Road	July 27, 2022	D. Frey N. Miller K. Hoo	750 m surveyed by foot along this reach. 3.0 person-hours. Adult odonates recorded and exuviae collected.	4 Riverine Clubtail exuviae collected.
QUEBEC				
Crique à Bernard				
East of Fort Coulonge, QC	July 4, 2011	A. Harris, R. Foster	1.0 person-hours. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	None observed.
Rivière Blanche				
Perkins/Val des Monts, QC – upstream of Pont du Moulin	July 5, 2011	A. Harris, R. Foster	0.75 person-hours. Adult odonates recorded and exuviae collected.	None observed.
Perkins/Val des Monts, QC – downstream of junction with Ruisseau à Rainville			0.25 person-hours. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	None observed.
Lac aux Cerises				
Ruis des Cerises, outlet of Lac Vert	July 4, 2011	A. Harris, R. Foster	1.25 person-hours. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	None observed.
Rivière Coulonge				
North of Fort Coulonge, QC	July 4, 2011	A. Harris, R. Foster	1.0 person-hours. Adult odonates recorded and exuviae collected.	2 Riverine Clubtail exuviae collected.
Rivière Désert				
Maniwaki, Montcerf, QC	July 3, 2011	A. Harris, R. Foster	0.5 person-hours. Adult odonates recorded and exuviae collected.	None observed.

River Reach	Survey Date	Surveyors	Search Effort	Riverine Clubtail Observations
Chutes Rouge at Montcerf, QC			0.5 person-hours. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	None observed.
Maniwaki, QC	July 4, 2011		0.5 person-hours. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	None observed.
Gatineau River				
Gatineau, QC – 1 km upstream from College Alexandre	July 3, 2011	A. Harris, R. Foster	0.5 person-hours; east bank of river searched. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	1 teneral adult Riverine Clubtail observed.
Wakefield, QC			0.75 person-hours. Adult odonates recorded and exuviae collected.	None observed.
Gracefield, QC – boat launch			0.5 person-hours. Adult odonates recorded and exuviae collected.	None observed.
Bouchette, QC			1.5 person-hours. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	None observed.
Maniwaki, QC	July 4, 2011		1.5 person-hours. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	1 Riverine Clubtail larva collected.
Gracefield, QC – bridge at Rue DuPont	July 5, 2011		0.75 person-hours. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	None observed.
Rivière Kazabazua				
Danford Lake, QC	July 4, 2011	A. Harris, R. Foster	0.2 person-hours. Adult odonates recorded and exuviae collected.	None observed.
Danford Lake, QC			1.0 person-hours. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	None observed.
Rivière du Lièvre				
North of Notre-Dame-de-la-Salette, QC	July 5, 2011	A. Harris, R. Foster	0.75 person-hours. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	None observed.
South of Notre-Dame-de-la-Salette, QC			0.5 person-hours. Adult odonates recorded and exuviae collected.	None observed.
Rivière Noire				
Waltham, QC	July 4, 2011	A. Harris, R. Foster	1.0 person-hours. Adult odonates recorded and exuviae collected.	None observed.
Ottawa River (Quebec)				
Montebello, QC	July 5, 2011	A. Harris, R. Foster	0.75 person-hours. Adult odonates recorded and exuviae collected	None observed.
Décharge du Lac à la Perchaude				
Saint-Sixte, QC	July 5, 2011	A. Harris, R. Foster	0.25 person-hours. Adult odonates recorded and exuviae collected.	None observed.
Rivière de la Petite Nation				
North Nation Mills, QC	July 5, 2011	A. Harris, R. Foster	2 person-hours. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	1 exuvia and 1 larva of Riverine Clubtail collected; Riverine Clubtail teneral adults observed.

River Reach	Survey Date	Surveyors	Search Effort	Riverine Clubtail Observations
Ripon, QC			1.0 person-hours; searched 300 m upstream from picnic area to bridge at Ch. Legault. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	None observed.
Rivière Picanoc				
Pont Picanoc – 1 km upstream	July 5, 2011	A. Harris, R. Foster	0.75 person-hours. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	None observed.
East of Lac à Crête, QC			1.5 person-hours. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	1 Riverine Clubtail exuvia collected.
Pont Cousineau, QC			1.0 person-hours. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	6 exuviae and 1 larva of Riverine Clubtail collected.
Priest Creek				
West of Notre-Dame-de-la-Salette, QC	July 5, 2011	A. Harris, R. Foster	0.5 person-hours. Adult odonates recorded, exuviae collected, mature larvae collected using metal sieve.	None observed.
Unnamed creek near Saint-Sixte				
Near Saint-Sixte, QC	July 5, 2011	A. Harris, R. Foster	0.25 person-hours. Adult odonates recorded and exuviae collected.	None observed.
St. Lawrence River				
Between île d'Orléans and Deschambault, near Quebec City	1997	J.M. Perron	Approximately 60km searched along this stretch of river.	1 adult Riverine Clubtail observed.
Unnamed creek near Vinton, QC				
Near Vinton, QC	July 4, 2011	A. Harris, R. Foster	0.2 person-hours. Adult odonates recorded and exuviae collected.	None observed.

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EOO) in Canada is 753,150 km^2 and the index of area of occupancy (IAO) is 224 km^2 based on all known records. The EOO prior to 2012, including historical and extant sites, was 693,551 km^2 with a known IAO of 148 km^2 (COSEWIC 2012). The increase in EOO is considered to be due to additional search effort.

HABITAT

Habitat Requirements

Riverine Clubtail inhabits freshwater vegetated riparian riverine areas (COSEWIC 2012; ECCC 2021). Watercourses where the species occurs are generally wide enough so that the riparian canopy does not completely cover the width of the channel (Catling *et al.* 1999). Habitat requirements vary with life stage and consist of aquatic habitats for larval development and adult egg laying, and terrestrial habitat for larval emergence, teneral perching, adult foraging, thermoregulation, and breeding (Corbet 1999).

Across most of its Canadian range, Riverine Clubtail appears to prefer medium-to-large rivers with substrates of deltaic origin dominated by deep sand deposits (e.g., Big East River, Big Otter Creek) (Mills pers. comm. 2022). The sand deltas over which these watercourses flow provide increased channel bed mobility and create a meandering planform. In parts of their United States range, Riverine Clubtail also inhabit rivers with gravel substrates (Paulson 2009a; Leppo pers. comm. 2011). In Canada, however, all observations of Riverine Clubtail have been found in rivers with pure sand shorelines and bottoms (Catling *et al.* 1999; Hughes and Catling 2005; Harris and Foster 2011; Mills pers. comm. 2022).

Females oviposit directly in shallower areas of fast-flowing open streams or rivers (Corbet 1999; Mills pers. comm. 2022). Egg incubation habitat may occur in backwater eddies or slower water where eggs settle out of the water column after being deposited at the surface upstream (Dobbyn and Mills 2021).

Larvae are fully aquatic and develop while burrowed in fine sand or silt substrates. They occupy shallow (0.5–1.0m deep) watercourses of variable size with moderate to rapid flow velocities (Walker 1958; Catling *et al.* 1999; Needham *et al.* 2014; Harris and Foster 2011). In general, gomphid larvae tend to occupy microhabitats in deeper pools more than shallow riffles, since predation can be avoided to a greater extent (Corbet 1999). Riverine Clubtail therefore requires watercourses with both fast-flowing areas for adult egg laying and wider stretches with slower-moving water for larval development (Catling *et al.* 1999; Corbett 1999; Dobbyn and Mills 2021).

Larvae emerge directly on channel banks or nearby vegetation. Most exuviae tend to be found within 20–60 cm of the water's edge, most frequently on bare sandy banks and bars upstream or downstream of swift water (Ménard 1996; Hughes and Catling 2005; Harris and Foster 2011). Teneral dragonflies generally require deciduous trees and shrubs within 200 m of their emergence site on which to perch for at least 24 hours while their exoskeletons harden (Corbet 1999).

Immature adults spend at least two weeks foraging and basking in the canopy of adjacent deciduous forest habitats before entering the reproductive life stage (Paulson 2009a; Mlynarek 2015; Mills pers. comm. 2022). When sexually mature, males patrol for females in both the canopy and over fast-flowing portions of the watercourse before returning to the treetops (Mills pers. comm. 2022). While intact riparian forests are likely preferred, confirmed adult (teneral to mature) foraging and thermoregulation habitat also includes urban rivers running through municipal parks in the cities of Winnipeg and Gatineau, where trees are present but continuous forest cover is absent (Harris pers. obs. *in* COSEWIC 2012).

Riverine Clubtail prefers relatively clear waters but is likely tolerant of varying river conditions including high turbidity and elevated nutrient loads (Gehring 2006; Harris and Foster 2011; Craves pers. comm. 2022). For example, the Red and Assiniboine rivers in the Winnipeg area (#1) have relatively high turbidity and elevated concentrations of

phosphorus and nitrogen (Hughes and Catling 2005; Rosenberg *et al.* 2005; Harris and Foster 2011). Although the species is found on the St. Lawrence River at Quebec City, it is not known at what point salinity will limit habitat suitability farther downstream (Perron pers. comm. 2012). There are no records from lakes or reservoirs on the Gatineau River or other rivers in Canada.

Habitat Trends

Habitat trends specific to Riverine Clubtail relate to water quality (e.g., affects larval development) and riparian habitat (e.g., tree removal, shoreline alteration). Habitat trends are discussed below by province, and in cases where data are available, by subpopulation. When available, Google Earth imagery is used to evaluate land use changes (measurements such as riparian forest width are approximate).

Manitoba

From 70% to 80% of the Red and Assiniboine River watershed (#1) has experienced agricultural development (Armstrong 2002; Rosenberg *et al.* 2005). From 2010–2020, minor degradation of riparian habitat occurred as a result ofh tree removal for residential development and agricultural practices (Google Earth 2021). Some tree removal and shoreline habitat alteration along the Assiniboine River associated with the construction and maintenance of dikes for flood control is also evident on aerial imagery fromin the past 10 years (Google Earth 2021).

The total area of agricultural land in MB declined by approximately 5% between 2011 and 2021 (Statistics Canada 2022a). The Assiniboine and Red rivers continue to be impacted by agricultural effluents with high levels of nitrogen and phosphorus, due to inputs from naturally fertile prairie soils and anthropogenic inputs from municipal, industrial, and agricultural sources (Armstrong 2002; Rosenberg *et al.* 2005; Benoy *et al.* 2016; Newton 2016). Increased nutrient input (eutrophication) has resulted in increased algal blooms. The die-off and decay of algal blooms consumes dissolved oxygen, leading to extensive fish kills (Armstrong 2002) and possibly degraded habitat for dragonfly larvae.

Ontario

Riverine Clubtail habitat trends differ across the watersheds where the species occurs. Within southern ON, the spatial area dedicated to agriculture has declined since the early 1900s (Riley and Mohr 1994). From 2001 to 2021, agricultural land use in ON decreased by approximately 8% (Statistics Canada 2022a).

Big Otter Creek (#2) and Big Creek (#3) in Norfolk County show no change in riparian forest cover over the previous decade (2009–2021); approximately 20% of the watershed is forested (Google Earth 2021; LPRCA 2018). Some small restoration and planting areas were noted in the Big Creek subwatershed (Google Earth 2021). Municipalities in Norfolk County are generally small with low population growth rates (e.g., Tillsonburg), and much of the catchment will remain agricultural for the foreseeable future (Statistics Canada 2017).

Water levels are controlled by dams and agricultural drawdown (discussed further under Threat *7.2 Dams & water management/use*). Historically, agriculture in Norfolk County favoured tobacco farming, which is damaging to aquatic habitats and fauna. However, this crop is no longer grown in this area.

The central/northern ON subpopulations are located along waterways that run through natural forested habitat. Habitat along the Big East River (#5) remains unchanged (2009–2021) since the first COSEWIC (2012) report, although some forest removal (11 ha) has occurred approximately 750 m south of the watercourse and west of Highway 3 (Google Earth 2021). Big East River (#5) has good water quality, with consistent cold-water conditions and super-saturated oxygen levels (Bowles and Sõber 2005). No lakes within this subwatershed exceed provincial thresholds of total phosphorus (Muskoka Watershed Council 2018) and there is no habitat trend data that indicate water quality will decline in the foreseeable future.

Habitat adjacent to the Aux Sables and Spanish rivers (#4) appears unchanged (2009–2021) (Google Earth 2021). However, the Spanish River is downstream from sites with historical water pollution from mining and pulp and paper operations near Sudbury. The levels of heavy metals in the Spanish River and its tributaries have decreased since the early 1900s owing to a reduction in inputs of these pollutants from such operations (Government of Canada 2017). However, toxic metals remain buried under deposits of contaminated soil at the mouth of the Spanish River, and the Spanish Harbour has been designated an “Area of Concern in Recovery” by the International Joint Commission (Government of Canada 2017). The implementation of Ontario’s Municipal Industrial Strategy of Abatement regulations in the mid-1990s has led to a decline in toxic effluents entering waterways from pulp and paper operations (Government of Canada 2017). Given these measures, it is likely that water quality in this region will continue to improve in comparison to historical conditions.

Salt application throughout Ontario has resulted in a twofold increase in chloride concentrations in watercourses since the 1960s, although most values remain well below the Canadian Water Quality Guideline of 120 mgL^{-1} for protection of aquatic life (Sorichetti *et al.* 2022). In urban areas within ON, mean chloride concentrations in watercourses increased from 110.96 mgL^{-1} in the 1960s to 272.71 mgL^{-1} in the 2010s (Sorichetti *et al.* 2022). Watercourses that are predominantly agricultural have experienced an increase in chloride concentrations from 38.64 mgL^{-1} (1960s) to 54.97 mgL^{-1} (2010s), while treed watercourses continue to have the lowest mean concentrations (7.65 mgL^{-1} to 17.36 mgL^{-1}) during this period (Sorichetti *et al.* 2022). All ON subpopulations (#2–7) occur in areas dominated by agriculture (Middlesex and Norfolk County) or forest (central/northern ON). Chloride concentrations in watercourses are directly and positively correlated with human population and road density, and as urban areas grow and expand within the catchments of rivers with known subpopulations, chloride concentrations are expected to increase as well (Sorichetti *et al.* 2022).

Quebec

Habitat trends in southern (#9, #16) and northern QC (#8, #10, #11, #14, #15) differ from those in eastern QC near Quebec City (# 12, #13). The southern part of the province and areas further north generally remain forested while most of the riparian woodlands have historically been removed from areas near the St. Lawrence River.

In Quebec, the human population has grown by 10% since 2010 (Statistics Canada 2022b). The Gatineau River (#10) has experienced recent encroachment on its eastern bank, which is evident in aerial imagery of the Limbour Construction residential subdivision (observable between 2007–2021) (Google Earth 2021; Limbour Construction 2022). Construction at this site is ongoing and will likely result in further tree removal based on development plans (Limbour Construction 2022). However, riparian forest cover in this immediate area remains >50% and the western shoreline is almost entirely forested (Google Earth 2021). Similar urban expansion is likely to occur at sites near Quebec City, although no additional impacts to riparian habitat are evident on aerial imagery from the past decade (Google Earth 2021).

Wood harvesting continues to be widespread near QC subpopulations; from 2010–2020, approximately 298,000 ha of forest was logged, primarily in northern QC (Global Forest Watch 2022). From 2009–2021, logging was noted near the Rivière Coulonge (#8), Picanoc (#9), and the Rouge (#11): from 12 ha to >150 ha was removed (discussed further within Threat *5.3 Logging & wood harvesting*) (Google Earth 2021). Some mixed-deciduous forest also appears to have been removed and replaced by coniferous plantations in these areas, further changing the character of riparian habitat. Despite the loss of forest cover, these watersheds generally retain high forest cover (e.g., the Ottawa River watershed is 73% forested) (Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques 2015).

No forest cover was removed to make way for farming in areas adjacent to known Riverine Clubtail subpopulations between 2009 and 2021 within QC (Google Earth 2021).

Hydroelectric facilities and water control measures are present on most of the watercourses in Quebec (Government of QC 2022a) and have undoubtedly altered (and continue to alter) the character of these rivers in terms of flow rate, deposition of sediments, water temperature, etc.

Overall water quality on the Gatineau River improved from 1979 to 1994 (MDDEP 2012) and, in general, water remains unpolluted in the Gatineau (#9, #10), Coulonge (#8), and Petite-Nation (#16) rivers (Ottawa Gatineau Watershed Atlas 2012). These trends have continued to 2022, with general water quality on the Gatineau River and these tributaries ranging from "satisfactory" to "good" (Ministère de l'Environnement et de la Lutte contre les changements climatiques 2022). Industrial effluent and sewage have caused some impairment of water quality on the Ottawa River downstream from Ottawa / Hull (Thorp *et al.* 2005). The Riverine Clubtail subpopulation on the St. Lawrence River (#13) is exposed to potentially higher levels of pollutants originating from the Great Lakes basin, but

monitoring has shown no increasing trends in nutrient loading or suspended solids (MDDEP 2012). Although there are instances of impaired water quality up to 50 km downstream of Montreal, water quality is “satisfactory” near the Quebec City occurrences of Riverine Clubtail (MDDEP 2012). Monitoring stations on the Mistissani (#14) and Ashuapmushuan (#15) Rivers in eastern QC have recorded “poor water quality,” but little information is available for these rivers to determine trends (Ministère de l'Environnement et de la Lutte contre les changements climatiques 2022).

BIOLOGY

Little information is available on Riverine Clubtail biology. The information below is from other river-inhabiting clubtails (see Walker 1958; COSEWIC 2010a; and Corbet 1999).

Members of the genus *Stylurus* are referred to as “hanging clubtails” owing to their habit of hanging vertically when perched on streamside vegetation (Dunkle 2000). Riverine Clubtail is apparently less wary than other hanging clubtails and easily approached (Dunkle 2000).

Life Cycle and Reproduction

Riverine Clubtail follows a life cycle that has an aquatic larval stage and terrestrial adult stage.

The terrestrial adult life stage is when mating occurs. In Canada, adults fly from late June to early September, with peak numbers in early July (Jones *et al.* 2013). Emergence in Canada is recorded from June 26 (Walker 1928) to July 5 (Harris and Foster 2011). Farther south in the United States, the flight season extends from May through September (Paulson 2011). Adults are predators and inhabit the floodplain corridor and appear to forage in the canopy of the surrounding forest (Jones *et al.* 2013). In the Midwest, the species is reported to forage in thick grass and brush (Dunkle 2000).

Mating adult pairs have been observed on July 8 (de March pers. comm. 2010) and July 13 (Harris and Foster 2011). When ready to breed, males patrol in fast, low flights over the stream from mid-morning until late afternoon (Catling *et al.* 1999; Dunkle 2000). Males tend to fly over mid-river, but also cruise over slow-moving pools (Paulson 2011; Mills pers. comm. 2022). They do not appear to hold territories like other species of gomphids.

Mated females lay eggs in the current over the open stream (Corbet 1999; Mills pers. comm. 2022). On average, female dragonflies deposit 200 to 300 eggs. In other gomphids, like the Plains Clubtail (*Gomphus externus*), over 5,000 eggs have been produced by a single female.

Eggs reside within the aquatic environment and require at least five days and perhaps up to more than a month to hatch (Walker 1953; Corbet 1999). Eggs hatch into small larvae, which burrow into the top few centimetres of the river sediment; the larvae breathe through gills in the tip of the abdomen which remains raised above the sediments (Corbet 1999). Riverine Clubtail larvae were recorded in the upper 20 cm of sediments in 20–30 cm of water and within 2 metres of shore along the Gatineau and Petite-Nation rivers in 2011 (Harris and Foster 2011).

The duration of the Riverine Clubtail larval stage is undocumented; however, it probably lasts two or more years. A generation time of two years is thought to be characteristic of this species as it is for most other members of the family Gomphidae (COSEWIC 2008, 2010a). Other gomphids, at temperate latitudes in Europe, require at least three to four years to reach adulthood (Walker 1953; Corbet 1999). The length of the larval stage may be shorter in areas where food is abundant.

Before the final moult, larvae crawl onto the stream bank or vegetation close to the edge of the stream. This life stage is when the species goes from aquatic to terrestrial. Larvae have been observed emerging near midday (10:00–14:00) on sunny days (Ménard 1996; Harris and Foster 2011). Exuviae (shed exoskeleton) distribution along a river is not random and emergence sites are most abundant on sandy banks or bars above or below swift water. Riverine Clubtail emerges within 20–60 cm from the water's edge (farther on more gentle slopes) on a bare sandy bank (Ménard 1996; Harris and Foster 2011). Flood conditions on the Red River in 2011 forced emerging larvae to crawl up into lawns and into forest vegetation (Harris and Foster 2011). After emergence, teneral (newly emerged) adults make short flights to shrubs on the riverbanks. Dozens of dragonflies, including Riverine Clubtail, were observed at heights of 1–3 m within 20 m of the riverbank on the Red River in July 2011 (Harris, pers. obs. *in* COSEWIC 2012). After a period of feeding on small invertebrate prey (generally lasting a week or more in other dragonfly species), adult males return to the stream to breed (Walker 1953).

Adults are probably generalist and opportunist predators, feeding on small flying insects (Walker 1953). Much of their feeding presumably takes place in the forest canopy, where adults tend to spend most of their time. Larvae ambush prey from the sediments using their prehensile labium. Young clubtail larvae feed on small prey (e.g., ciliates and rotifers) and the size of the prey increases as the larvae grow (Corbet 1999). Larger larvae feed on bottom-dwelling macroinvertebrates such as chironomid midges, tubificid worms, and burrowing mayflies (Bright and O'Brien 1999).

Physiology and Adaptability

The physiological requirements of Riverine Clubtail are unknown. Larvae are probably sensitive to pesticides, especially organochlorines and organophosphates (Corbet 1999). The effects of pollutants on odonate larvae include slow growth, developmental deformities, and behavioural abnormalities (Corbet 1999). Biological accumulation of persistent chemicals may be significant given their predatory diet and relatively long life cycle.

Riverine Clubtail has demonstrated a certain degree of adaptability in that it inhabits a wide range of river sizes across a wide range of latitude and longitude. It has been able to persist in the Gatineau, St. Lawrence, Red and Assiniboine rivers, despite nutrient enrichment, water level alterations due to dams, and other habitat changes; however, information on the severity of these potential threats in these places is lacking.

Dispersal and Migration

Riverine Clubtail is non-migratory. Dispersal distance is unknown for this species; however, the average distance travelled between reproductive and roosting or foraging sites by adult dragonflies, in general, is less than 200 metres (Corbet 1999).

Other stream-dwelling dragonflies tend to remain close to their breeding sites, moving short distances upstream and downstream and short distances inland (Corbet 1999). Unlike dragonflies inhabiting ephemeral pools or other seasonal habitats, Riverine Clubtail lives in relatively stable habitats where the requirement for dispersal is lower and the likelihood of finding unoccupied suitable habitat is lower. Their flight behaviour of remaining close to the river surface or in forest cover makes them less vulnerable to passive dispersal by winds than is the case for odonates that habitually swarm above the canopy. Downstream dispersal of eggs or young larvae by river currents could result in the establishment of new subpopulations where suitable unoccupied habitat exists.

Interspecific Interactions

Interspecific interactions are unknown for Riverine Clubtail. Both adults and larvae are probably generalist predators, feeding on a wide range of prey species within the suitable size range.

Predators on Riverine Clubtail larvae include Smallmouth Bass (*Micropterus dolomieu*), bullheads (*Ameiurus* spp.), Northern Pike (*Esox lucius*), and Rock Bass (*Ambloplites rupestris*), all of which were observed at QC sites in 2011. Lake Sturgeon (*Acipenser fulvescens*) is a potential predator at some MB and QC sites. Emerging larvae and teneral adults are predated upon by birds, frogs, and Raccoon (*Procyon lotor*). Potential adult predators include insectivorous birds such as Eastern Kingbird (Tyrannus tyrannus) or Great Crested Flycatcher (Myiarchus crinitus), and larger dragonflies such as the Dragonhunter (Hagenius brevistylus), which co-occur on most rivers with Riverine Clubtail (iNaturalist 2022).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Most surveys for Riverine Clubtail in Canada have been conducted to determine their presence/absence rather than to measure abundance (see **Search Effort**).

Abundance

Estimating total population sizes for odonates is difficult (Corbet 1999). There is insufficient data available to estimate the Canadian population.

Most Canadian records consist of six or fewer adults and/or emerging larvae at a given date and site (Tables 3 and 4). Catling *et al.* (1999) observed up to 10 adults along 100 m of Big Creek, and approximately 25 adults along the 250 m stretch surveyed on July 11, 1999. Riverine Clubtail does not appear to have mass emergence like some other gomphids. Exuviae counts are one measure used to estimate abundance; however, no reliable estimates have been completed for Riverine Clubtail.

Fluctuations and Trends

Trends in Canadian population size are unknown due to a lack of repeated, quantitative surveys. The only evidence of trend data come from repeated sightings at some subpopulations (see Table 1).

Riverine Clubtail has not shown a range-wide population decline (Paulson 2009b). The species is apparently declining in North Carolina (LeGrand pers. comm. 2011) and known only from historical records in Georgia (Beaton pers. comm. 2022), Maryland (McCann pers. comm. 2022), New York (White pers. comm. 2022), and Pennsylvania (Leppo pers. comm. 2011). In contrast, it is thought to be more common in Wisconsin (Smith pers. comm. 2011) and New Hampshire (Cairns pers. comm. 2011) and was recently recorded in Tennessee (Abbott 2022).

Rescue Effect

The likelihood of natural dispersal from United States populations is relatively low and genetic exchange between Canadian and United States populations is probably infrequent or non-existent. Rescue from adjacent jurisdictions is unlikely; populations are imperiled in all adjacent states. Quebec subpopulations are approximately 300 km from the nearest known records in Vermont (S1), the southern ON subpopulation is 240 km from the nearest known populations in Michigan (S1S3), and there is little suitable intervening habitat. Manitoba subpopulations are approximately 230 km from the nearest known occurrence in Minnesota (where they are considered uncommon statewide, Mead pers. comm. 2011) and approximately 200 km from the nearest occurrence in North Dakota (Abbott 2022).

THREATS AND LIMITING FACTORS

Threats

The threats to Riverine Clubtail were assessed over the entire Canadian range in accordance with the IUCN-CMP (International Union for the Conservation of Nature–Conservation Measures Partnership) unified threats classification system (see Salafsky *et al.* 2008 for definitions and Master *et al.* 2012 for guidelines). The threat assessment process consists of assessing impacts for each of 11 main categories of threats and their subcategories, based on the scope (proportion of population exposed to the threat over the next 10-year period), severity (predicted population decline within the scope during the next 10 years or 3 generations, whichever is longer up to ~100 years), and timing of each threat. The overall threat impact is calculated by considering the separate impacts of all threat categories.

The overall threat impact for Riverine Clubtail is medium which corresponds to an anticipated further decline of between 3% and 30% over the next ten years. These values are to be interpreted with caution, as they may be based on subjective information, such as expert opinion. However, efforts have been made to corroborate the scores with available studies and quantitative data. Details are discussed below, from highest to lowest threat impact, using the IUCN-CMP headings and numbering scheme.

IUCN Threat 9. Pollution (overall threat impact Medium-Low)

9.1 Domestic & urban wastewater (Unknown impact)

Pollution consisting of domestic and urban wastewater impacts the egg and larval life stages and is a likely threat at most subpopulations of Riverine Clubtail (Table 5). Subpopulations within urban areas in MB (#1), southern ON (#2, #3, #6) and southern/eastern QC (#9, #12, #13, #16) are the most likely to be impacted. The subpopulations within central/northern ON (#4, #6, #7) and northerly sites in QC (#8, #10, #11, #14, #15) are less likely to be impacted, although some wastewater input likely occurs from cottages and small urban developments.

The application of road salt has the potential to adversely affect water quality and thereby healthy growth at the dragonfly's larval life stage (Castillo *et al.* 2018). Subpopulations near urban areas (i.e., MB, southern and eastern QC) are at greater risk of this threat. Chloride concentrations in watercourses are positively correlated with human population and road density (Todd and Kaltnecker 2004, 2012; Sorichetti *et al.* 2022). Chloride concentrations are expected to increase in rivers as urban centres expand, although in the next 10 years this threat is expected to remain constant. The persistence of Riverine Clubtail in urban areas such as Winnipeg, Gatineau and Quebec City suggests some tolerance to chloride, although the level of tolerance is unknown.

Big East River (#5) is crossed by Highway 11. Road salt is used throughout the colder months of the year to control ice hazards on the highway. During spring when ice begins to melt, runoff may impair water quality downstream of Big East River and before Lake Vernon. Lawncare and mosquito control chemicals used by private residences abutting the south shore of Big East River may also impair downstream water quality although impacts are unknown (Mills pers. comm. 2022).

Anthropogenic hormones and prescription drugs have the potential to impact water quality and aquatic species (Vajda *et al.* 2008). These hormones include estrogenic and androgenic compounds and are found in high concentrations in rivers, including those throughout the range of Riverine Clubtail (Arlos *et al.* 2015; Cantwell *et al.* 2018). Effects of these compounds have been documented in fish, although impacts to aquatic invertebrates are inconclusive.

9.2 Industrial & military effluents (Unknown impact)

The impacts of industrial and military effluents entering waterways containing Riverine Clubtail subpopulations remains unknown. The Winnipeg (#1) and St. Lawrence River (#13) (Table 5) subpopulations are located near industrial areas, although the impacts are unknown. Trucking facilities are present in Walsingham, adjacent to Big Creek (#3) and < 250 m from this subpopulation, and a tissue factory is located approximately 8.5 km downstream of Big East River (#5). The nature of industrial effluents and their potential impacts on Riverine Clubtail subpopulations are unknown. Industrial facilities are largely absent in proximity to the other known subpopulations.

9.3 Agricultural & forestry effluents (Medium-Low impact)

Intensive agricultural land use is predominantly applicable areas adjacent to the Norfolk and Middlesex County subpopulations in ON (#2, #3, #6) and the Assiniboine and Red Rivers in MB (#1) (Table 5). The use and harmful effects of fertilizers, pesticides, and sediment that enter the water from adjacent agricultural lands are known to impair insect larval development and survivorship (Beketov and Liess 2008; Stoughton *et al.* 2008; Jinguji *et al.* 2013).

Insecticides, including neonicotinoids, have a high runoff and leaching potential and are often present in aquatic environments adjacent to agricultural lands (Bonmatin *et al.* 2015). Numerous studies have confirmed that these chemicals have widespread negative impacts on non-target invertebrates (Pisa *et al.* 2015). Aquatic invertebrates such as odonates are particularly susceptible to pesticides because the chemicals mix with the aquatic habitat and eggs/larvae cannot easily move to uncontaminated areas (Pisa *et al.* 2015). A study on the impacts of imidacloprid and fipronil on odonates showed that survival of *Sympetrum* larvae decreased by nearly 64% after exposure to imidacloprid (52.8 µg/L at 24 hrs) and by 18% for fipronil (1.38 µg/L at 6 hrs) (Jinguji *et al.* 2013). Mean concentrations of neonicotinoids in the environment are found to be lower than these levels (Berens *et al.* 2021); however, macroinvertebrate abundance has been shown to consistently decline along a gradient of increasing imidacloprid concentrations (Van Dijk *et*

al. 2013). Riverine Clubtail larvae prey on macroinvertebrates and these food sources are likely impacted by the presence of these chemicals in the water. For example, mayfly, mosquito and *Chironomus* midges were found to be sensitive to these chemicals (Beketov and Liess 2008; Stoughton *et al.* 2008).

The Government of Canada has released new guidelines for the application of neonicotinoids in response to concerns related to aquatic insects, and these guidelines include revised pesticide application rates and spray buffer zones (Government of Canada 2020). A previous proposal was aimed at banning imidacloprid chemicals; however, this decision was reversed based on evidence that the concentrations of neonicotinoids may not be as high as initial studies had documented (Government of Canada 2021a). Some provinces, including Ontario, have reduction targets in place, to reduce potential impacts from these chemicals on insect populations. In 2015, ON established the goal of reducing the treatment of corn and soybean seeds with neonicotinoids by 80% by 2017 (Government of Ontario 2017). However, in 2019, previous provincial legislation related to the prohibition and regulation of sales of neonicotinoids in ON was amended under Bill 132 (Legislative Assembly of Ontario 2019), and the widespread use of these chemicals in agricultural settings continues.

The effects of insecticides on aquatic invertebrate populations are compounded by other known stressors, such as sedimentation, and lead to a reduction in their abundance (Chara-Serna and Richardson 2017). It is unknown whether Riverine Clubtail larvae are impacted by sedimentation, given this species' preference for sandy rivers and the (presumed) tendency of this species to burrow in fine sediments.

Nitrate and phosphorus concentrations in the Big Otter Creek (#2) and Big Creek (#3) watersheds, which are approximately 78% farmland, consistently exceed the Canadian Guidelines and Provincial Water Quality Objectives (PWQO) (Lake Erie Source Protection Region Technical Team 2008). Over half of the monitoring stations on rivers and streams within the Long Point Region Conservation Authority watershed were found to have levels exceeding the PWQO for phosphorus, although both Big Otter and Big Creek were given grades of "fair" water quality (LPRCA 2018). Increasing phosphorus and nitrate levels could threaten Riverine Clubtail larvae by promoting eutrophication and decreasing dissolved oxygen availability. Impacts to Riverine Clubtail from fertilizer runoff containing nitrates, nitrites and phosphorus has not been studied. Some studies have found that benthic invertebrate abundance may decrease as much as threefold in watercourses adjacent to agricultural land where elevated levels of nitrates, nitrites and phosphorus levels are found (Quinn *et al.* 2010).

The remaining Riverine Clubtail subpopulations are found in predominantly forested habitats and threats from agricultural effluents are not applicable (#5, 7-17). The Big East River (#5) subwatershed is 98% forested and none of the lakes within the catchment for this river were found to be impacted by phosphorus or other agricultural contaminants (Muskoka Watershed Council 2018).

The RYAM sawmill is located west of Highway 11 near Big East River (#5). Potential impacts to the dragonfly from this facility have not been studied. A pulp mill near Saint-Félicien (QC) on the Ashuapmushuan River (#15) discharges industrial effluent directly into the river approximately 10 km upstream of this subpopulation and could potentially impair water quality for the species (Desrosiers pers. comm. 2022). Water quality on the Mistassini (#14) and Ashuapmushuan (#15) rivers in eastern QC is poor (Ministère de l'Environnement et de la Lutte contre les changements climatiques 2022).

In addition to being exposed to agricultural pollutants, approximately 75 km of both Big Creek (#3) and Big Otter Creek (#3) have been treated with TFM (3-trifluoromethyl-4-nitrophenol) every 3–4 years on average since 1986–1987 to control Sea Lamprey (*Petromyzon marinus*) (Sea Lamprey Control Centre, Sault Ste. Marie, unpubl.). Although dragonfly larvae appear to be resistant to TFM (Smith 1967; Maki *et al.* 1975), impacts on their prey species and other aspects of the stream ecosystem are unknown.

IUCN Threat 1. Residential & Commercial Development (overall threat impact Low)

Threats from residential and urban development are related to the loss of riparian tree cover which is critical for foraging, staging and resting adult dragonflies. Riverine Clubtail has been found in urban parks within Winnipeg (#1), suggesting that large forested areas may not be required for subpopulation persistence. However, whether this subpopulation is increasing or decreasing is unknown.

1.1 Housing and urban areas (Low impact)

Habitat alteration within the urban centre of Winnipeg may be unlikely given that these areas are already substantially built-out, and riparian areas are protected from additional development by regulations related to flooding.

Most of the subpopulations in ON and QC are located away from urban centres, although private residences are present along most of the rivers where the species is found. Big East River (#5) is protected along the northern shoreline by the associated provincial parks (Arrowhead and Big East River); however, there are homes along the southern shoreline has existing residences, with the potential for additional development. Due to concerns about substantial shoreline erosion on Big East River, some landowners have constructed cinder block walls and other erosion control measures to prevent loss of shoreline property, which degrades riparian habitat for this species (Mills pers. comm. 2022). Habitat at Aux Sables River (#4) is mostly protected from housing development by Chutes Provincial Park. However, south of Highway 17 near Massey, development has degraded a portion of riparian habitat through the removal of adjacent vegetation. Nonetheless, tree cover along the Spanish River remains high (Google Earth 2021). In Ontario, provincial policies restrict development within floodplains and provide some woodland protection. Consequently, substantial tree removal associated with urban developmental is unlikely (Ontario Ministry of Municipal Affairs and Housing 2020).

There is low human population growth in the small communities near these Norfolk County sites (such as Tillsonburg) (Statistics Canada 2017). Development pressure is low and unlikely to result in substantial alterations to riparian habitat. Much of the remaining tree cover is located within the floodplain and is also protected by provincial policies (Long Point Region Conservation Authority 2013; Ontario Ministry of Municipal Affairs and Housing 2020).

Subpopulations on the St. Lawrence River (#13) and tributaries of the Ottawa and Gatineau rivers (#9) are near areas altered by residential and urban development (Google Earth 2021), including the removal of riparian vegetation and alteration of shoreline habitat. This is also evident along the St. Lawrence River near Quebec City and reaches of the Rivière Bastican (#12) near Saint-Adelphe. Along the Rivière Rouge near L'Ascension (#11), vegetation has been removed up to the waterline around riverside private residences. However, this river and other Ottawa River tributaries continue to have high forest cover, particularly in comparison with the eastern subpopulations in QC (Google Earth 2021). The exception to this is the Gatineau River subpopulation (#9). Residential development extends to the river edge at this site and riparian tree cover ranges from 0 to 350 metres (Google Earth 2021).

Significant changes to tree cover along the rivers inhabited by Riverine Clubtail are not expected in the next 10 years since policies restricting riparian tree removal are in place at the local, provincial, and federal levels.

IUCN Threat 4. Transportation & Service Corridor (overall threat impact Low)

4.1 Roads & railroads (Low impact)

Roads and/or railroads bisect all the rivers with Riverine Clubtail subpopulations. Impacts include direct mortality to adults from vehicle/train collisions, and potential sedimentation/chloride impacts to larvae through road runoff. The scope of road or rail mortality is unknown. Roads with traffic speeds greater than 50 km/hour probably pose the greatest risk, although large highways with wide cleared areas tend to kill fewer odonates (Brunelle pers. comm. 2007). All rivers with Riverine Clubtail subpopulations have several bridge crossings, most of which have speed limits higher than 50 km/hour. The subpopulation on the Big East River (#5) is located immediately adjacent to Highway 11 and vehicle collisions likely cause some incidental adult mortality (Mills pers. comm. 2022).

IUCN Threat 5. Biological Resource Use (overall threat impact Low)

5.3 Logging & wood harvesting (Low impact)

Forested habitat adjacent to waterways is important for adult foraging, staging, mating and resting. Threats from logging and wood harvesting are applicable to subpopulations in central ON (#4, #5, #7) and along the QC tributaries of the Ottawa and Gatineau Rivers (#8, #10, #11). The other subpopulations (#1, 2, 3, 6, 12, 13) have sparse forest cover and/or evidence of historical logging and future logging is unlikely (Table 5).

Numerous sites in southern QC show evidence of tree removal within the past decade. Habitat along the Rivière Coulonge near Leclair, downstream from a subpopulation (#8), has undergone approximately 12 ha of selective logging adjacent to the watercourse since 2009. An area near the Rivière Picanoc sites (#9) shows 100 ha of logging, and on the Rivière Rouge (#11) along Chemin de Iles north of L'Ascension 150 ha of forest has been selectively logged or clear-cut, leaving an approximately 20 m wide woodland buffer strip in accordance with the *Forest Act* (Ministère du Travail, de l'Emploi et de la Solidarité sociale 2013; Google Earth 2021; Global Forest Watch 2022). In some cases, harvesting appears to be within, or partially within, existing plantations. It appears that mixed-deciduous forest is being replaced by conifer plantations at various sites, although it is unclear what impact this could have on a canopy foraging species such as Riverine Clubtail. Despite the tree removal that has occurred in southern QC, forest cover in these regions remains higher than in areas where other subpopulations are found, except for the subpopulations in central/northern ON (Google Earth 2021).

The central/northern ON subpopulations do not appear to be directly impacted by logging or wood harvesting. The persistence of Riverine Clubtail within sparsely forested areas suggests that impacts to the species from the removal of tree cover deserves further study.

IUCN Threat 7. Natural System Modifications (Overal threat impact Unknown)

7.2 Dams & water management/use (Unknown impact)

Dam construction is a historical threat. Dams are operated for recreation, water supply, flood control and flow augmentation (Lake Erie Source Protection Region Technical Team 2008). Dams and water control structures are present on most of the watercourses with Riverine Clubtail subpopulations. The main ongoing threat from such structures is the alteration of aquatic and shoreline characteristics. Small changes in the use of dams and water level regulation can cause changes to natural patterns of sediment accumulation and can alter water temperature regimes. Although water management associated with dams continues to impact the characteristics of these rivers, Riverine Clubtail continues to persist at these subpopulations. No new dam projects are proposed on rivers with Riverine Clubtail subpopulations.

The water levels on the Assiniboine River and the Red River (#1) are controlled to mitigate flood risks. The Red River floodway diverts flows from the main river channel through Winnipeg. A control structure is also present on the Assiniboine River at Portage la Prairie and near Riverine Clubtail sites.

The Aux Sables (#4) and Big East (#5) rivers do not have dams or water control structures. Decommissioned dams are present within the Big East River watershed, including the Distress Dam approximately 25 km upstream from the existing subpopulation near Highway 11 (Bowles and Sõber 2005). Hydroelectric dams were proposed at sites along the Vermilion River (#7) but applications have been withdrawn (Vermilion River Stewardship 2019).

Big Creek (#3), Big Otter Creek (#2) and their tributaries have dams and other water control structures and are regulated for flood control. Dams are present on Big Otter Creek upstream of Tillsonburg at Norwich and at Otterville. Big Creek has a dam and reservoir at Teeterville (upstream from Delhi) and on the North Creek and South Creek tributaries. Deer Creek, a major tributary of Big Creek, also has a reservoir.

Water extraction for agricultural irrigation likely occurs at Big Creek and Big Otter Creek. Irrigation can significantly reduce summer creek flows, particularly in dry summers (Lake Erie Source Protection Region Technical Team 2008). This reduces wetted width and water depth, increases water temperature, and decreases water quality by concentrating pollutants. These water quality changes increase larval vulnerability to chemical spills and sea lamprey control treatments.

The growing human population in southern ON and global warming could put increased pressure on scarce water supplies and affect flows in Big Otter Creek and Big Creek. Recent dry periods have resulted in substantial stress in the farming community and, although there has been some planning to reduce future stresses, it has not addressed the needs of Riverine Clubtail or other aspects of the aquatic environment of the creeks (Shortt *et al.* 2006). Increased water resource demands are expected in the Norfolk Sand Plain area (Wong and Bellamy 2005).

Dams present along Quebec rivers and tributaries may have degraded Riverine Clubtail habitat by converting potentially suitable riverine habitat into lentic reservoir habitats, and by altering natural flow regimes. The main channel of the Ottawa River has seven dams and more than 300 dams on its tributaries (Thorp *et al.* 2005). There are four dams on the Gatineau River, including the Chelsea Dam immediately upstream from Riverine Clubtail occurrence at Gatineau (Ottawa Gatineau Watershed Atlas 2012). The Mercier Dam created the 300 km^2 Baskatong Reservoir in 1927 and the 434-km^2 Cabonga Resevoir was created in 1928 (QCT 2022). The Dozois Reservoir and flow throughout the Gatineau River is controlled to reduce spring peaks (MDDEP 2012). On the Rivière Coulonge, a hydroelectric dam was built at the head of the Grandes Chutes in 1994 (Government of Quebec 1992). This dam immediately downstream of subpopulation #8 may have raised water levels and altered the flow regime in this reach of the river (data on water level changes are unavailable). The mouth of the Rivière de la Petite-Nation (#16) was flooded by the Carillion hydroelectric dam on the Ottawa River; Riverine Clubtail has only been found above the waterfalls near Plaisance on this river.

7.3 Other ecosystem modifications (Unknown impact)

Other ecosystem modifications include indirect threats to the species, such as threats to food (i.e., prey). Riverine Clubtail larvae feed on benthic invertebrates, which change in abundance depending on water quality. Chironomid midges, tubificid worms, and burrowing mayflies are affected by increases in salinity (Bright and O'Brien 1999; Castillo *et al.* 2018). Macroinvertebrates in cold climates (such as those inhabited by Riverine Clubtail) are more sensitive to the effects of salinity than those in warmer environments (Castillo *et al.* 2018).

Invasive species likely to be detrimental to the aquatic habitat characteristics needed to sustain Riverine Clubtail subpopulations include Curly Pondweed (*Potamogeton crispus*) and Zebra Mussel (*Dreissena polymorpha*). Zebra Mussels have been found in the reservoir on Big Otter Creek (#2) upstream from Tillsonburg (Dextrase pers. comm. 2009) and have the potential to alter water chemistry through filtration, which increases water clarity and plant growth (Bulté *et al.* 2012). This species also occurs broadly throughout the Great Lakes basin as well as in MB (although not at Riverine Clubtail habitats) and along the St. Lawrence River (Government of Canada 2021b).

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

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

Many invasive aquatic species are present throughout the Canadian range of Riverine Clubtail. Species likely to predate on Riverine Clubtail larvae include Common Carp (*Cyprinus carpio*), Round Goby (*Neogobius melanostomus*), and Rusty Crayfish (*Orconectes rusticus*). Subpopulations that are likely to be most affected are those where boat traffic and fishing is prevalent such as in MB (#1), southwestern ON (#2, #3, #6), and QC subpopulations along the St. Lawrence River (#13) (Table 5).

Rainbow Trout (*Oncorhynchus mykiss*) has increased in abundance at the subpopulations in Norfolk County (#2, #3) through directed efforts to improve the fishery and the spring run (Dextrase pers. comm. 2009). It is unclear what impact this abundance would have on Riverine Clubtail.

Rusty Crayfish occurs widely throughout the Great Lakes basin and the St. Lawrence River (Conard *et al.* 2015) and has the potential to impact all subpopulations through predation of eggs or larvae (Gunderson 1999). To date, this species has not been reported in MB, although it is located close to the border with ON (Government of Manitoba 2022).

Round Goby is present in all five Great Lakes and many tributaries throughout Ontario (Government of Ontario 2022). This species was introduced to Big Otter Creek (#2) and Big Creek (#3) circa 2004 and is now common and widespread. These highly aggressive and often abundant predators are likely the greatest threat related to invasive species in these systems (Dextrase pers. comm. 2009). Round Goby feeds on a wide range of benthic invertebrates (MNRF 2022), and Riverine Clubtail larvae are particularly vulnerable when they leave the sediment at the time of emergence. Round Goby invasion has altered the

benthic invertebrate community of several eastern Lake Erie tributary streams (Krakowiak and Pennuto 2008). Round Goby also occurs within the St. Lawrence River (#13) in QC and has been found to cause changes to the littoral fish communities in these areas (Morissette *et al.* 2018). Round Goby is not known to occur at Riverine Clubtail subpopulations in MB, at inland sites in central/northern ON or elsewhere in QC.

The overall impact of these and other invasive species on Riverine Clubtail is unknown. Nonetheless, the persistence of the dragonfly in areas where invasives occur suggests some tolerance, at least in the short term.

IUCN Threat 11. Climate change and severe weather (overall threat impact Unknown)

11.1 Habitat shifting & alteration (Unknown impact)

Habitat shifting and alteration due to climate change has the potential to negatively influence odonate species (Collins and McIntyre 2017). This may occur as climatic warming causes waterbodies to increase in temperature beyond the optimal range for dragonfly larval development. Changes in water temperature can reduce larval growth rate and size, which affects adult survivorship and reproduction (Sweeney and Vannote 1978). Based on current climate modelling, many riverine species in the northeastern United States are expected to experience range contractions, particularly at southern locales, as previously inhabited waterbodies will become unsuitable with continued warming (Collins and McIntyre 2017). Given that in Canada Riverine Clubtail occurs at the northern extent of its global range, it is unclear how this species will be impacted by habitat shifting and alteration caused by climate change. Current data suggest that, unlike lentic species, lotic species such as Riverine Clubtail are unlikely to substantially expand their ranges northward with climate change (Grewe *et al.* 2013).

11.2 Droughts (Unknown impact)

Climate change induced droughts have the potential to exacerbate other impacts on Riverine Clubtail by reducing baseflows in the rivers used by this species for larval development. The effects of drought are likely to be amplified at subpopulations located on smaller rivers in areas with high levels of water withdrawal for agricultural irrigation. The tolerance of Riverine Clubtail larvae to reduced base flows and lower water levels unknown.

11.4 Storms & flooding (Unknown impact)

Precipitation and flooding are projected to increase because of climate change (Melillo *et al.* 2014). An increase in the frequency and severity of storm events can adversely affect the survival of emerging dragonfly adults (Thompson 1990). The overall impact on Riverine Clubtail is unknown.

Limiting Factors

Limiting factors for Riverine Clubtail are not well understood. The species' larval habitat appears to be restricted to sandy-bottomed rivers and its dispersal ability may limit its ability to colonize new sites. Aquatic predators on the larval life stage may limit its abundance within an area.

Number of Locations

There are 17 (based on the number of extant subpopulations) to 22 (estimate based on the number of waterways the species occurs) locations[3] proposed for Riverine Clubtail. The most serious plausible threat to this species is water pollution (Table 5) given that the species occurs in 22 different waterways, all of which may be exposed to sources of water pollution. Locations have been identified as separate from one another where observations are located on a different watercourse regardless of proximity, since water quality threats could vary between sites.

Table 5. Riverine Clubtail (Stylurus amnicola) subpopulation-specific threats.

Subpopulation Number	Subpopulation Name	1.1 Housing & urban areas	1.2 Commercial & industrial areas	4.1 Roads & railroads	5.3 Logging & wood harvesting	6.1 Recreational activities	7.2 Dams & water management	7.3 Other ecosystem modifications	8.1 Invasive non-natives	9.1 Household sewage & urban wastewater	9.2 Industrial & military effluents	9.3 Agricultural & forestry effluents	11.1, 11.2 and 11.3 Climate change
1	Manitoba	X	X	X		X	X	X	X	X	X	X	X
2	Big Otter Creek	X		X		X	X	X	X	X	X	X	X
3	Big Creek	X		X		X	X	X	X	X	X	X	X
4	Aux Sables			X	X	X	X	X	X	X			X
5	Big East River			X		X	X	X	X	X			X
6	Middlesex County	X		X		X	X	X	X	X	X	X	X
7	Vermilion River			X		X	X	X	X	X	X	X	X
8	Rivière Coulonge			X	X		X	X	X				X
9	North Gatineau River and Tributaries			X	X		X	X	X				X
10	Southern Gatineau River	X		X		X	X	X	X	X	X		X

[3] 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 (IUCN 2010, 2011). In the absence of any plausible threat for the taxon, the term "location" cannot be used, and the sub-criteria that refer to the number of locations will not be met (IUCN 2010, 2011).

Subpopulation Number	Subpopulation Name	1.1 Housing & urban areas	1.2 Commercial & industrial areas	4.1 Roads & railroads	5.3 Logging & wood harvesting	6.1 Recreational activities	7.2 Dams & water management	7.3 Other ecosystem modifications	8.1 Invasive non-natives	9.1 Household sewage & urban wastewater	9.2 Industrial & military effluents	9.3 Agricultural & forestry effluents	11.1, 11.2 and 11.3 Climate change
11	Rivière Rouge			X	X		X	X	X				X
12	Rivière Bastican			X	X		X	X	X	X			X
13	St. Lawrence River	X	X	X		X	X	X	X	X	X	X	X
14	Rivière Mistassini			X	X		X	X	X	X	X	X	X
15	Rivière Ashuapmushuan			X	X		X	X	X		X	X	X
16	Rivière Petite-Nation	X		X			X	X	X	X	X	X	X
17	Jacques-Cartier River in St-Catherine-de-la-Jacques-Cartier			X		X	X	X	X	X		X	X

PROTECTION, STATUS AND RANKS

Legal Protection and Status

In the first COSEWIC (2012) status report, Riverine Clubtail was assessed as three DUs: the Boreal population (Data Deficient), the Great Lakes Plains population (Endangered), and the Prairie population (Data Deficient) (COSEWIC 2012). The Great Lakes Plains population was listed under Schedule 1 of the federal *Species at Risk Act* (SARA) on February 2, 2018. The Boreal and Prairie populations are not listed under SARA.

The Riverine Clubtail Great Lakes Plains population was listed under the Ontario *Endangered Species Act* (ESA) on June 27, 2014. The provincial recovery strategy recommends that regulated habitat under the ESA include up to 30 m of riparian vegetation to maintain river quality and protect teneral dragonflies, in addition to broad-leaved vegetation such as trees, shrubs, and thickets extending inland 200 m (Mlynarek 2015). Regulated Habitat for Riverine Clubtail has not been added to Ontario Regulation 242/08 of the ESA.

In 2021, the federal recovery strategy for Riverine Clubtail defined critical habitat as the portion of the watercourse 200 m upstream and downstream of a known observation as well as the terrestrial habitat within 200 m of this portion of the watercourse (ECCC 2021).

Riverine Clubtail is not protected under Manitoba's *Endangered Species and Ecosystems Act* (C.C.S.M. c. E111, Regulation 25/38) or under the *Loi sur les espèces menacées ou vulnérables du Québec (*Act respecting threatened or vulnerable species, E-12.01 r.2).

Riverine Clubtail is not listed federally under the United States *Endangered Species Act*.

Non-Legal Status and Ranks

The national and subnational conservation status ranks for Riverine Clubtail are shown in Table 2. Riverine Clubtail is listed as Least Concern on the International Union for the Conservation of Nature (IUCN) Red List (Paulson 2017).

Habitat Protection and Ownership

Ontario

The Big East River subpopulation (#5) is located within the Big East River Provincial Park (the boundaries of which are limited to the bed of the river and its banks up to the high-water mark) and immediately south of Arrowhead Provincial Park. The south bank of the Big East River abuts privately owned land. Therefore, habitat for this subpopulation of Riverine Clubtail is protected under the *Ontario Provincial Parks Act* as well as under general habitat provisions of the provincial ESA (Mills pers. comm. 2022). The species occurs within Chutes Provincial Park on the Aux Sables River (#4), and much of the habitat at this site is also protected under the *Provincial Parks Act*. All southern ON occurrences are on private land and road allowances and are protected under the general habitat provisions of the Ontario ESA.

Manitoba

Several sites on the Red and Assiniboine rivers (#1) are in municipal parks. Most QC occurrences appear to be on private land or on provincial government land, except for the site at the Rivière de la Petite-Nation (#16), which is in a municipal and regional park, and one site near Quebec City (#9) that is adjacent to a municipal park.

Federal protection

The instream habitats of Riverine Clubtail are indirectly protected under the federal *Fisheries Act*.

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Peter Mills took the cover photo and Allan Harris took the photos in Figures 1-4.

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Desta Frey, M.Sc., has over 10 years of experience conducting biological research. As an NRSI biologist, Desta regularly carries out insect surveys targeting odonates throughout Ontario, as well as surveys for a variety of other taxa. She has been the lead field investigator for the Kapuskasing River project targeting the Broad-tailed Shadowdragon and conducted exuviae and netting surveys under the direction of Nathan Miller. In southern Ontario, Desta leads insect surveys at proposed development sites to identify suitable habitats and determine the presence of sensitive odonate species. One of her current projects involves the development of a mitigation and habitat restoration plan targeting Unicorn Clubtail (*Arigomphus villosipes*), a provincially rare species that Desta identified during surveys in 2020.

Kathryn Hoo, B.Sc., has over 9 years of professional experience conducting wildlife surveys and studies on a wide range of taxa, including odonates and other insects. As a Terrestrial & Wetland Biologist at NRSI, Kathryn leads natural resource inventories and evaluations, environmental impact studies, and research, and has extensive experience working on projects focused on species at risk and species of conservation concern. She regularly carries out insect surveys targeting odonates at a variety of sites in Ontario, is familiar with various field survey techniques and has experience identifying sensitive species and their habitats. Kathryn is also experienced in the preparation of COSEWIC status reports and is the primary writer on the updated COSEWIC Status Report on Eastern Whip-poor-will (*Antrostomus vociferus*) (unpublished).

Nathan Miller, M.Sc., has over 15 years of experience carrying out insect surveys and studies on a wide range of insect taxa including odonates. Nathan's insect related experience has been accrued through his time working as a graduate student, naturalist, and environmental consultant. While working as a Terrestrial & Wetland Biologist at Natural Resource Solutions Inc. (NRSI), Nathan has planned and completed many projects requiring odonate surveys, including area searches/netting of adult dragonflies and damselflies, habitat assessments for odonate species at risk, collection/identification of exuviae of a wide range of odonates and evaluations of impacts of development on sensitive odonate species. Nathan's research on insect species has been funded by the American Conservation Foundation, Global Forest Pure Science and the Explorer's Club among others and his research has been published in several prestigious scientific journals such as Biology Letters (Royal Society) and Behavioral Ecology.

COLLECTIONS EXAMINED

Canadian National Collection of Insects (CNCI). Owen Lonsdale, Collection Manager, Agriculture and Agri-Food Canada, 960 Carling Avenue, Ottawa, Ontario, Canada, K1A 0C6.

- Clemson University. Mike Ferro, Clemson University Arthropod Collection, Clemson University, 307 Long Hall, Clemson, South Carolina, United States, 29634.
- Collection Ouellet-Robert. Colin Favret, Université de Montréal, 4101 East Sherbrooke Road, Montreal, Quebec, Canada, H1X 2B2.
- Florida State Collection of Arthropods. Ken Tennessen, Research Associate, University of Florida, 1911 SW 34th St, Gainesville, Florida, United States, 32608.
- Manitoba Museum. Randall Mooi, Curator of Zoology, 190 Rupert Avenue, Winnipeg, Manitoba, R3B 0N2.
- North Dakota State University. Garald Fauske, Curator, North Dakota State University, 1230 Albrecht Boulevard, Fargo, North Dakota, United States, 58102.

- Royal Ontario Museum (ROM). Brad Hubley, Entomology Collection Manager, Department of Natural History, 100 Queen's Park, Toronto, Ontario, Canada, M5S 2C6.
- University of Alabama. John Abbott, Chief Curator & Director of Museum Research and Collections, University of Alabama, 357 Mary Harmon Bryant Hall, Box 870340, Tuscaloosa, Alabama, United States, 35487
- University of Guelph Insect Collection. Steven Paiero, Curator, University of Guelph, 601 Gordon St, Guelph, Ontario, Canada, N1G 1Y2
- University of Kansas. Zachary Falin, Collections Manager, University of Kansas, Biodiversity Institute, 1501 Crestline Drive, Suite 140, Lawrence, Kansas, United States, 66045-4401.
- University of Minnesota. Robin Thomson, Curator, University of Minnesota, 1980 Folwell Avenue, 219 Hodson Hall, St. Paul, Minnesota, United States, 55108.
- Western University. Nina Zitani, Curator, Zoological Collections & Assistant Professor, Western University, Room 0124, BGDSB, London, Ontario, Canada, N6A 5B7

Appendix 1. Results for the Riverine Clubtail (*Stylurus amnicola*) 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 CMP (2010). Threats may be observed, inferred, or projected to occur in the near term. Threats are characterized here in terms of scope, severity, and timing. Threat "impact" is calculated from scope and severity. For information on how the values are assigned, see Master *et al.* (2012) and footnotes to this table.

Species Scientific Name	Riverine Clubtail (*Syylurus amnicola*)
Date:	September 12, 2022
Assessors:	Nathan Miller (report writer), Jennifer Heron (facilitator & Co-chair), David McCorquodale (Co-chair), Robert Buchkowski (SSC), Allan Harris (SSC), John Klymko (SSC), Jayme Lewthwaite (SSC), John Richardson (SSC), Chris Friesen (MB), Isabelle Gauthier (QC), Peter Mills (external expert), Holly Bickerton (ECCC), Larry de March (external expert), Joanna James (COSEWIC Secretariat), Marie-Eve Corbin (COSEWIC Secretariat).
References:	Environment and Climate Change Canada. 2021. Recovery Strategy for the Riverine Clubtail (*Stylurus amnicola*), Great Lakes Plains population, in Canada. Species at Risk Act Recovery Strategy Series. Environment and Climate Change Canada, Ottawa. 3 parts, 37 pp. + v + 22 pp. + 5 pp. Mlynarek, J. 2015. Recovery Strategy for Riverine Clubtail (*Stylurus amnicola*) in Ontario. Ontario Recovery Strategy Series. Prepared for the Ontario Ministry of Natural Resources and Forestry, Peterborough, Ontario. v + 22 pp.

		Level 1 Threat Impact Counts	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	0	0
C	Medium	1	0
D	Low	3	4
	Calculated Overall Threat Impact:	High	Medium

Assigned Overall Threat Impact:	**C=Medium**
Impact Adjustment Reasons:	Several subpopulations persist in highly urbanized and agricultural environments, suggesting the species is tolerant of some levels of pollution. The species is wide ranging and has a large distribution within many habitats; threats are likely lower than calculated and there could be some double-counting of threats.
Overall Threat Comments	The species limiting factors may include dispersal ability and limited sandy-bottomed riverine habitats for larval development.

Threat		**Impact (calculated)**		**Scope (next 10 Years)**	**Severity (10 Years or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development	D	Low	Small (1-10%)	Moderate - Slight (1-30%)	High (Continuing)	
1.1	Housing & urban areas	D	Low	Small (1-10%)	Moderate - Slight (1-30%)	High (Continuing)	See Threats and Limiting Factors.

Threat		Impact (calculated)		Scope (next 10 Years)	Severity (10 Years or 3 Gen.)	Timing	Comments
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Serious - Moderate (11-70%)	High (Continuing)	In general, development is historical and new development is sparse along most rivers. Potential for small footprint development is present at #1, 10, 13, which are also urban centres. More remote sites (e.g., #8, #9, #11, #14-16) have some commercial and industrial land use nearby. The newly recorded sites in Central Ontario near Chutes Provincial Park (#4) and Big East River Provincial Park (#5) have some trucking operations and small distribution centres. The Kimberley-Clark Corporation has a factory along Big East River downstream of the known subpopulation of Riverine Clubtail with infrastructure located near the river.
1.3	Tourism & recreation areas						Not applicable.
2	Agriculture & aquaculture						
2.1	Annual & perennial non-timber crops						Not applicable. Most agricultural development is historical or there are riparian or aquatic protection measures in place. Agriculture applies to Norfolk and Manitoba subpopulations but is considered negligible.
2.2	Wood & pulp plantations						Not applicable. Mixed coniferous and deciduous forests are used as adult perching and foraging areas. Some conversion of native forest to conifer plantations has occurred along Quebec rivers.
2.3	Livestock farming & ranching						Not applicable. Not common although cattle grazing has been observed near Norfolk subpopulations.
2.4	Marine & freshwater aquaculture						Not applicable.
3	Energy production & mining						
3.1	Oil & gas drilling						Not applicable.
3.2	Mining & quarrying						Not applicable. There are sand and gravel quarries near some sites in Ontario and Quebec and there is no known expansion to these sites and no new sites.
3.3	Renewable energy						Not applicable. Not generally present near known sites, although hydroelectric power infrastructure is located on some Quebec rivers.
4	Transportation & service corridors	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
4.1	Roads & railroads	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	See Threats and Liming Factors.
4.2	Utility & service lines						Not applicable. Near Sudbury, some but negligible. Existing lines not included here. Limited to new lines. Maintained on a schedule for vegetation management, potentially pesticides (scored elsewhere), could be a benefit, hunting corridors.
4.3	Shipping lanes						Not applicable.
4.4	Flight paths						Not applicable.

Threat		Impact (calculated)		Scope (next 10 Years)	Severity (10 Years or 3 Gen.)	Timing	Comments
5	Biological resource use	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						Not applicable.
5.2	Gathering terrestrial plants						Not applicable.
5.3	Logging & wood harvesting	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	See Threats and Liming Factors.
5.4	Fishing & harvesting aquatic resources						Not applicable.
6	Human intrusions & disturbance		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
6.1	Recreational activities		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Recreational impacts such as boating and all-terrain vehicle (ATV) use occurs within Riverine Clubtail sites. Boating activity can cause excessive shoreline wake. Riverine Clubtail uses sand or emergent shoreline vegetation close to the high-water mark for ecdysis. These same habitats are susceptible to motorboat wake that could dislodge emerging adults. However, most of the rivers where this species occurs are too small to have substantial motorboat traffic and this threat is considered negligible. ATV disturbance of shoreline vegetation was noted at the Big East River site (#5) (Bowles and Sõber 2005). Disturbance of adults could also occur but is unlikely to result in mortality since this species does not typically perch low in vegetation. Since this species does not engage in mass emergence, it is unlikely that a single event such as boat wake or ATV use on an emergence date could substantially impact a given subpopulation, although sustained activity could reduce recruitment over time. Since Riverine Clubtail occurs on sandy rivers that are also utilized for recreational beach activities, some damage to isolated stretches of shoreline has been noted on rivers with known subpopulations. On the Vermilion River (#7) at several access points, the shoreline had considerable trampling from swimmers, dogs, and beach goers where sand deposition had created wide beaches. However, these impacts were found to be limited and likely only have negligible impacts on this species as most river habitat remains largely inaccessible to foot or vehicular traffic.
6.2	War, civil unrest & military exercises						Not applicable. The Assiniboine River runs adjacent to Canadian Forces Base Shiloh; however, activities do not likely impact Riverine Clubtail subpopulation.
6.3	Work & other activities						Not applicable.

Threat		Impact (calculated)		Scope (next 10 Years)	Severity (10 Years or 3 Gen.)	Timing	Comments
7	Natural system modifications		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
7.1	Fire & fire suppression						Not applicable.
7.2	Dams & water management/ use		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	See Threats and Liming Factors.
7.3	Other ecosystem modifications		Unknown	Unknown	Unknown	Moderate (Possibly in the short term, < 10 Years/3 gen)	See Threats and Liming Factors.
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 Liming Factors.
	Problematic native species/ diseases						Not applicable.
8.3	Introduced genetic material						Not applicable.
8.4	Problematic species/ diseases of unknown origin						Not applicable.
8.5	Viral/prion-induced diseases						Not applicable.
8.6	Diseases of unknown cause						Not applicable.
9	Pollution	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	
9.1	Domestic & urban wastewater		Unknown	Large (31-70%)	Unknown	High (Continuing)	See Threats and Liming Factors.
9.2	Industrial & military effluents		Unknown	Large (31-70%)	Unknown	High (Continuing)	See Threats and Liming Factors.
9.3	Agricultural & forestry effluents	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	See Threats and Liming Factors.
9.4	Garbage & solid waste						Not applicable.
9.5	Air-borne pollutants						Not applicable.
9.6	Excess energy						Not applicable.
10	Geological events						
10.1	Volcanoes						Not applicable.
10.2	Earthquakes/ tsunamis						Not applicable.

Threat		Impact (calculated)		Scope (next 10 Years)	Severity (10 Years or 3 Gen.)	Timing	Comments
10.3	Avalanches/ landslides						Not applicable.
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 Years/3 gen)	
11.1	Habitat shifting & alteration		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 Years/3 gen)	See Threats and Limiting Factors
11.2	Droughts		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 Years/3 gen)	See Threats and Liming Factors.
11.3	Temperature extremes						Not applicable. Heat domes and early/late season frosts could impact roosting individuals.
11.4	Storms & flooding		Unknown	Pervasive (71-100%)	Unknown	Moderate (Possibly in the short term, < 10 Years/3 gen)	See Threats and Liming Factors.
11.5	Other impacts						Not applicable.

[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 area of interest. (Pervasive = 71–100%; Large = 31–70%; Restricted = 11–30%; Small = 1–10%)

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

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

Appendix 2. Field Summary Report for Riverine Clubtail (*Stylurus amnicola*) surveys completed in 2022 as part of the preparation of this status report. Contact the COSEWIC Secretariat for a copy of Appendix 2.

Appendix 3. Maps of each of the 17 Riverine Clubtail (*Stylurus amnicola*) subpopulations in Canada (numbers on the maps represent subpopulations listed in Table 3). 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. The separation distance is 10 km (i.e., records of individuals greater than 10 km apart are considered separate subpopulations. Note that subpopulations have a 5 km radius around each). For some subpopulations, records are separated by over 10 km, yet 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. There appears to be suitable intervening habitat and there may be unrecorded individuals between known sightings. Contact the COSEWIC Secretariat for a copy Appendix 3.